LIFE CYCLE COST ANALYSIS OF UPGRADING BROWN COAL (UBC) PROCESS IN INDONESIA

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A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING IN ENERGY TECHNOLOGY AND MANAGEMENT

THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

2ND SEMESTER 2013

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A Thesis Submitted as a Part of the Requirements
for the Degree of Master of Engineering
in Energy Technology and Management

Double Master Degree Program
The Joint Graduate School of Energy and Environment
At King Mongkut's University of Technology Thonburi
and
The School of Graduate Program Sriwijaya University

2nd Semester 2013

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ABSTRACT

International Energy Agency (IEA) has forecasted in that the demandfor coal would increase by 59 % between the years 2010 and 2035. In Indonesia, coal is expected to become a major energy source to replace oil as set on The National Energy Policy of Indonesian Presidential Decree No. 5, 2006. Indonesia which is one of the top 5 of coal producers mostly concern to fulfill the domestic needs and exporting to other countries in order to increase the income from the energy sector.The potential of Indonesia's coal are low and moderate calorific coal which classified as brown coal. Due to the low heating value, high moisture content and the trend towards higher emissions, brown coal is difficult to be applied directly.

Improving the quality of brown coal, known as Upgrading of Brown Coal (UBC) process is a way out of this issue. The UBC process increases the added value of brown coal so that it is able to meet the coal needs of domestic energy sources and can be exported at a higher price. This study provides an overview of the opportunities of UBC implementation projections based on its life cycle cost (LCC) then make energy policy recommendations. LCC method was conducted to investigate the UBC plant with capacity of 5,000,000 tons/year. The investment costs of UBC plant is USD557.05 million with production costs of USD 92.35/ton. In this study, the UBC product prices selected was USD 93.94/ton (the average coal prices with calorific value of 6,052kcal/kg in 2010 – 2014). The prices of brown coal as feedstock highly influenced, more than half, the net production costs of UBC product.

In terms of economic performance, annual cash flow (ACF) and net present value (NPV) were positive after the production process.The internal rate of return (IRR) is 9.36 % and the payback period (PBP) is 9 years of 20 years of lifetime project. In summary, the analysis showed that the UBC plant is most likely to be feasible.

The total greenhouse gas emission potential, which occurs in the transport section, is divided into two parts: UBC feedstock distribution and product distribution in both the domestic and export sales, 0.059 kg CO_2-eq/ton UBC product, 2.112 kg CO_2-eq/ton UBC product and 1.692 kg CO_2-eq/ton UBC product respectively. While at UBC process, emissions that occur during the process of power generation asenergy source to run the process at UBC 74.454 kg CO_2-eq/ton UBC product or 372,268,800 kg CO_2-eq/year. The UBC process itself takes place in a closed and recycled system, so it can be assumed that almost no emissions form during the process. In terms of UBC product competitiveness, it can reduce feed consumption were used by 50% compared to brown coal in mass basis. Furthermore, the greenhouse gas emission potential which occurs between the two scenarios is 1.141billion kg CO_2-eq/year as net saving.

The Government of Indonesia should pay attention to the mining sector and the UBC process development sector to support the Energy Mix target for 2025. Only by the reduction in feedstock price, improvement in UBC product conversion and also the prevention direct sales of brown coal, UBC process can be developed so that Indonesia can benefit greater in the long term. Coal policy is needed for UBC process development and to prevent direct sales of brown coal to keep coal prices remained stable.

Keyword: Brown coal;Upgrading brown coal; UBC; Life cycle costs; Economic Feasibility; Energy Policy; UBC product competitiveness;

ACKNOWLEDGMENTS

The author would like to express her sincere gratitude to her God, Allah SWT for the blessings, inspiration and help during the completion of this study. A special gratitude to her parents (Drs.Abd.Rahman and Arfianna Novera, S.H, M.Hum) and siblings (Muhammad Zaki Al-Afrani and Miftahurrizka Afrah)for theirwillpower, encouragement, patience, and endless love during her graduate study program. Thank you in advance for her best partner, Muhammad Ihsan Riady, S.T, M.T, classmates and best friends in Indonesia and Thailand.

The author is greatly indebted to Indonesian government through the Super Scholarship Award and the Joint Graduate School of Energy and Environment (JGSEE) for their financial support of her study in JGSEE.

The author is grateful and appreciates the valuable guidance and comments on this thesis report from both her advisors, Dr. Boonrod Sajjakulnukitand Dr. Ir. H. Muhammad Djoni Bustan, M.Eng. The author truly appreciates constructive comments and suggestions of her committee, Assoc. Prof. Dr. Suneerat Fukuda, Assoc. Prof. Dr. Chumnong Sorapipatana, Dr. Thapat Silalertruksa and Asst. Prof. Dr. Phomthong Malakul Na Ayudhaya as her external examiner in order to complete this report.

At the end, the author would also like to give special thanks to the Research and Development Center for Mineral and Coal Technology / RDCMCT (*TekMira*), PT. Upgraded Brown Coal Indonesia / Kobe Steel Ltd. Representative office, PT. Bukit Asam and the Indonesian Central Bureau of Statistics (BPS),which facilitated the data collection in order to complete this research.

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CHAPTER 1
INTRODUCTION

1.1 Rationale and Background

Energy is important in industry, transportation, and other economic sectors, as it feeds and drives the global economy. Availability of energy supply and energy demand including the environmental impact of energy usage became a hot issue in this decade. International Energy Agency (IEA) United States (U.S) in the Annual Energy Outlook 2013 (AEO 2013) with projection to 2040 which was released July 25 states that the Gross Domestic Product (GDP) of world will increase by 3.6 per year until 2040 [1]. This condition will lead the increasing of world energy demand.

The International Energy Agency (IEA) estimates that nearly 80% of the world's energy needs up to 2035 which is fulfilled by fossil fuels. Regarding to world primary energy demand in 2035, coal will replace the position of oil which is expected to remain the largest energy source. Based on the current policies scenarios which are developed by IEA forecast that the coal's demand will increase 59 % between 2010 and 2035 [2]. This condition will happen because the amount of volume of oil as a primary energy source is very limited, while the demand for it is endless further will cause the scarcity of oil in the future. The reliance on using of oil as an energy source and the decreasing of its availability requires us to maximize other sources of energy.

Table 1.1 World Primary Energy Demand and Energy Related CO_2 Emissions (MtoE) [2]

	2000	2010	Current Policies	
			2020	2035
Total	**10,097**	**12,730**	**15,332**	**18,676**
Coal	2,378	3,474	4,417	5.523
Oil	3,659	4,113	4,542	5,053
Gas	2,073	2,740	3341	4,380
Nuclear	679	719	886	1,019
Hydro	226	295	377	460
Bioenergy	1,027	1,277	1,504	1,741
Other Renewable	60	112	265	501
CO_2 emissions (Gt)	**23.7**	**30.2**	**36.3**	**44.1**

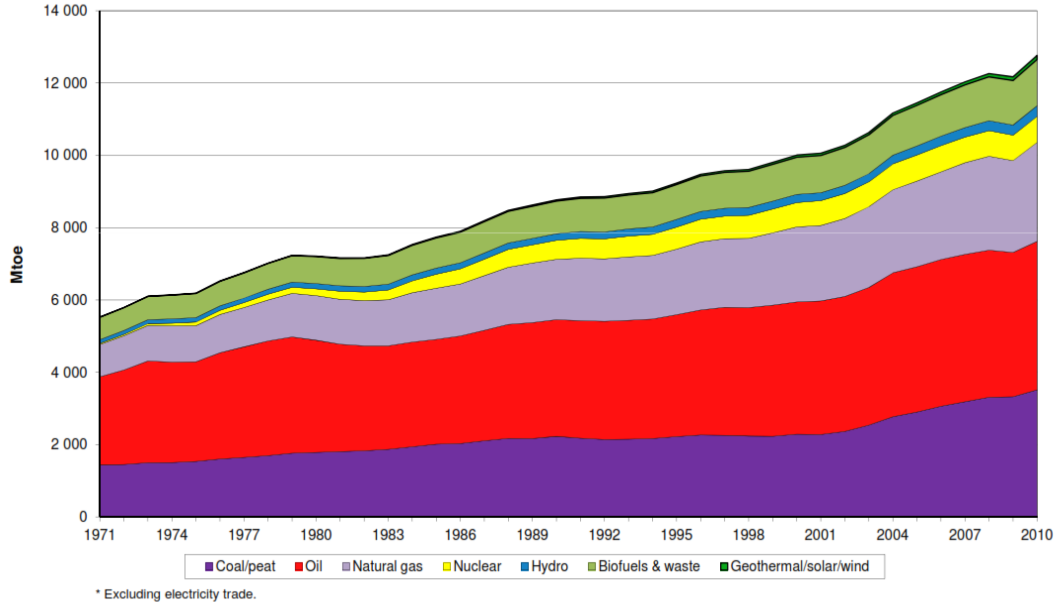


Figure 1.1 World's Total Primary Energy Supply [3]

According to the total energy supply data above, coal supply rapidly increased from 2001 until 2010. The increasing of coal supply was propositional to the increasing of coal demand until 2010 and the coal demand forecasting in 2035. IEA said as it released its annual *Medium-Term Coal Market Report* (*MCMR*) [4] that coal's share of the global energy mix will continue to rise close to surpassing oil as the world's top energy source by 2017. Based on IEA medium-term projections, global coal consumption will stand at 4.32 billion tons of oil equivalent (btoe) by 2017. It means that coal consumption will be higher than oil consumption, around 4.40 btoe [4].

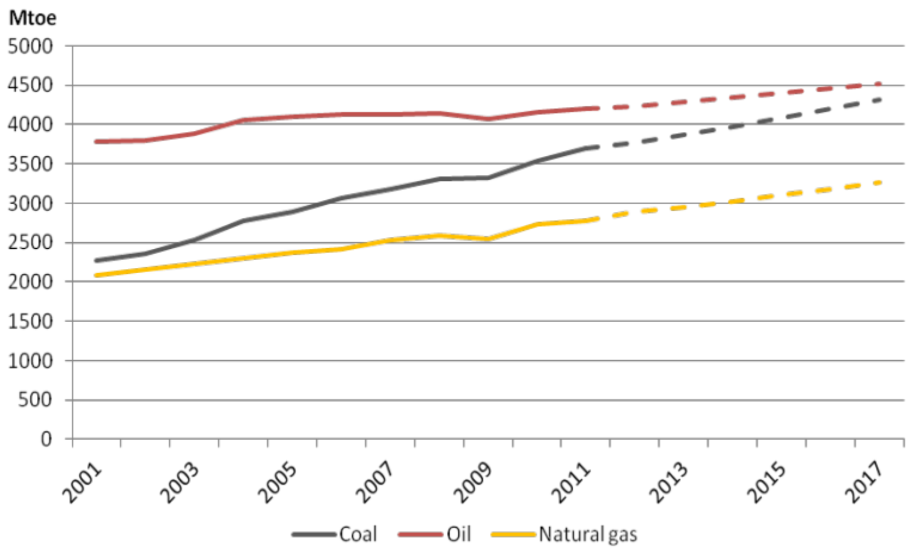


Figure 1.2 Global Primary Energy Supply from Fossil Fuel (MCMR) [4]

The use of coal as the first source of electricity generation and other energy source has never stopped increasing.Forecasts indicate that this trend will continue in the future. This prediction is reinforced by the IEA estimation that currently almost 1.3 billion people lack of access to electricity (around 20 % of the global population). According to that, the use of energy (especially coal) as sources of electricity generation should be increased into maximizes condition. Based on IEA projection, the number of people who still lack access to electricity in 2030 will decrease into 990 million people [2].

The last decade's growth in coal use was driven by the economic growth of developing economies (e.g. China, India, and Indonesia). Coal providing around 30% of global primary energy needs and generates 41% of the world's electricity was produced up to a record level of 7831Mt in 2012. Most of this coal production was produced by the following countries [5].

Table 1.2 Top Ten Coal Producers in 2012 [5]

No.	Coal Producers	Amount of Coal Producing (Mt)
1.	China	3 549
2.	United States (US)	935
3.	India	595
4.	Indonesia	443
5.	Australia	421
6.	Russia	359
7.	South Africa	259
8.	Germany	197
9.	Poland	144
10.	Kazakhstan	126

Indonesia, which is one of the top 5 coal producers,is mostly concern with national coal as an energy source. It can be seen in the Indonesian Presidential Decree No. 5 of 2006 on National Energy Policy embodied in national primary energy mix target on 2025 [6]. From this following picture is shown clearly that the use of coal will continue to be improved to become the biggest energy source, i.e. 33%. This is also done in order to reduce dependence on diminishing of oil quantity.

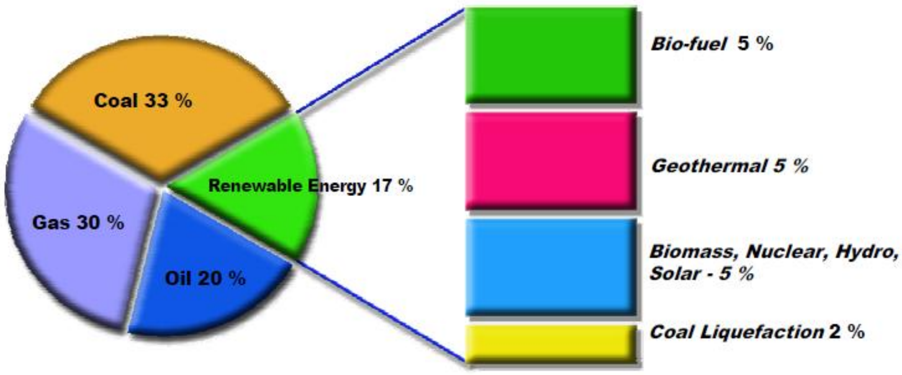


Figure 1.3 Indonesian Energy Mix Years 2025

Source: Ministry of Energy and MineralResources, Directorate General of Mineral and Coal

Besides the good impact in avoiding dependence on oil as a primary energy source, it also brings negative impact especially in the environmental sector. Parts of environmental concern issues are global, regional, and local environmental impacts. Using of coal as an energy source will increase the probability of global, regional and local environmental impacts. Due to the heating value is not too high and the trend towards higher emissions, brown coal is still difficult to be applied directly as an energy source for electricity generation. Meanwhile, the number of brown coal is quite abundant in the world, especially in Indonesia.

In using of brown coal as an energy source for electricity generation, upgrading brown coal (UBC) as one of the clean coal technologies that are being widely applied in developing countries in order to increase the efficiency of combustion processes in the power plant sector. Besides being able to meet the needs for supplying of environmentally friendly domestic energy sources, UBC also can increase the added value of brown coal itself so it can fully utilized for domestic needs and able to export at a higher price. On the other side, government should also interference in this problem by making energy policy. The defined Energy policy should contain the standards for clean coal technology clearly. Energy policy for the UBC is important to set considering the high quantity of brown coal and its impact when it is used directly, especially in Indonesia. Life cycle cost about the UBC is important to calculate in order to set up coal upgrading policy in Indonesia.

1.2 Problem Statement

Indonesia is the largest archipelago country in the world. This fact triggers the increasing of growth population rapidly. In 2011 recorded, the population of Indonesia was as much as 241,133.70thousand people [7]. This is one of the causes of its high energy demand and use to meet the needs and the level comfort for every citizen in Indonesia. These conditions reinforce for the occurrence of energy scarcity. The amount of energy is very limited should be able to meet the needs of people which are not bounded.

Indonesia has relied on the fulfillment of energy demand from fossil fuel energy sources, mainly oil. This happened because it is influenced by the position of Indonesia a few years ago that was one of the largest oil producer especially South East Asia. Therefore, Indonesia joined OPEC in December 1962 [8], two years after the organization was established. Position of Indonesia as oil exporting countries discontinues surviving when oil production dropped during the economic crisis affecting the energy reserves in Indonesia. Indonesia's crude oil production continued to decline from 517 million btoe in 2000 to 348 million btoe in 2007 or a decline of 5.5 % per annum [9].

High oil production in the past has led the government to apply a high subsidy to fuel as the final form of energy for Indonesia's poor and wealthy. In May 2008, the Co-coordinating Ministry of Economy Affairs of Indonesia advised that the top 40% of high income families benefit from 70 % of the subsidies, while the bottom 40 % of low income families benefit from only 15 % of the subsidies. In essence, the subsidies missed their target and benefiting the rich more than the poor [10]. Minister of Finance Agus Martowardojo said that until December 28, 2012, fuel subsidies reached IDR 211.9 trillion, or reached 154.22% of the maximum amount of fuel subsidies in the 2012 state budget of IDR 137.4 trillion [11].This subsidy highly pampers Indonesian society and indirectly increases the amount of energy consumption in Indonesia. The energy diversification opportunities which are announced by the government were being hampered. People prefer to buy oil as final energy, because its price is cheaper than other fuel. With the quantity of oil that is owned, Indonesia can no longer exported oil to other countries. In September 2008 OPEC announced that Indonesia had formally suspended its membership in the oil cartel [12]. Indonesia's original position is the oil exporting countries were turned into oil importing countries to fulfill the high demand for oil.

To overcome the dependence on oil as an energy source, the Government of Indonesia (GoI) launched to maximize the use of other energy sources. Coal is expected to replace oil as a major energy source in the target set out in the energy mix of the Indonesian Presidential Decree No. 5 of 2006 on National Energy Policy. Besides as domestic consumption, coal is also expected to continue to be exported to other countries in order to increase the income from the energy sector. This desire increased when Indonesia was no longer able to export oil as it is today.

Using coal as solid fuel and increases in the state income from the coal sector has yet to reach the maximum point, because Indonesian coal is low quality coal, called brown coal. Brown coal has a low calorific value (CV) and there are lots of ash content, sulfur content, volatile matter (VM) and inherent moisture (IM). Meanwhile, most of the brown coal used in the country as a source of power generation. With an abundant quantity of brown coal in Indonesia, it is very likely to increase state income.

Therefore, the use of brown coal to generate electricity generation should be maximized. This can be done by increasing the efficiency of the electricity generation process itself. One of the goals in the UBC application process is to improve the efficiency of combustion in the boiler in an electricity generation process. Brown coal has high moisture content while the UBC process can reduce the moisture content of brown coal by up to 80%. High content of moisture which can decrease the efficiency of combustion in the boiler because it would increase the likelihood of heat losses occur. The process for the generation of electricity can be used as a standard to see UBC competitiveness when compared to brown coal as usual. The purpose of the application UBC process as the added value of brown coal can be displayed throughout this section.

As mentioned before, improving the quality of brown coal called the UBC process is a solution to this issue. Unfortunately, UBC has not been maximized and still as demonstration plant. There has been no basis in detail from GoI in the form of energy policy to support the UBC process development. This study provides an overview of the opportunities and advantages in the implementation of UBC projections based on its life cycle costs production before brown coal is used to fulfill domestic needs and exported out of the country and makes recommendations in the field of energy policy.

1.3 Literature Review

1.3.1 Energy Profile in Indonesia

Geographically, Indonesia which is a part of Southeast Asia is located between $6^0$08’ North latitude, 11° 15’ South latitude, and between 94° 45’ 141° 05’ East Longitude, and lies on equator line located at 0° latitude lines [13]. Here are descriptions of socio-economy conditions in Indonesia [7]

- Territorial Area : 7,788,810.32 km^2

- Land Area : 1,910,931.32 km^2
- Population : 241,133.70 Thousand People
- GDP Regional
  a) Total Value : 7,427.09 Trillion Rupiahs
  b) Per Capita : 30,800.70 Thousand Rupiahs per year

Figure 1.4 Indonesia

As a developing country, Indonesia continues to strive in for economic growth and rate of GDP per capita with the consequence that energy consumption will continue to rise. This case should not be a big challenge for Indonesia, regarding to the conditions of Indonesia which contains a lot of natural resources. Potential of natural resources did not ensure that high welfare of the Indonesian people as a whole. Economically, this statement was evidenced by the decrease in the rate of economic growth of Indonesia in 2008 - 2009, which was originally at 6.0% to 4.6% [13].

As reported in the Handbook of Energy and EconomicsStatistics of Indonesia 2012[7], Indonesia currently uses six primary energy resources: crude oil, natural gas, coal, hydro power, geothermal and biomass. Final energy from transformation facilities then consumed in five different sectors: industry, transportation, commercial and public services, households, and other sectors. Figures 1.5 – 1.7 summarize Indonesia's demand-supply structures, the production of primary energy supply by energy source and final energy consumption by sector in 2011 [7].

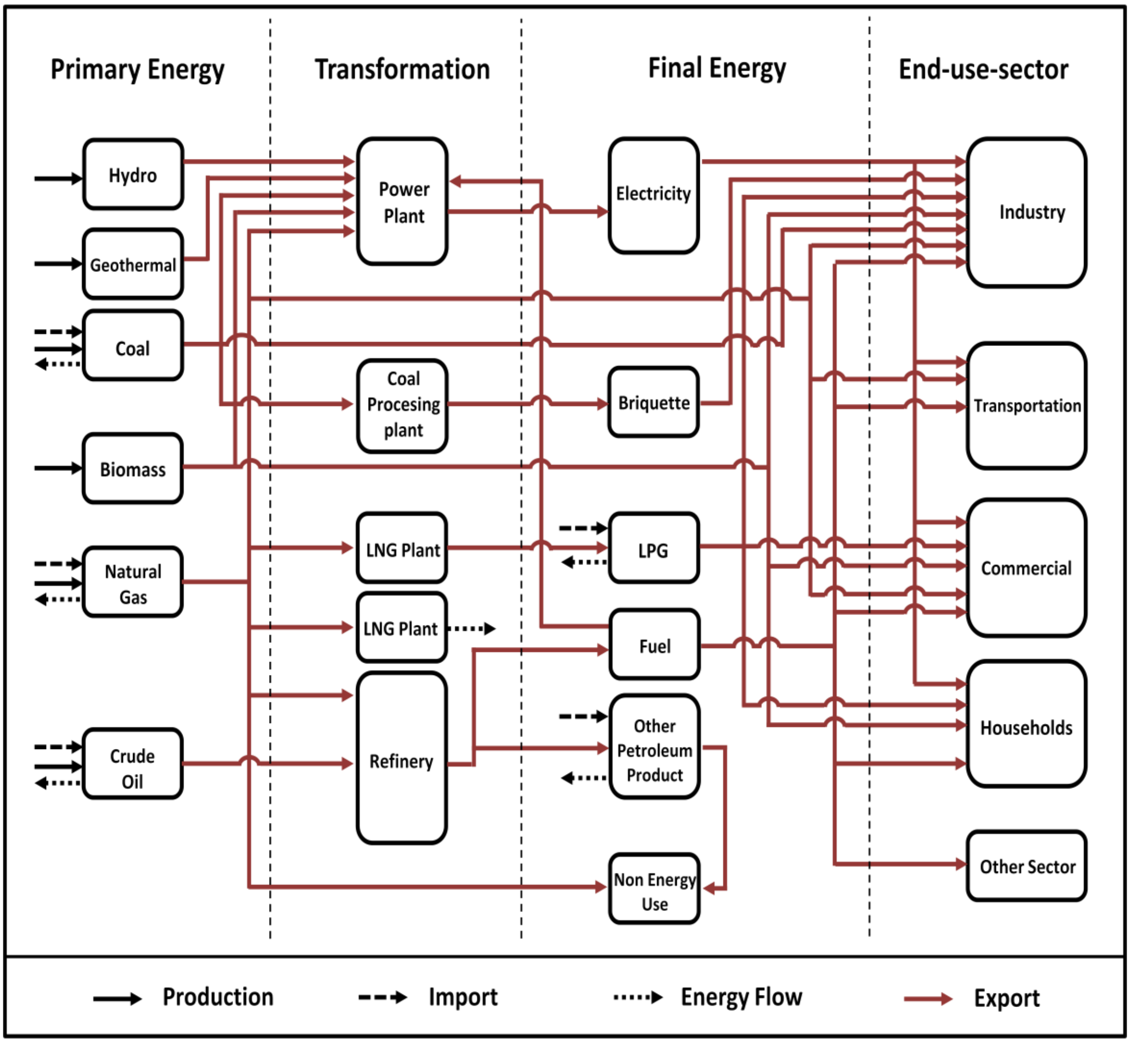


Figure 1.5 Indonesian Energy Supply-Demand Structures [7]

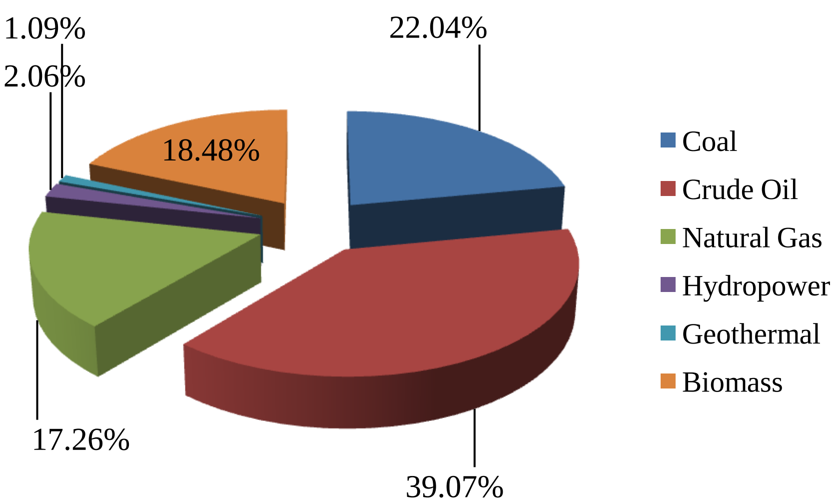


Figure 1.6 Primary Energy Supply by Sources in Indonesia 2011 [7]

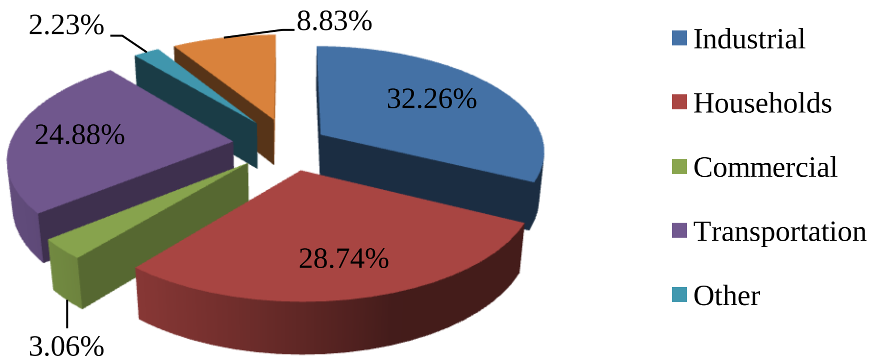


Figure 1.7 Final Energy Consumption by Sector in Indonesia 2011 [7]

1.3.2 Energy Policy in Indonesia

Immediate responsibilities for Indonesia's energy policy lie with the Ministry of Energy and Mineral Resources (MEMR). Policy for coal is the responsibility of the Directorate General of Minerals, Coal and Geothermal (DGMC&G). Energy policies objectives in Indonesia are based on the Presidential Decree No.5 of 2006 on National Energy Policy and its Blueprint of National Energy Management 2006 – 2025 (*Pengelolahan Energi Nasional* – PEN) [14].

Indonesia's coal industry has shown impressive growth in the last ten years and has benefited from the record high coal prices in the global markets. Indonesia's Energy Policy aims to bring coal more strongly into the country's energy mix (diversification). It can be seen from one of the objectives in the Blueprint of National Energy Management 2006 - 2025, namely the realization of security of energy supply by increasing the role of coal to 33% in 2025. This improvement is done through the use of brown coal, coal liquefaction and coal briquettes.

Indonesia's announcement in May 2008 of its universal goal of an absolute cut in GHG emissions is to be applauded. The goal is to cut energy sector emissions by 17% by 2025 and implement bold reductions in forest burning. How the cuts are to be achieved is not clear, as Indonesia also will increase emissions intensively by coal as the primary energy source in the domestic energy mix [10]. Within MEMR, the Agency for Research and Development co-ordinates four specialized R&D centre, one of them is *TekMira*which is related to mineral and coal technologies [9]. Through Development Policy part launched a range of targets; one of them is Upgrading Brown Coal (UBC) process to increase the added value of quality brown coal in Indonesia. Here is the implementation to get the purpose of National Coal Policy related to the UBC process [15].

1. *Short Term Program through 2005*

   Developing Low Rank Coal Utilization Centre (UBC, Liquefaction, Gasification)

2. *Medium Term Program 2005 – 2010*

   Planning & Developing Upgrading Plant for Low Rank Coal

3. *Long Term Program 2010 – 2020*

   Developing UBC Plant

1.3.3 Coal as Energy Source in Indonesia

In accordance with projections up to the year 2035 by the International Energy Agency (IEA), coal is expected to be the energy source to replace oil’s dominance. As one of the 5 major coal producing countries, Indonesia did not miss the opportunity to maximize the potential of coal-owned. Here are the total coal resources and reserves in Indonesia [16].

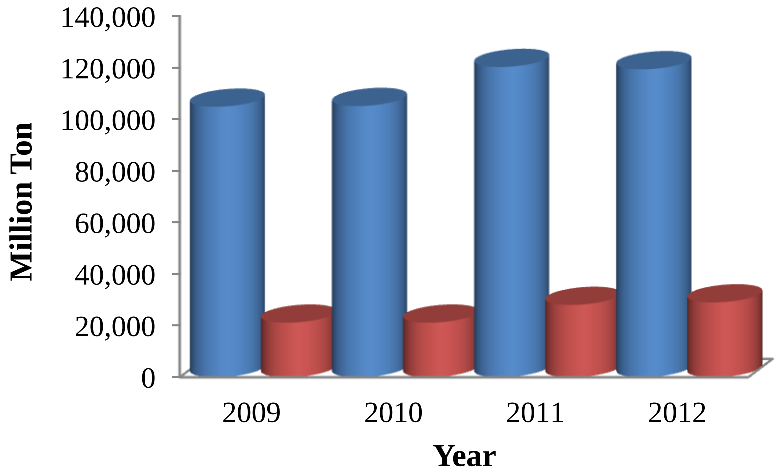


Figure 1.8 Coal Resources and Reserves in 2009 – 2012 [16]

Through the Indonesian Presidential Decree No. 5 of 2006 as the target energy mix, the use of coal as an energy source is expected to reach 33% in 2025. This policy is fully supported by the total coal resources in Indonesia until 2012 stood at 119,446.36 million tons with total coal reserves of 28978.61 million tons.

Based on the Presidential Decree No. 13 A of 2000, which was renewed by Government Regulation 45 of 2000, the quality of coal in Indonesia in terms of calories are divided into four classes; namely low calorific coal, moderate calorific coal, high calorific coal and very high calorific coal. Resources and total coal reserves in Indonesia in detail based on its quality can be seen in the following table [16].

Table 1.3 Coal Qualities and Resources in Indonesia 2012

Quality	Resources(million tons)					Total (%)
	Hypothetical	Estimated	Designated	Measured	Total	
Low Calorie	4,784.03	9,278.15	9,512.10	10,990.10	34,564.38	**28.94**
Moderate Calorie	27,278.45	22,343.02	14,311.11	9,895.18	73,827.76	**61.81**
High Calorie	848.97	2,679.28	2,252.50	3,495.70	9,276.44	**7.77**
Very High Calorie	39.61	1,107.00	324.27	306.90	1,777.78	**1.49**
Total	**32,951.05**	**35,407.44**	**26,399.98**	**24,687.89**	**119,446.36**	**100.00**

Table 1.4 Coal Quality and Reserves in Indonesia 2012

Quality	Reserves(million tonss)		
	Estimated	Confirmed	Total
Low Calorie	5,824.84	3,755.25	9,580.09
Moderate Calorie	12,952.29	4,574.96	17,527.25
High Calorie	384.74	1,090.86	1,475.60
Very High Calorie	195.05	200.62	395.67
Total	**19,356.92**	**9,621.69**	**28,978.61**

Quality classes based on calorific value are taken from Presidential decree No.13 of 2000 amended by Government Regulation No.45 of 2003)

A. Low Calorific Coal < 5,100 kcal/kg
B. Moderate Calorific Coal 5,100 – 6,100 kcal/kg
C. High Calorific Coal 6,100 – 7,100 kcal/kg
D. Very High Calorific Coal > 7,100 kcal/kg

Clearly visible intheTable 1.5 is the potential of Indonesia's coal being low calorific coal (< 5,100 kcal/kg) and moderate calorific coal (5,100 to 6,100 kcal/kg) which are included in the category of brown coal. Brown coal is widely used to meet domestic demand as a source of energy for power generation in Indonesia. While the high quality coal will be exported to several countries

The Position of Indonesia as one of the largest coal exporters in the world becomes an opportunity to earn a greater income with the potential for Indonesian coal-owned. It is slightly obstructed by the high quality coal demand from other countries. With the UBC, brown coal can be enhanced by increasing the calorific value of the brown coal. At the end of coal reserves in Indonesia is expected to be maximized and to increase state revenues.

1.4 Research Objectives

1. To assess the investment and production costs of Upgrading Brown Coal (UBC) commercial plants in Indonesia.
2. To estimate the economic feasibility of Upgrading Brown Coal (UBC) process as added value to brown coal in order to improve the economy in Indonesia.
3. To analyze greenhouse gas (GHG) emissions of upgrading brown coal (UBC) process and the transportation sector.
4. To evaluate the competitiveness of Upgrading Brown Coal (UBC) process in order to increase the quality of brown coal in Indonesia.
5. To set energy policy recommendations in the field of using brown coal as the primary energy source.

1.5 Scope of Work

1. The technology used in the UBC process is based on the planning of UBC commercial plants in Indonesia and demonstration plants. Then in this study, the data are scaled up into the production capacity for commercial plants.
2. Life cycle cost analysis, economic feasibility analysis, greenhouse gas emission calculation, UBC product competitiveness and policy recommendations are five main parts discussed in this study.
3. The life cycle cost in this study is calculated from the purchasing of feedstock, energy and transportation costs during the upgrading process, the landcosts without salvage value of the land needed, company services and the organizational structure of a UBC plant.
4. Demolishingcostsare not included in the life cycle costs analysis.
5. The UBC process is a closed system, so that GHG emissions only come from the electricity generation to run it.
6. GHG emissions as global warming potential by the transportation sector were calculated by IPCC 2007 from the feedstock supplier until the last pier or port as the distribution sector.
7. UBC competitiveness was measured by the combustion process of brown coal and UBC product in the boiler of 660 MW of a power plant in order to generate electricity.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Coal

Coal is a chemically and physically heterogeneous, “combustible,” sedimentary rock consisting of both organic and inorganic material [17].

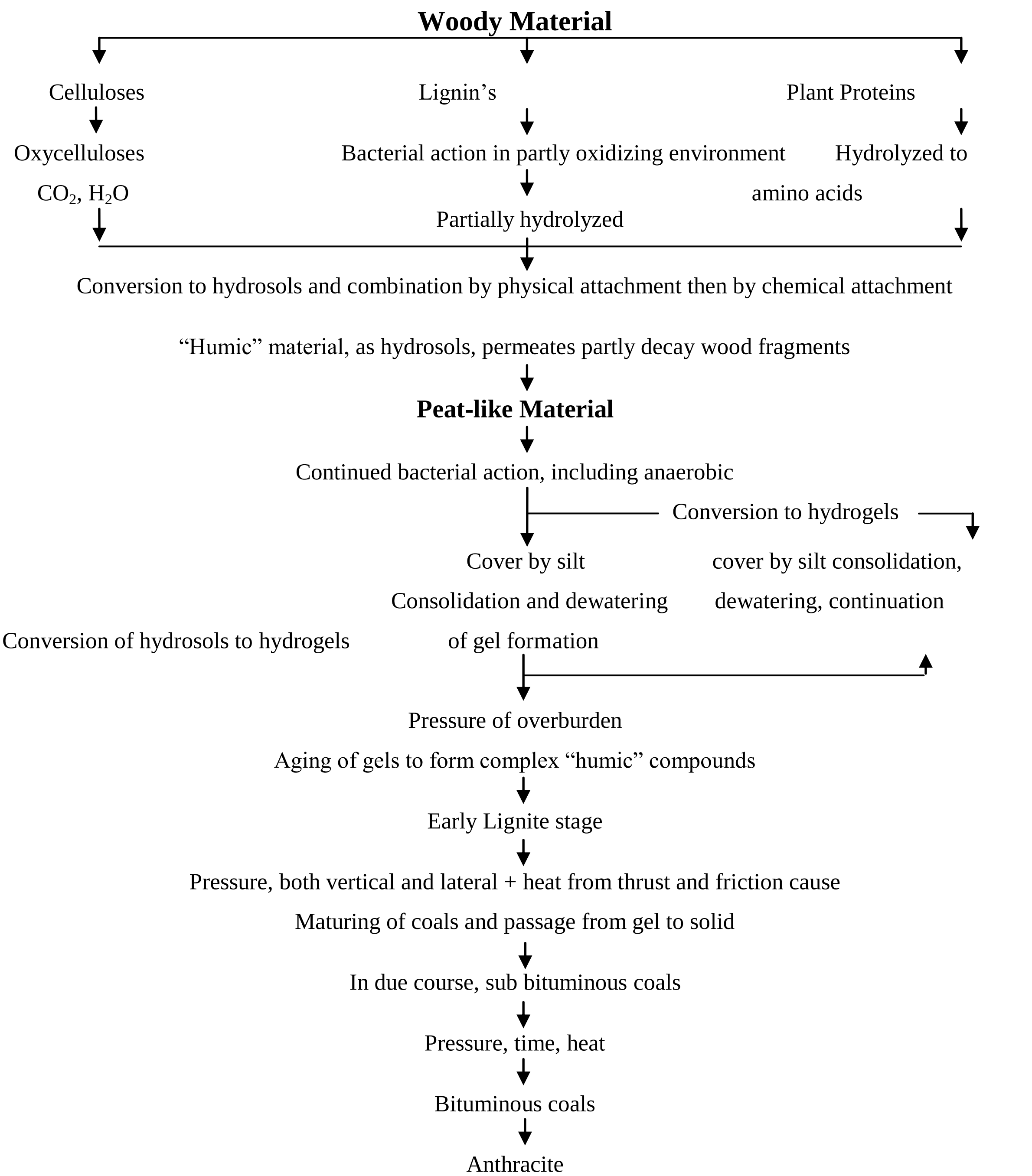


Figure 2.1 Schematic Diagram of Coalification [18]

Coalification process ultimately determines the type of coal that exists today:

1. Lignite
2. Sub bituminous coal
3. Bituminous coal
4. Anthracite

Organically, coal consists primarily of carbon, oxygen, and hydrogen, with fewer amounts of sulfur and nitrogen. Inorganically, it consists of a diverse range of ash-forming compounds and volatile matter. Ultimate analysis describes coal in terms of its elemental composition.Specifically, it is used to measure weight percentages of carbon, hydrogen, nitrogen, sulfur, and ash for a dried coal [19]. The proximate analysis of coal is an assay as determined by series of standard test methods which is include of some contents, namely:

1. Moisture
   a. Free Moisture

      Free moisture is the water from external sources, such as weather or coal washing.
   b. Inherent Moisture

      Inherent moisture is water held within the pore system and capillaries of coal [20].
2. Ash

   Ash is the residue remaining after the combustion of coal under specification conditions and is composed primarily of oxides and sulfates [20].
3. Volatile matter

   Volatile matter is material that is driven off when coal is heated to 950°C (1,742°F) in the absence of air under specified conditions [21].
4. Fixed carbon

   Fixed carbon is the material remaining after the determination of moisture, volatile matter, and ash, which were used as parameters in the coal classification system [20].

2.2 Coal Classification

According to the World Energy Council (WEC), there is no universally accepted system for the classification of coal. Thus, the allocations to these coal groups may differ from one country to another and the systematic variation of the properties of coal with rank, and the possibility of measuring these properties by some analysis so as to assess the sustainability of coal for industrial purposes, has led to the creation of a number of classification systems. [18].

2.2.1 ASTM Coal Classification System

The American Standard for Testing Material (ASTM) Classification system, ASTM D 388, distinguishes among four coal classes.Each of which is subdivided into several groups. ASTM coal rank classifies on the basis of two variables: the percentage of fixed carbon and volatile matter for high rank coal and gross calorific value for low rank coal.

Table 2.1ASTM D 388-05 Classification [22]

Class	Group	Fixed Carbon Limits (% dmmf)		Volatile Matter Limits (% dmmf)		Gross Calorific Value Limits (Btu/lb mmmf)	
		Equal / greater than	Less than	Greater than	Equal / less than	Equal / greater than	Less Than
I. Anthracite	1.Meta-anthracite	98			2		
	2.Anthracite	92	98	2	8		
	3.Semi-Anthracite	86	92	8	14		
II.Bituminous	1. Low Volatile	78	86	14	22		
	2. Medium Volatile	69	78	22	31		
	3. High Volatile A		69	31		14,000	
	4. High Volatile B					13,000	14,000
	5. High Volatile C					11,500	13,000
III.Sub-bituminous	1. Sub bituminous A					10,500	11,500
	2. Sub bituminous B					9,500	10,500
	3. Sub bituminous C					8,300	9,500
IV. Lignite	1. Lignite A					6,300	8,300
	2. Lignite B						6,300

Note: % dmmf: % dries mineral-matter-free basis % mmmf: % moist mineral-matter-free basis

2.2.2 UK National Coal Broad (NCB) classification

The NCB classification, called the British Coal Classification, was developed in the 1920s from the need to predict the caking properties of a new coal. This Ranking method was devised for British-like coals only, and a number of more universal methods were devised in the US, Europe, and Australia. This system uses dry, ash-free volatile matter yield as rank parameter and has sub-classifications according to an empirical laboratory means of assessing caking power (the Gray King coke test).

2.2.3 The International Coal Classification Scheme (ISO)

The ISO (International Organization for Standardization) scheme is used in both coke production and power industrial countries. This classification has been accepted by the European Commission. There are two kinds of coal in this system: hard coal and soft coal, or brown coal. Hard coal is calculated as the sum of cooking coal and steam coal. Brown coal or soft coal has been classified arbitrarily as coal having a moist, ash-free, calorific value below 10,260 Btu/lb, and hard coals above this value [20]. According to The International Coal Classification of The Economic Commission for Europe (UN/ECE), hard coal is defined as a coal with gross calorific value (CV) of greater than 5,700 kcal/kg (23.9 MJ/kg) on an ash-free but moist basis and with a mean random reflectance of vitrinite of at least 0.6 [23].

2.3 Brown Coal

In the IEA Coal Information Edition 2011, a significant proportion of Indonesian hard coal production has been re-classified as brown coal. This has changed Indonesia’s relative position in the ranking of both hard and brown coal producers [24].

Table 2.2 Major World Brown Coal Producers

Coal Producers	2008 (Mt)	2009 (Mt)	2010 (Mt)
Germany	175.3	169.9	169.9
Indonesia	120.1	140.9	162.6
Russia	82.5	69.0	76.0
Turkey	76.8	76.6	69.0
Australia	66.0	68.3	67.2
United States	68.7	65.8	64.8
Greece	65.7	64.9	56.5
Poland	59.7	57.1	43.9
Czech Republic	47.5	45.4	37.3
Serbia-Montenegro	38.7	38.5	34.2

***Source: IEA Coal Information 2011**

Brown coal is usually produced by surface mining, which keeps extraction costss much lower than those of hard coals that are extracted through underground mining. These coals typically include lignite and somesub bituminous coals [23].It is a broad and variable group of low-rank coals characterized by [25]:

1. High moisture content (> 30%)
2. High volatile matter (40–55%)
3. High oxygen content (15–20%)
4. Low calorific value
5. Weathers and is easily ignited (stacking time <30 days)
6. Difficult to transport
7. Low combustion efficiency
8. Almost no direct gasification
9. Suitable only for in situ power generation or processing

The consumption and production trends of brown coal and hard coal in global reserves are quite different. The world consumes much more hard coal than brown coal and the gap between the two has become wider over the years. The low energy density and typically high moisture content makes long-distance transport of brown coal costly and therefore, international trade of brown coal is essentially low. The use of brown coal is limited mainly to power generation at, or close to, the mining site [26].

2.3.1 Sub-bituminous Coal

The International Coal Classification of the Economic Commission for Europe (UN/ECE) recognizes that Brown coal is comprised of sub-bituminous coal and lignite.

Figure 2.2 Sub-bituminousCoal

Sub-bituminous coals may be dull, dark brown to black, soft and crumbly at the lower end of the range, to bright jet-black, hard, and relatively strong at the upper end. Sub-bituminous coal isa type of coal that has properties ranging from those of lignite to those of bituminous coal, and is used primarily as fuel for steam-electric power generation[27]. Sub bituminous coal is defined as the part of brown coal that has characteristics as follows [26]:

1. Gross Calorific Value between 4,165 kcal/kg (17.4 MJ/kg) and 5,700 kcal/kg (23.9 MJ/kg)
2. Containing more than 31% volatile matter on a dry mineral matter free basis
3. Relatively low density and high water content

2.3.2 Lignite

Lignite with all the characteristics is a part of brown coal. Lignite is considered to be the lowest rank of coal, is a soft fuel and is often referred to as brown coal due to its brownish-black color. Lignite is a coal in the early stages of coalification, with properties intermediate to those of bituminous coal and peat. In general, lignite is any variety of coal that contains [23]:

1. A low carbon content of around 25 – 35%
2. A calorific value lower than 4,165kcal/kg (17.4 MJ/kg)
3. A high inherent moisture content sometimes as high as 70%
4. Ash content ranging from 6% to 19%.
5. Volatile matter > 31% on a dry mineral matter free basis

Lignite is insusceptible to spontaneous combustion, which can give rise to transport, storage and handling problems. In spite of generally high moisture content of lignite, the organic matter is inherently more reactive than in older coals. The characteristics of lignite's are different in each country. Here are the characteristics of lignite [26]:

1. Moisture content : 35 – 75% as-mined
2. Ash content : 1 – 15% db
3. Sulfur content : 0.1 – 2.4% db
4. Calorific Value : < 17.4 MJ/kg LHV

Figure 2.3 Lignite

2.4. Brown coal as a Solid Fuel in Power Generation

The economic value of brown coal is relatively low compared with the hard coal due to its calorific value and other undesirable properties that limits its use in coal utilization equipment. Also, the huge ash and moisture content of brown coal makes its long distance transport very costly and increases overall environmental impacts [26].

Currently, 40% of the world's electricity production comes from coal. The numbers of coal-fired power plants are estimated to grow 2.3% annually through 2030 [28]. Due to the combination of high moisture content (high transport costs) and high reactivity (risk of spontaneous combustion) brown coals are used close to the mine, and they are used almost executively for power generation. The majority of existing brown coal power stations are pulverized coal fired steam cycle plants [26].

In Indonesia, according to the brown coal's quantities, GoI lately has been more serious in seeking to reduce oil consumption and use coal, which is much cheaper to generate power. In 2009, Indonesia relied on coal for 47.09% for its electricity generation [29]. Having population growth of 1.3% and annual economic of 6.1%, respectively, the need for electricity is estimated to grow around 9.2% per year [30]. It is also forecasted that coal will account for 63% of energy mix for power generation in 2018 [31]. Meanwhile, renewable energy share in the country's energy mix grows very slowly. Therefore, coal-fired power plant is seen as a viable option to meet Indonesia's energy need due to its abundant availability and stability of supply. When Indonesia has recovered from its economic crisis, there will be an increasing demand for power. It is projected that country's consumption of coal in 2020 will be two point fivefold of in 2005, reaching 75 million tons with CO_2 emissions increasing from 69.4 million tons in 2005 to 171 million tons in 2020 [32].

Figure 2.4 Emissions Release from Coal Power Plant

Low efficiency of brown coal used in boilers means not only to reduce economic values of brown coal but also to increase the impact on its overall behavior on the thermal efficiency and so on the amount of CO_2 and other pollutants, such as emissions of particulates, SO_2, NOx and mercury produced per MW of power. The starting point for increasing efficiency of power generation is the quality and consistency of brown coal feed to any combustion and gasification process. The efficiency can be improved by upgrading the quality of brown coal itself before it burns. Such as removing the coal moisture prior to utilization, by improving the power generation cycle efficiency, or by combination of these approaches [26].

2.5. Upgrading Brown Coal (UBC)

According to the low quality of brown coal and its potential as a source of CO_2 emissions and other pollutants, there are various way developed to reduce the bad impacts, such as [33]:

1. Coal Upgrading includes coal washing/ drying and briquetting. The application is costs-effective in many developing countries, such as Indonesia
2. Efficiency improvements in existing plants
3. Advanced Technologies
4. Carbon Capture Storage (CSS) could reduce emissions of CO_2 to near zero with highest costs than other ways.

Coal Upgrading is a process to increase the quality of low rank coal (lignite and or sub-bituminous) to become similar to the quality of bituminous coal [34]. Upgrading increases the heating value of coal and improves the consistency of the fuel, leading to more efficient and controllable production combustion. Thus, the thermal efficiency of both of boilers and stoves is increased and CO_2 emissions per unit of energy used are reduced [33].The upgrading of a thermal coal is intended not only to improve its combustion properties, but to minimize the presence of abrasive and corrosive materials

There are many types of coal upgrading, including hot water drying (HWD), coal water slurry (CWS) or coal water mixture (CMW), hydrothermal upgrading, binder less coal briquetting (BCB), upgrading brown coal (UBC), etc. UBC process which is being developed into a commercial scale in Indonesian been discussed in this study. UBC is the process of increasing the caloric value of low-grade coal through reduction of water content in the coal moisture. [35].

2.5.1 UBC Principles

Upgrading brown coal may allow coals to be more successfully utilized. Upgrading reduces the transport costs for low rank coals (on a delivered energy basis) [34].

Figure 2.5 UBC Principles [36]

In Figure 2.5, it can be seen that the process is carried out with the aim of UBC as a stabilizer of the brown coal feed as well as the added value of brown coal into premium coal. As feed stabilizer, products from the UBC will be used as fuel for power generation and coal fires are also some industries. Meanwhile, as a means of increasing the value of the coal itself is done for s more economical purpose, that is to increasing the export value. In Indonesia, the UBC conducted over several principles, namely to increase quality coal with the following standards [37]:

1. Reduce moisture of low rank coal / brown coal up to 80%, by moisture reduction from 25- 50% to <10%
2. Increase CV of low rank coal / brown coal (<5,000 kcal/kg) into a product similar to high rank coal / hard coal (>6,000 kcal/kg) based on slurry dewatering process

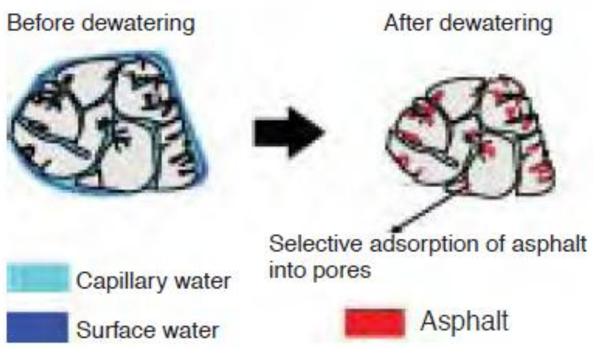


Figure 2.6 Fundamentals of Low Rank Coal / Brown Coal Upgrading [38]

Low-rank coal contains numerous pores and the moisture within them is removed in the course of evaporation. Asphalt is an organic compound, which has some similarities to the chemical properties of coal [36]. Moreover, the water-repellant nature of heavy oil functions to prevent the re-adsorption of moisture and accumulation of the heat of wetting [38].For transportation as a commodity export, UBC will be molded into briquettes, while shipments to the industry at a relatively close distance can be through a pipe. For ease of distribution through pipelines, UBC will be mixed with water. This does not degrade the quality of UBC because coal is mixed with the residue remaining stable.

2.5.2 UBC Process

A low-rank coal or brown coal upgrading technology (UBC process) has been developed to enable the effective use of such low-rank coal. This process is an adaptation of the slurry dewatering technique in the brown coal liquefaction process [38].

Figure 2.7 Block Diagram for Upgrading Low-Rank Coal / Brown Coal [38]

UBC process produces two forms of products, i.e.:

1. Powder form

   Upgraded Brown Coal contains moisture of 0% and calorific value (CV) of 6670kcal/kg or more. UBC product in powder form use as direct feed to mine-mouth power plant feed to UBC power plant in distant location [39].

2. Briquette form:

   Upgraded Brown Coal briquette contains moisture of 8-10% and calorific value (CV) of 6000kcal/kg. The briquetting process would facilitate the transportation section of UBC production from the plant, such us the ocean or rail transport for long distance to be used as fuel for industries and households.

Figure 2.8 UBC Products

2.5.3 Upgrading Brown Coal (UBC) Potential

Upgrading Brown Coal (UBC) provides many positive impacts associated with a high quantity of brown coal, but it cannot be fully utilized because the quality is lower than that of hard coal. In summary, the overall benefits from coal upgrading include [33, 35]:

1. Added value to the coal
2. Increased the utilization of low rank coal to help the energy conservation program.
3. Prevented the secure and stability of energy supply
4. Stabilized coal quality feed for power generation and industries
5. Increased combustion efficiency
6. Reduced CO_2emissionsand other emissions such as Sox, Nox, and PM
7. Lower ash and/or moisture content
8. Raised lower heating value (LHV)
9. Reduced transport volumes, and hence, costs
10. Reduced sulfur content in many cases
11. Reduction in amount of various trace elements present in most cases
12. Simple operation conditions (low temperature and low pressure)
13. Free from chemical reactions
14. Waste water is free from pollutant materials
15. The resulting product is stable

Coal upgrading processes, such as coal washing or coal drying, can be applied for power plants and industries. Unfortunately, the resulting products of these two types of coal upgrading are less stable to be stored for a long time or to be transported over long distances. UBC as a one of coal upgrading processes produces a more stable product with a series of processes. This condition makes UBC product can be used to fulfill domestic demand and to increase the selling value of export to other countries. Coal qualities in Indonesia are mostly categorized as brown coal lead Indonesia as a developing country to maximizes UBC application which is expected to give significant positive impacts on economic development in Indonesia is most likely to use upgrading also to reduce CO_2 emission, as it exports large amount of coal. The overall reduction in CO_2emissions which are possible cannot be quantified. However with other plant and operational measures as well, there are substantial potential benefits to be gained from upgrading coal [33]. Based on IEA projection and Crouch [35], an additional 100 Gt of coal could usefully be upgraded between 2009 and 2020 compared with current practice.

2.6 Upgrading Brown Coal (UBC) Development in Indonesia

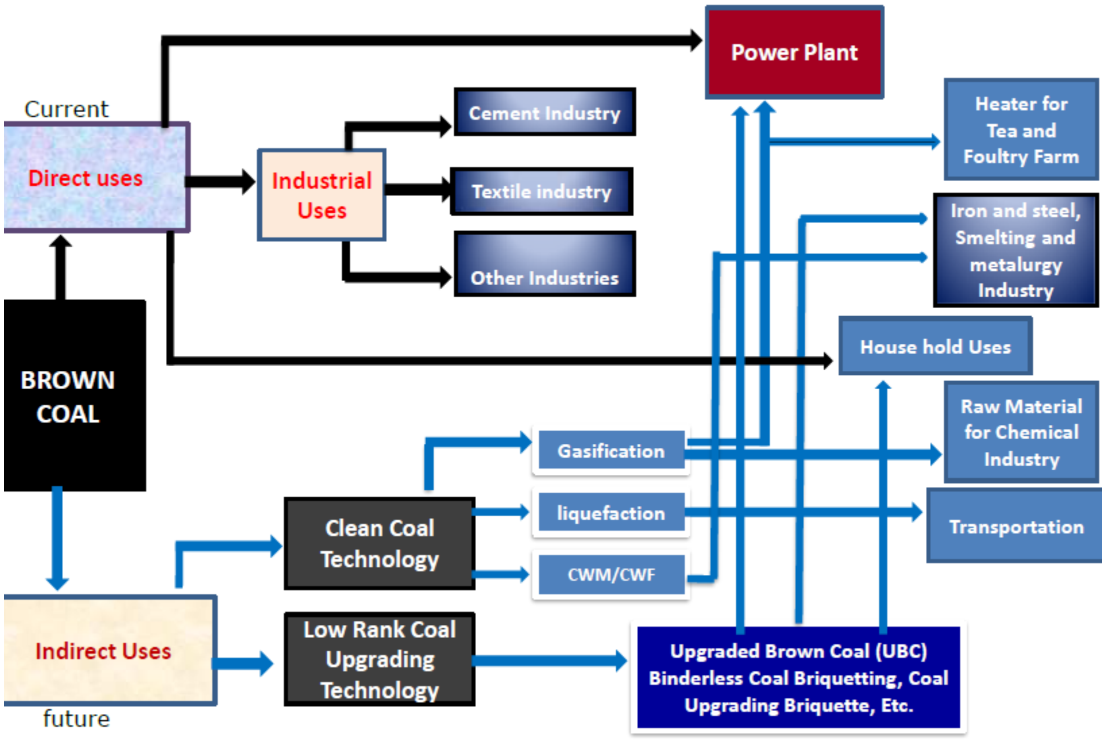


Figure 2.9 Current and Future Brown Coal Utilization in Indonesia [40]

This block diagram is brown coal utilization that has either been executed or is still being developed. In the future, GoI expect considerable significant progress in the development of coal added value in order to meet market standards and to maximize the use of low rank coal or brown coal to meet domestic needs. Indonesia is interested in developing clean coal technology for low rank coals utilization, some technologies (Coal upgrading, liquefaction, gasification and coal water mixture) now ready for commercialization.

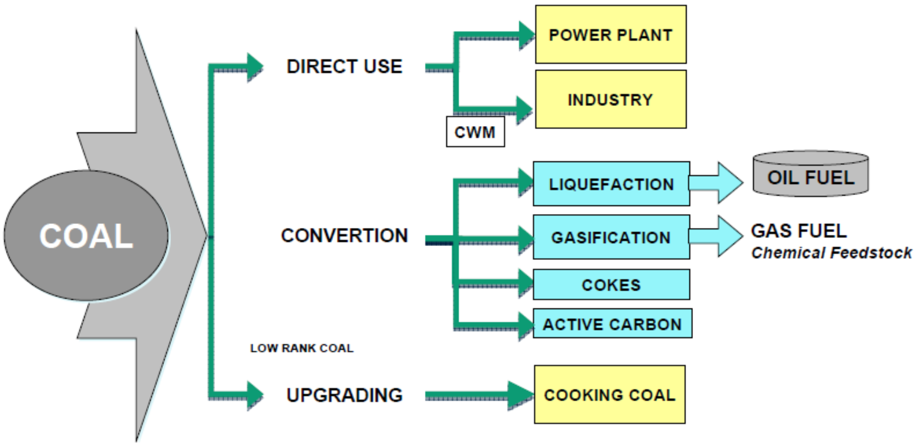


Figure 2.10 Connection Chain of Coal Added Value in Indonesia [34]

Some brown coal in Indonesia has low sulfur and low ash content. Therefore, it can be turned into an attractive fuel coal if it is upgraded using an economical dewatering method.

Table 2.3 Characteristics of Raw and Upgrading Brown Coal in Indonesia [41]

Analysis	Standard	Raw Coal	Upgrading Brown Coal (UBC)
Proximate			
Inherent moisture, wt% ad	ASTM D 3173-00	18.03	4.81
Ash, wt% ad	ASTM D 3174-00	7.76	3.28
Volatile matter, wt% ad	ASTM D 3175-01	45.38	49.05
Fixed carbon, wt% ad	By difference	46.86	47.67
Ultimate			
Carbon, % daf	ASTM D 3178-89	75.40	71.59
Hydrogen, % daf	ASTM D 3178-89	8.69	6.82
Nitrogen, % daf	ASTM D 3178-89	2.12	1.12
Total Sulfur, % daf	ASTM 4239-02	0.74	0.52
Oxygen, % daf	By difference	13.05	19.95
Calorific value, MJ/kg, ad	ASTM D 5865-04	21.84	26.27

Production of low rank coal has grown significantly over the last 5 years. Low rank coal production totaled almost 45Mt in 2010. We expect low rank and sub-bituminous coals to account for the majority of Indonesia's coal production and exports in the future with the same quality as bituminous coals[42].

2.6.1 UBC Pilot and Demo Plant Highlight

The UBC process that has been developed in Indonesia is the result of the collaboration of Research and Development of Indonesia's Ministry of Energy and Mineral Resources (MEMR), Centre for Research and Development of Mineral and Coal Technology (*Puslitbang TekMira*), Agency for the Assessment and Application of Technology (BPPT), the Japan Coal Energy Centre (JCOAL), Kobe Steel Ltd., and Sojitz Corporation. Based on the MoU between GOI through MEMR and JCOAL, Japan, signed on July 19, 2001, has built a UBC pilot plant in the Palimanan, Cirebon, with a capacity of 5 tons / day [38].

Figure 2.11 UBC Pilot Plants in Palimanan, Cirebon

Figure 2.12 Operation of the UBC Pilot Plant in Palimanan, Cirebon

Previous UBC process testing was conducted in a bench scale with a capacity of 100 in Takasago, Japan. This pilot plant produce low rank coal with calorific value of <5,000 kcal/kg increased up to > 6,200 kcal/kg [37]. The functions of UBC pilot plant are:

1. Test facilities to obtain engineering data for commercial plant
2. Research to develop UBC processes
3. Operator training for UBC commercial plants

After obtaining the results expected from UBC in Pilot Plant Palimanan, GoI through the MEMR's collaboration with the Ministry of Economy, Trade and Industry of Japan (METI), who wants to develop a UBC scale demonstration plant. UBC demonstration plant which is the first UBC plant in the world has been constructed in April 2007 in Satui, South Kalimantan [37].

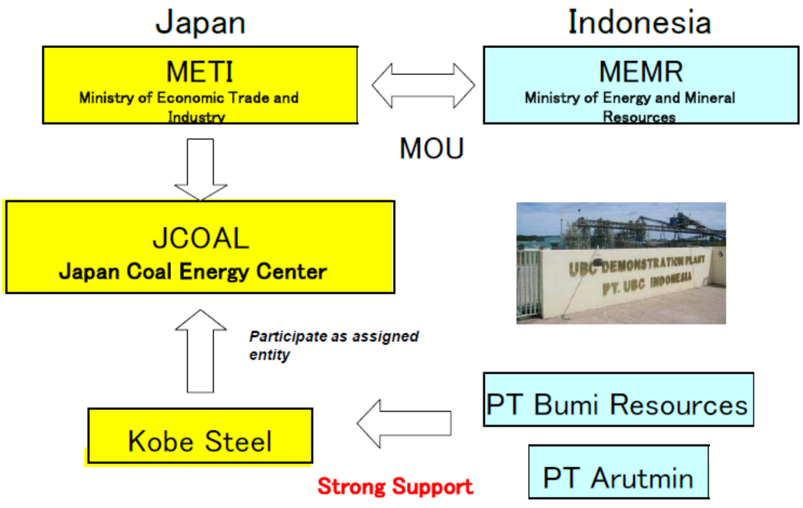


Figure 2.13 UBC Demonstration Plant's Project Structure [39]

Raw brown coal as feed in this process was taken from Arutmin Eco coal with total moisture of 35%.In 2009, the basic performance of the entire process was verified through a continuous operation charged with coal. In 2010, samples of UBC briquettes were produced for a combustion test using a real combustor [43].

In order to commercialize the UBC process, GoI accelerated the UBC commercial plant. The first UBC commercial plant start to construct in 2012 in Satui, South Kalimantan as the development of UBC demonstration plant in that site [40]. The next UBC commercial plant project is UBC Plants by PT. Pendopo Energi Batubara, South Sumatera which is planned to start up in 2014[40].

2.7 Greenhouse Gas (GHG) Emissions

Energy use is central to the greenhouse effects in the form of climate change, so that it will be the main part of the environmental sustainability indicator. The earth's greenhouse effect is based on the concentration of a few greenhouse gases in the atmosphere, such as carbon dioxide (CO_2), methane (CH_4), Nitrous Oxide (NO_2), etc.[44].

Coal combustion emits particulates, sulfur oxides, nitrogen oxides, mercury and other metals, including some radioactive materials, at a much higher proportion than oil or natural gas, and therefore, causes local and regional pollution problems (contributing to acid rain and increased ground-level ozone levels), and global climate change. CO_2 accounts for 75% of the warming effect from human created greenhouse gasses [44]. Burning coal is a major contributor to the production of the CO_2 [45]. The transportation sector also contributesa huge number of GHG emissions.

2.8 Previous Studies

Table 2.4 Coal Upgrading Process

No	Process	Description	Disadvantages
1	Coal Washing	By reducing the amount of mineral matter and/or sulfur in the product coal and recovering the maximum practical amount of organic coal.	The characteristics of brown coal do not generally lend themselves to separation of mineral matter by such means.
2	Coal Drying [46]	As preparation coal before burning in power plant. Drying is carried out in and around the mill by recirculation some of the flue gases from the upper part of boiler.	• It is acceptable in only part of power generation. • Boiler has to be increased in size (30-40% of re-circulated gas). • High risk of spontaneous combustion.
3	Hydrothermal Dewatering [47]	Brown coal mixed with water, converted to coal/water slurry and kept at 300°C and 15 Mpa to prevent evaporation of water. The porous of coal collapsesand forces out the moisture from coal. The	• Combustion process using coal water slurry as feed has disadvantages in the heat required for processing. • Upgrading process results in the generation of more CO_2

		excess water then removed by centrifuge	
4	Steam and Hot Water Drying [40]	• Steam drying The crushed and screened coal was heated at 275^{o}C by steam for 1 hour. • Hot water drying The pulverized raw coal was mixed with water and heated at 300^{o}C for 1 hour.	• Highercosts than the UBC process, because these 2 processes use high temperatures. • It's acceptable only at close to power generation station. • High risk of spontaneous combustion if coal is transported to another country.

Steam and hot water drying reduce moisture content more than the UBC process, because the UBC process is operated at a lower temperature. Here are the Indonesian coal characteristics after upgraded process: Upgrading brown coal (UBC), steam drying and hot water drying.

Table 2.5 Characteristics of Raw and Upgraded Indonesian Coal [39]

Analysis	Raw Coal	UBC	Steam Drying	Hot Water Drying
Proximate				
Inherent moisture, wt% ad	18.03	4.81	1.35	1.58
Ash, wt% ad	7.76	3.28	0.85	1.11
Volatile matter, wt% ad	45.38	49.05	42.96	43.81
Fixed carbon, wt% ad	46.86	47.67	56.19	55.08
Ultimate				
Carbon, % daf	75.40	71.59	77.15	76.05
Hydrogen, % daf	8.69	6.82	5.31	5.72
Nitrogen, % daf	2.12	1.12	1.21	1.05
Total Sulfur, % daf	0.74	0.52	0.56	0.42
Oxygen, % daf	13.05	19.95	15.77	17.21
Calorific value, MJ/kg, ad	21.84	26.27	29.59	29.84

There are few studies that discuss the life cycle of coal upgrading coal, because the increase in efficiency obtained in power generation coal upgrading as feedstock is not worth upgrading the technology in power generation. On the other hand, coal upgrading to be effective for developing countries such as Indonesia with acheaper cost and related to the abundant stock of brown coal.

The development of the Pilot Plant in UBC Palimanan obtained excellent results. The Head of R&D CMCT, Ministry of Energy and Mineral Resources, Bukin Daulay, said that UBC plan has a fairly high economic value, through the technology of coal calories increase from 5000 kcal/kg to over 6800 kcal/kg. Production costs are only 7-9 dollars per ton, while the price of coal rises from 16 USD/tons to 45 USD/tons[48]. Shigeru Kinoshita, Dr. Seiichi Yamamoto, Tetsuya Deguchi, and Takuo Shigehisa along with Technical Development Group of PT Upgraded Brown Coal Indonesia conduct a the feasibility of study to develop their UBC demonstration plant with a capacity of 600tons/day on product basis (1,000 t/day on feed coal basis) [43].

Table 2.6 Outline of UBC Demonstration Plant

Project Structure	By “JCOAL” jointed by Kobe Steel Ltd with partnership Arutmin & Bumi Resources. Indonesia Government also supports the project.
Period	2006 – 2009
Budget	80 M$
Scale	600 tons/day (Product base), 1,000 tons/day (Feed base)
Place	Satui area in South Kalimantan, Indonesia.
Coal	Several Lignite (4,000-5,000 kcal/kg as received base)
Product Evaluation	By several companies (Kobe Steel Ltd, Power Companies)

Gandhi Kurnia Hudayafrom R&D Center for Mineral and Coal Technology [49] wrote that the utilization of low rank coal, UBC and BCB (Binder less Coal Briquetting) will give some advantages, namely:

1. Increase the state income of US$ 140-210 million per year
2. Increase government tax revenues of IDR 130-200 billion per year
3. Create 1,000 jobs
4. Create a multiplier effect for regional economic
5. Create a better investment climate for mining and processing industries

As mentioned previously on the UBC process excellence among other coal upgrading processes, Indonesia is aggressively developing UBC processes for commercial-scale plants. UBC process adopted from the results of Japanese technology in Indonesia is the first in the world.

A UBC commercial plant currently still in the process of development was targeted to run in 2012. This study of the life cycle cost can be further insights to analyze the development of UBC plant in Indonesia. This study was also associated with energy policy in Indonesia, so it can make recommendations for energy policy in the field of the use and development of brown coal as an energy source in Indonesia. For the future, this study is expected to describe an idea to increase the quantity of use and revenues from the coal sector in Indonesia.

CHAPTER 3
METHODOLOGY

3.1 Basic Principles

The basic principles of this study will be divided into five main parts: life cycle cost analysis, economic feasibility analysis, greenhouse gas emission calculation, UBC product competitiveness and policy recommendations. These sections should be analyzed and linked to obtain results which were consistent with the objectives in this study. In this study, the analysis is based on upgrading brown coal (UBC) processes in Indonesia.

3.1.1 Life Cycle Cost Analysis

Life Cycle Cost (LCC) isall of thecosts which related to the activities of production processes. The scope of life cycle is raw material expense, production costs and including transportation costs within the production process. The other activities, such as purchasing, installation, maintenance, repairing, disposal costs, etc. are also considered [50]. So that, LCC of the UBC process can be calculated during the process of UBC process.

The UBC process, which improves the quality of brown coal, increases the efficiency of using and the selling price of brown coal before it is used domestically or exported to other countries. This can be seen by comparing the selling price of UBC products with brown coal that without going through the process of UBC. This comparison also noticed element of the life cycle costs that must be incurred to produce a product that can meet the UBC standards in order to export to other countries. The elements of life cycle costs can be divided into two parts, such as investment costs and production costs.

In this study, the life cycle was used to analyze the whole part of the UBC plant in terms of its economics. The coststhen annualized and with the annual UBC process to obtain the production costs of UBC product per its calorific value. There are large number LCC models which have been developed over the years.LCC was determined by identifying the applicable functions in each phase of the life cycle, costing these functions, applying the appropriate costs by function on a year– to–year basis, and then accumulating the costsover the entire span of the life cycle. Completely, LCC is included all producer and consumer costs from origin of concept to phase-out and disposal [51].

3.1.2 Economic Feasibility Analysis

An economic feasibility analysis is used to determine the feasibility of UBC product, whether the product can be accepted for customer or not. It will be conducted to assess the UBC plant's economic performance. Economic feasibility analysis can be divided by net Annual Cash Flow (ACF), Net Present Value (NPV), Internal Rate of Return (IRR) and Payback period (PBP). This assessment which is based on the parameters mentioned above will provide valuable information about economic performance and feasibility of UBC plant development.

3.1.3 Greenhouse Gas (GHG) Emissions Calculations

The potential of Greenhouse Gas(GHG) emissions are generated from the UBC process and transportation phase. In the transportation phase, the calculation isdivided into feedstock distribution from suppliers to UBC plant and UBC product distribution. UBC product distribution is separated into domestic and exporting purposes.

3.1.4. UBC Product Competitiveness

The reason for UBC process application development in Indonesia is to increase the added value of brown coal. Therefore, UBC competitiveness product can be measured by comparing the UBC product with brown coal as usual. Brown coal and UBC product will be used as fuel to generate electricity at the power plant with the same condition.

3.1.5 Energy Policy Recommendations

As already mentioned in the objectives, the economic calculation for the UBC process is expected to set a policy recommendation in the energy sector. This policy recommendation is expected to be a way to maximize the development of the UBC process which is being applied in Indonesia. Some problems in the development of this process will also be analyzed in order to get an appropriate way out. The policy recommendations are prepared by the field of techno economic has been done on this study, so the results cannot be applied directly considering a policy was influenced by the political conditions of a country that is not being in the scope of this study. However these policy recommendations could be advanced considerations in order to support the development UBC process as added value in low rank coal and increase state revenues of Indonesia.

These results will be used to promote the development of the UBC process in Indonesia and to make policy recommendations in the field of coal as part of a way to increase the added value of brown coal. This is in accordance with the Energy Mix Target Indonesia, as stated in Presidential Decree No. 5 of 2006 on National Energy Policy that targets coal as a primary energy source in 2025. However, if the UBC product is not competitive in the market, the result of the study will be analyze to investigate the major costs element that contribute to the total UBC product price and discuss the strategy to minimize the costs element in order to improve the competitiveness of UBC product.

3.2 Initial Considerations

In the calculation process of three important parts as it has been mentioned before, it takes some consideration to keep in mind. The following are some of the considerations.

3.2.1 Plant Site Selection

Plant site selection was based on a review and assessment of possible areas in a province or region that may be best suited for UBC processes. The location of the plant is expected to have a crucial effect on the profitability of a project and the scope for future expansion. The principal factors to consider are [52]:

1. Location and availability of suitable land, with respect to the marketing area.
2. Raw material supply.
3. Transport facilities.
4. Availability of labor.
5. Availability of utilities: water, fuel, power.
6. Environmental impact, including effluent disposal.
7. Local community considerations.
8. Climate.
9. Political and strategic considerations.

3.2.2 UBC Plant Production Capacity

The UBC plant production capacity selected in this study was based on GoI’s planning and the source availability of technical UBC product data. The GoI suggested through the Directorate General of Mineral and Coal Department in the Ministry of Energy and Mineral Resources to build a UBC plant with production capacity of 5,000,000 tons/year[52]. Since the UBC commercial plant in Pendopo, South Sumatera (2016) being targeted by the GoI with a capacity not completed, so that the selected capacity of UBC Plant for this study is 5,000,000 tons/year. The selected capacity is expected to be a model for future development of UBC commercial plant in Indonesia.

3.2.3 Operational Condition and Lifetime of UBC Plant

The plant is expected to operate with 300 operating days for a year. The base year decided to be year 2014, therefore all of the price will be adjusted at the base year. The feedstock used is brown coal and the main product is UBC product. The life time of plant service decided to be 20 years with no expansion in the future, hence the capital investment will be divided into 20. The plant was assumed to be self-generated and funded 100% by investor. The technology used was based on the existing pilot and demonstration scale of UBC plant in Indonesia tailored to the target of UBC commercial plant capacity desired in this study.

3.2.4 UBC Plant Costs Element Considerations

The costs element in UBC plant consideration based on the scope of this study will be divided into five parts as follow.

1. Availability of Feedstock and Other Raw Materials

   Availability of raw materials is one of the most important parts in the construction of a plant. When evaluating the net feedstock costs, some factors such as the following needed to be considered. Here are the factors [53]:

   a) The quantity and availability of feedstock historically in the area;
   b) Price history and trends in the area from which the UBC plant is most likely to acquire the feedstock;
   c) Location of the plant related to cover the demand of feedstock and methods of transporting feedstock to the plant on a year round basis;
   d) On site and off site feedstock storage selected options and methods of moving required feedstock volumes.

2. Technology and Energy Costs

   Technology is included in the type and number of devices used, where its use is tailored to the capacity target of UBC plant in this study. An energy balance calculation, including utilities system, was conducted to calculate the energy needed to operate the plant. Since the plant is assumed to be self-generated, the selection of process energy sources needed to be carefully selected. As already mentioned, that there is no chemical reaction in the UBC process so that the energy used is also not much. Energy sources were needed to run a series of equipment and adjust the operating conditions in the process of upgrading it so that it can generate UBC product with good quality. This section also includes the costs of utilities. The word utilities are used for the ancillary services needed in the operation of any production process [52].

3. Transportation Costs

   Transportation is added to the life cycle costs of UBC processes in order to estimate the costs to transport brown coal from mining site to the UBC plant then distribute to power plant as domestic needs and port as exporting activity. UBC plant and power generation for domestic need will develop nearly of mining site so that it can reduce transportation costs.

4. Land and Company ServiceCosts

   The quantities of equipment used in this plant and building layout are needed to calculate the area of the land needed. The equipment configuration and company services area were needed to determine the land use for UBC plant. The supporting building is including the main office, cafeteria, clinics, employee facilities, security, and fire department.

5. Organizational Structure

   The company business entity of the UBC plant as a commercial plant needs to be calculated. One of the important of the commercial plant is workers, so that the amount of workers the plant and office needed to be defined in order to calculated their wages. The source for salary estimation can be based on minimum regional wages or based on the data from consulting company and GoI’s planning of UBC plant development. The data will provide the amount of money the company should spend to operate the UBC plant, in other words the operating costs in terms of employee salary.

3.3 Data Collection

Based on various consideration of the foregoing, the process of collecting data to support this study was done at various sources in Indonesia.

3.3.1 Site Selection

This data was very important to determine the best possible place to support the UBC process. In this study, the Central Bureau of Statistics Indonesia was selected. The bureau will provide the site due to its potential availability of surplus brown coal as feedstock and productivity of mining site.

3.3.2 Feedstock Price

Feedstock prices in this study include current and historical feedstock prices. The source of data is Indonesia Ministry of Energy and Mineral Resources (MEMR) as well as direct survey from PT. Bukit Asam as the biggest mining company in Indonesia. A current price of brown coal is used to compare the price of brown coal without upgrading process and UBC product.

3.3.3 Technical Process Data

The UBC commercial plant in Indonesia is still in the planning stages, as previously explained. Therefore, the suitable sources for the data retrieved from the UBC Pilot Plant in Palimanan, Cirebon and UBC demonstration Plant in Satui, South Kalimantan as result of cooperation among Research and Development of Indonesia Ministry of Energy and Mineral Resources (MEMR), Research and Development Center for Mineral and Coal Technology / R&DCMCT (*TekMira*), Agency for the Assessment and Application of Technology (BPPT), the Japan Coal Energy Centre (JCOAL), Kobe Steel Ltd., and Sojitz Corporation. This has been running and gets the appropriate results. In this study, UBC plant to be analyzed was based on commercial plant so that there will be adjustments to the capacity of the desired product. The draft plan of GoI in the development of commercial plant UBC also is hold as technical process data used in this study.

3.3.4 Plant Construction Data

In this study, the UBC process for a commercial-scale plantdoes not exist yet. Therefore, the expected data source for plant construction were obtained from the planning of UBC commercial-scale plant with specific capacity and tailored to the capacity in this study.

Table 3.1 Details of Data Collection

Data	Description	Source
1. Site selection	The availability of surplus brown coal as feedstock and productivity of mining site	Indonesian Central Bureau of Statistics (BPS)
2. Feedstock price	Current and historical pricesof brown coal.	Ministry of Energy and Mineral Resources (MEMR) and PT. Bukit Asam (Coal index)
3. Technical process data	Technical process data of UBC process	UBC Pilot Plant and UBC Demonstration Plant in Indonesia
4. Plant Construction data	Building Construction and company service expenses	Research and Development Center for Mineral and Coal Technology / RDCMCT (*TekMira*)

3.4 Assumptions for the Estimation of UBC Processes in this Study

To facilitate the calculations in this study due to the possibility of rapid changes in the data during the production processwould require some assumptions. This assumption plays an important role in the calculation of production costs in the UBC plant. In this study, the calculation for the production costs was based on the following assumptions.

1) Plant capacity is 5,000,000 tons/year.
2) The plant is assumed to operate for 300 days/annum.
3) The project lifetime is assumed to be 20 years.
4) The interest rate is 7.5 %/annum (average value from 2005-2013) [54].
5) The increase in the calorific value and the characteristics of the UBC product obtained from the production processes at the UBC Pilot Plant Palimanan, Cirebon.
6) The location of the power plant used in order to reduce GHG emissions for domestic need is close to the UBC plant.
7) Exchange rate IDR 10,698.90/USD (Average from June 2011 – May 2014) [55].

3.5 Breakdown Costs

This study analyzestotal costs in the UBC plant in Indonesia. The elements of life cycle costs can be divided into two parts, namely: Investment costs and production costs. Investment costs include costs incurred in the early construction of UBC plant, while production costs include costs incurred to produce UBC products continuously in accordance with its targeted capacity.

3.5.1 Estimation of UBC Plant Investment Costs

The first step in this study was to estimate the investment costs of the UBC plant. Therefore, direct quotation from manufacturer, UBC plant and constructing company were preferable than handbook calculation. The components of UBC plant investment costs data will obtain from a Research and Development Center for Mineral and Coal Technology / R&DCMCT (*TekMira*). However, due to the limitation of the company's policy regarding the confidentiality of the data, some data needs to be estimated based on handbook quotation. Mainly, the quotation is taken from the handbook with titled Plant Design and Economic for Chemical Engineers [56]. The explanation of the method used in this study will describe clearly.

3.5.1.1 Total Capital Investment(C_{TCI})

Total capital investment (C_{TCI}) includes funds required to purchase land, design, purchase, and install equipment and buildings, as well as to bring the facility into operation [57]. C_{TCI} breakdown structure of UBC plant consists of fixed capital investment (FCI) and working capital (WC). The formula to calculate the total capital investment is shown below.

$$C_{TCI} = FCI + WC \quad (3.1)$$

3.5.1.2 Fixed Capital Investment (FCI)

The fixed capital investment is the total costs of designing, constructing, and installing a plant and the associated modifications needed to prepare the plant site [51].

1. Land Costs

The land area was obtained from the construction plan of UBC commercial plant, while the price per area was obtained from average price in the selected location. The land area used is multiplied by the expenses for land per hectare.

Land costs per ha (USD/ha) x Land area (ha) = Land costs(USD)(3.2)

2. Plant / Technology Costs

Plant / technology costs consist of purchasing equipment delivered costs, equipment installation and insulation costs, electrical installation costs, instrumentation and control costs. The prices of equipment are obtained directly from the planning of UBC commercial plant in Indonesia with scale up base on the differences of UBC plant capacity. This cost the elements of this costs are also included by engineering and supervision costs, project management costs, construction expense, contractor's fee and contingency. Data from the planning of UBC commercial plant in Indonesia will be used as data for indirect costs which is used the percentage of total investment.

3. Building and Company Services Costs

Building and company services costs were estimated based on the data from the planning of UBC commercial plant in Indonesia with the differences of production capacity as the base calculation.

3.5.1.3 Working Capital (WC)

Working capital is the additional money needed, above what it costss to build the plant, to start the plant up and to run it until it starts earning income. The portion of working capital (WC) may differ in many projects, in this study WC estimated to be 5% of C_{TCI}. Here is the formula to calculate WC.

$$WC = 5\%\ C_{TCI} \quad (3.3)$$

3.5.1.4 Equal Annual Worth (A)

In the economic analysis of investments, a series of equal receipts or payments occurs at the end of a successive series of periods called annual payment [56]. In the framework to calculate the portion of the total capital investment in the production costs, it was important to annualize the total capital investment using the formula of equal annual worth as follow.

$$A = P\left[\frac{i\,(1+i)^n}{(1+i)^n - 1}\right] \quad (3.4)$$

Where,

A is the annual payments (USD/year)

P is the worth of the first investment costs (USD) i is the annual interest rate

n is the project life (years)

3.5.2 Estimation of UBC Plant Production Costs (C_{TPC}) in Indonesia

The costs elements of UBC plant production costs were categorized into four groups: the total capital investment costs, feedstock costs, total operating costs, and general expenses**.** All elements of costs are summarized in the net UBC plant production costs. Total capital investment has been discussed before, while the other costs elements are expressed interms of costs per ton of UBC product.

3.5.2.1 Feedstock Costs (C_F)

Total feedstock costs (C_F) is calculated from brown coal needed in one year (ton/year) multiplied by brown coal price (USD/tons) from mining site / company at base year in Indonesia. Feedstock costs may be different due to location, seasons, production, local supply and demand, or transportation [53]. In this study, the historical data of brown coal price was processed to select the minimum, average and maximum price of 1 tonbrown coal during 2010 - 2014. The selected data was expected to replace the possibilities of brown coal price at its optimistic and pessimistic state in the view of the feedstock of UBC plant production.

3.5.2.2 Operating Costs (C_{OC})

1. Raw Material Costs (RMC)

The raw material, except feedstock, consumption of producing 1 ton of UBC product are calculated and multiplied by its each raw material price to calculate the overall raw materials costs per tonof UBC product. Other raw material needed for producing UBC product is mixed heavy oil, commonly called asphalt.

2. Operating Labor (OL)

The construction of the UBC commercial plant in Satui has been planned, although there was a delay during the construction. For labor costss to be incurred by UBC commercial plant planning with adjusting the engineering processes at UBC pilot and demonstration plant in Indonesia will assist in the calculation of the required number of employees, structure and operating labor costs. Since the data for employee wages are highly confidential, thus the estimation will be based on data provided by "*Indonesia Salary*

Guide Handbook". The costs will be annualized and divided bythe amount of UBC product to obtain the operating labor costs per tonof UBC product.

3. Utility Costs (UC)

Utility costs represent costs incurred to help UBC plant operation continuity. Utility costs consist of water, steam, electricity, and fuel costs. The amount of each component in the utility costs will be obtained by this formula:

$$\boldsymbol{UC = 5\%\ TPC} \quad \textbf{(3.5)}$$

4. Maintenance and Repair Costs (MRC)

Maintenance and repair costsare assumed based on the figure from Plant Design and Economics for Chemical Engineers [57]. It is obtained by estimation as much as 6% of fixed capital investment costs

$$\boldsymbol{MRC = 6\%\ FCI} \quad \textbf{(3.6)}$$

Then it will be divided with annual UBC product (ton) produced to obtain the machine repair and maintenance costs per tons UBC product.

3.5.2.3 General Expenses (C_{GE})

General expenses consist of administrative costss, research and development costs, product distribution and financing. Then this expenditure will be divided with annual UBC product (tons) capacity to estimate the general expenses per tons UBC product.

3.5.2.4 Transportation Costs (C_T)

Transportation costswere added to life cycle costs of Upgrading Brown Coal (UBC) processes in order to estimate production costs. Transportation sector is used to transport brown coal as feedstock then transport the UBC product to customer. The data for transportation costs was come from PT. Bukit Asam as commercial industry in field of coal.

3.5.2.5 Net UBC Plant Production Costs (C_{TPC})

Life cycle costs of UBC plant production is the sum of all elements in investment costs and production costs. By the whole estimation of net UBC plant production costs per tons UBC product can be expressed by following equation.

$$\boldsymbol{C_{TPC} = C_{TCI} + C_F + C_{OC} + C_{GE} + C_T} \quad \textbf{(3.7)}$$

Where,

C_{TPC} is the net UBC plant production costs (USD/ton)

C_{TCI} is the total capital investment costs (USD/ton)

C_F is the feedstock costs (USD/ton)

C_{OC} is the operating costs (USD/ton)

C_{GE} is the general expenses (USD/ton)

C_T is the transport costs (USD/ton)

3.6 Economic Feasibility Analysis

Economic feasibility analysis as a tool of project evaluation is used to determine the feasibility of the UBC product. UBC plant are required to increase the added value of brown coal in Indonesia so as to increase the selling price for the export purposes and improving the efficiency of brown coal to meet the domestic needs. Economic feasibility can be determined by net Annual Cash Flow (ACF), Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PBP). The details of these elements are further explained below.

3.6.1 Annual Cash Flow (ACF)

The next step after collecting all the expenses in the project is to express them in term of cash flow. During any project, cash initially flows out of the company to pay for the costs of engineering, equipment procurement, and plant construction. Once the plant is constructed and begins operation, then the revenues from sale of product begin to flow into the company. The net cash flow at any time is the difference between the earnings and expenditure [52].

Cash flow analysis results into knowing the major sources of cash inflows and outflows. Positive net cash flow is the goal of a project that reflects that it is able to get enough cash from its operation to meet business expenses on time basis and grow itself. On the other hand, negative net cash flow demands a check to speed up the receipts from sales and go for a short or long borrowing to meet the expenses. The annual net cash flow is defined as the annual benefit in excess of the annual costs[58].

$$\boldsymbol{A_{t,x} = B_{t,x} - C_{t,x}} \quad \textbf{(3.8)}$$

Where,

$A_{t,x}$ = the net annual cash flow at the end of the year t for the same investment

$B_{t,x}$ = benefit at the end of year t for an investment project x

$C_{t,x}$ = the annual costs at the end of the year t for the same investment project

x = amount of projects

t = represents the time stream over a plan of n years (0, 1, 2,...n)

The expected annual cash flow is positive value or ACF > 0, and then this plant can be categorized as economically feasible.

3.6.2 Net Present Value (NPV)

The net present value (NPV) of a project is the sum of the present values of the future cash flows [52]:

$$\boldsymbol{NPV = \frac{CF_1}{1+i} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \cdots + \frac{CF_n}{(1+i)^n} - I_0} \quad \mathbf{(3.9)}$$

$$\boldsymbol{NPV = \sum_{t=0}^{n} \frac{CF_n}{(1+i)^n} - I_0} \quad \mathbf{(3.10)}$$

Where,

CF_n = cash flow in year n;

n = project life in years;

I_o = the initial investment outlay

i = the interest rate, 7.5 %/annum (average value from 2005-2013)

The expected net present value is positive value or NPV > 0 then UBC plant can be categorized as economically feasible.

3.6.3 Internal Rate of Return (IRR)

When the NPV is calculated at various interest rates, it is possible to find an interest rate at which the cumulative net present value at the end of the project is zero. This particular rate is called the Internal Rate of Return (IRR) for the maximum interest rate measurement that the project could pay and still break even by the end of the project life:

$$\boldsymbol{\sum_{t=0}^{n} \frac{CF_n}{(1+i')^n} = 0} \quad \mathbf{(3.11)}$$

Where,

CF_n = cash flow in year n;

t = project life in years;

i' = the discounted cash flow rate of return (percent/100).

The value of i' is found by trial-and-error calculations or by using the appropriate function in a spreadsheet. The expected internal rate of return must exceed the discount rate that this plant can be categorized as economically feasible. The computationprocedure of IRR is described below.

1. Given the cash Flow and Investment outlay
2. Choose a discount rate
3. Calculate the project's NPV
4. If NPV > 0, choose a higher discount rate and go to 3

   If NPV < 0, choose a lower discount rate and go to 3

   If NPV = 0, choose discount rate = IRR

3.6.4 Payback Period (PBP)

Payback period (PBP) is the number of years required to recover the initial investment outlay from the project's future cash flow, as theindex of an investment's desirability. If the PBP was found to be half or lower than the total project lifetime, then the project was considered to be feasible and able to generate cash or profit in the remaining lifetime.

$$\sum_{t=0}^{n} CF_t \geq 0 \quad (3.12)$$

Where,

CF_t = the net cash flow in period t,

n = payback period, which is defined as the lowest value of n that satisfies the equation

3.7 Sensitivity Analysis

Sensitivity analysis is used to determine the effects of technical and economic parameters on the profitability of a project. It is concerned with the extent of change in a costs analysis resulting from variations in elements of a costs study. It will show the influence of possible changes of significant variables upon profitability. From this analysis, those variables that have a critical effect are identified. In this study, there are factors considered to conduct sensitivity analysis as be described further.

3.7.1. Effects of Brown Coal Price

Demand and supply of brown coal in Indonesia will influence the changing of brown coal price during this period of time. In this study, the period of time selected was monthly data from February 2010 until May 2014. Historical brown coal price is used as a base to conduct the sensitivity analysis in this study. By conducting a sensitivity analysis on the effect of feedstock costs, an ideal range of brown coal price as competitiveness consideration can be calculated. Eventually, it can be seen the differences in the selling price of brown coal exports through the UBC process or without UBC process.

3.7.2 Effects of UBC Product Selling Price

The development process in the future UBC is strongly influenced by the price of the UBC product itself. The main purpose of UBC process is to increase the quality of coal, which is expected to increase the selling price of UBC product close to the equivalent price of bituminous coal. UBC product selling price was obtained from Indonesian Coal Index (ICI) by adjusting the specifications on the type of coal in Indonesia. The use of ICI as a standard for UBC product selling price was based on the Minister of Energy and Mineral Resources Regulation No. 17 of 2010 concerning the procedures for determining the benchmark price of minerals and coal sales. Regulation Became effective on 23 September 2010 and must be adhered to by all of mineral and coal producers in Indonesia. This regulation is also supported by the director general of minerals and coal regulations no.15.K / 32 / DJB / 2011 on the benchmark coal pricing formula.

In this sensitivity analysis, the period of time selected was monthly data from February 2010 until May 2014. By conducting a sensitivity analysis on the effects of the UBC product selling price, an ideal range of brown coal price as competitiveness consideration can be calculated.

3.7.3 Effects of Interest Rate

Another way to determine the UBC product competitiveness is using the sensitivity analysis in terms of interest rate. Sensitivity analysis can also be conducted by varying the interest rate, by conducting a sensitivity analysis on various brown coal prices as feedstock costs and interest rates to obtain the relation between production costs of UBC product, brown coal prices and interest rate [59].

3.8 Greenhouse Gases Emissions Calculations

This calculation includes GHG emissions generated during the transportation phase and the UBC process itself. Figure 3.1 describes the scope of this calculation in this study.

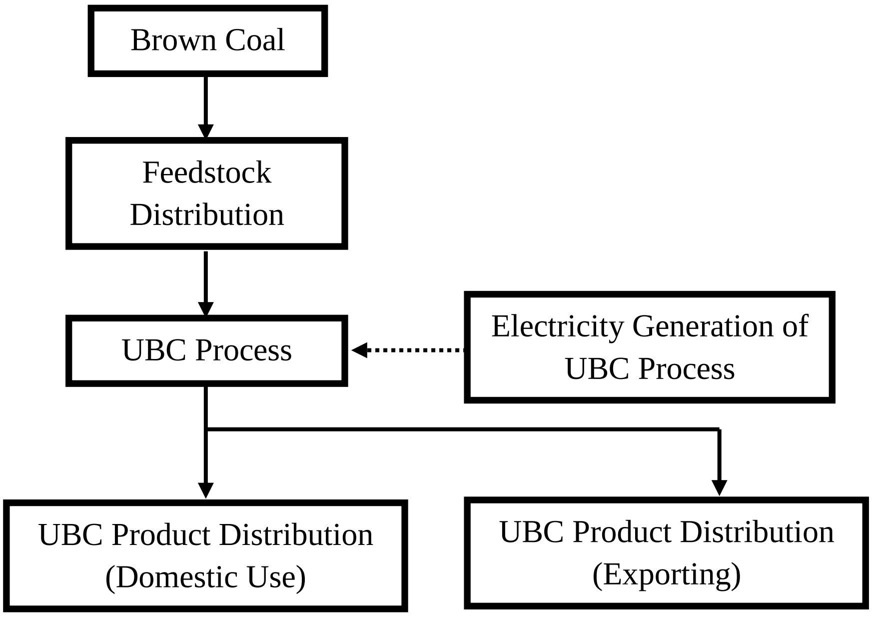


Figure 3.1 Boundary System of Greenhouse Gas Emission Calculations

Based on Figure 3.1, the following is the scope of the calculation of GHG emissions

1. Feedstock Distribution

   In this section of brown coal from PT. Bukit Asam as feedstock was distributed to the UBC Plant. This distribution was carried out using a truck with the distance of 3.8 km.

2. UBC Process

   Potential GHG emissionswere produced from electricity supply in order to run the process and the UBC process itself.

3. UBC Product Distribution

   As mentioned earlier, that the distribution of the product UBC adopted the system conducted by PT Bukit Asam. Here are the explanations of the UBC product distribution.

   a. Domestic

      For domestic sales, the UBC product will be distributed using the train until the end of the pier which is in Kertapati, Palembang. Therefore, the calculation of GHG emissions would include generated along the way from UBC plant towards Kertapati with the distance of ± 160.94 km

b. Export

Meanwhile, the UBC product will be distributed to the Last Port which is located Tarahan, Lampung, for export purposes. This trip was conducted with the distance of ± 409.52 km by train.

GHG emissionsare presented in carbon dioxide equivalent (CO_2 eq) units,which can be determined from this equation for the transportation sector [60]:

$$\boldsymbol{Emisions = \sum_{ij}(Fuel_{ij}\ x\ EF_{ij})} \quad \textbf{(3.13)}$$

Emissions	: emissions (kg)
$Fuel_{i,j}$	: fuel consumed (as represented by fuel sold) (TJ)
$EF_{i,j}$	: emission factor (kg/TJ)
i	: vehicle/equipment type
j	: fuel type

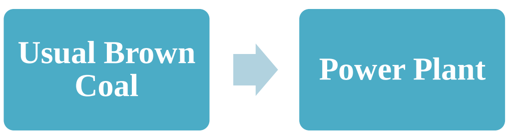
3.9 UBC Product Competitiveness

There are two scenarios used this calculation. Data for each scenario is taken by the combustion process of brown coal and the UBC product in the boiler. UBC product competitiveness was shown by the difference between the two scenarios. In this study, the technological data was taken from the 660 MW power plant. Furthermore, calculation was performed using the LEAP program (Long-range Energy Alternative Planning system). Each scenario has the same scope of the problem, so that the following will be calculated.

1. Brown coal / UBC product consumption as feed in power generation.
2. GHG emissions potential savings based on these two scenarios

Here are the descriptions of these two scenarios:

1. BAU (Business as Usual) Scenario

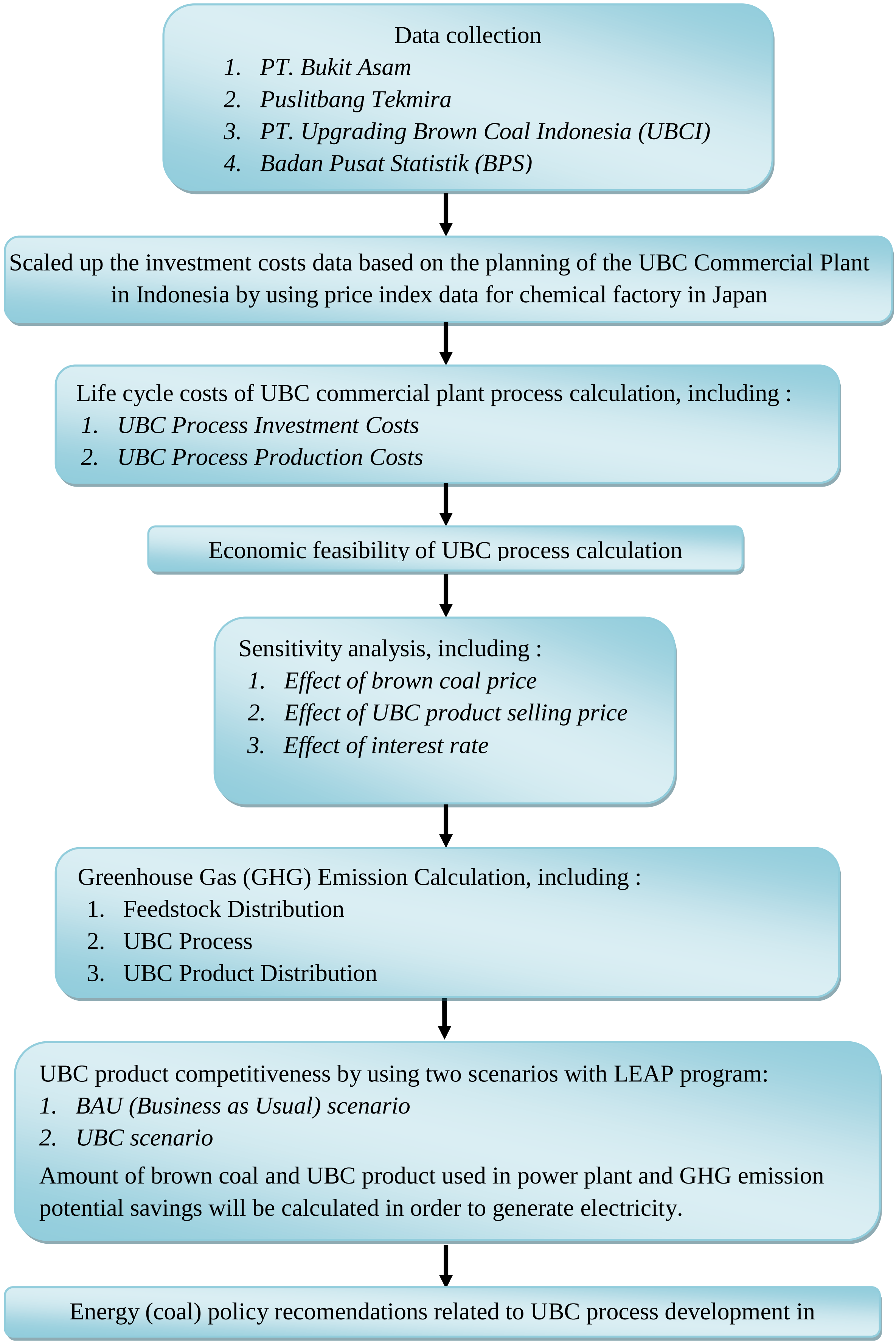


It is assumed that there is no upgrading process or brown coal as usual which has 36% moisture content, and then it is used as feed of combustion process in a boiler in order to generate electricity. In this case, the feedstock is brown coal with some characteristics as described in Appendix B.

2. *UBC Process Scenario*

In this scenario, brown coal through the UBC process firstly and its product will be used to generate electricity. In this scenario, the characteristics of UBC product which have only 8% of moisture content was taken from the UBC pilot plant and the UBC demonstration Plant. Then, we can calculate the total feedstock needed and heat losses during the combustion process in a boiler compared to the brown coal as usual.

3.10 Analysis Schematic Diagram



CHAPTER 4
RESULT & DISCUSSION

4.1 Initial Considerations

4.1.1 UBC Plant Site Considerations

Based on information from Chapter 3 (characteristics for plant site selection, P. 34), data from the Geological Agency of the Republic of Indonesia (Appendix A-1) and data from the "Statistics" in South Sumatra Province (Appendix A-2) state that the largest coal production is located in the Muara Enim and the Lahat region with the production number recorded in 2011 amounting to 20,020,669.41 tons. Total coal production in those areas continued to grow annually as shown in the previous year.

The magnitude of the total amount of coal resources in Indonesia in 2012 was 57,541.96 million tons in South Sumatra, which showed a high amount of projection of coal annually. Supported by the quality of information which is most of the coal in Indonesia is in the form of moderate and low in calories (Table 1.3), so that a suitable place for Upgrading Brown Coal (UBC) program development process in this study is the Muara Enim, South Sumatera.

South Sumatera is one of the largest coal producers in Indonesia, especially in Sumatera. Coal Resources Data in 2012 from the National Geological Agency (Appendix A-2) notes that almost 50% of Indonesia's coal resources are located in South Sumatra. This statement was also reinforced by the presence of PT. Bukit Asam in Tanjung Enim as the company's largest coal producer in Indonesia with the status of state-owned enterprises which is expected as a supplier of brown coal in the UBC process in this study (Appendix A-3).

Attracted by the potential of the brown coal producer, one commercial UBC Plant in South Sumatra planned to begin construction in 2014 by PT. Pendopo Energy [41]. Unfortunately, such development was hampered with many intern problems on it. UBC commercial plant will return to be built in 2016 by UBC product specifications which are better than ever. Due to the absence of an agreement with the development discourse, so in this study that data collection for investment and production costs of UBC process obtained from UBC pilot and demonstration plant in Indonesia, which has been running each from 2006 and 2011 with adjustments to the commercial scale of the plan Plant UBC commercial development from the Government of Indonesia (GoI).

4.1.2 UBC Technology and Feedstock Considerations

As mentioned before, the UBC process was based on the UBC process in the UBC pilot plant in Palimanan (Cirebon) and the UBC demonstration plant in Satui (South Kalimantan) which is lead by PT. Upgraded Brown Coal Indonesia (UBCI) as representative of Kobe Steel, Ltd and GoI.

Figure 4.1 UBC Demonstration Plant in Satui, South Kalimantan

Initially, the UBC process on a commercial scale started to be developed in 2012 with the supply of coal from PT. Arutmin. Unfortunately, this plan is seen various delay with the internal reasons such as the deal the two countries, Indonesia – Japan as well as the current coal price. However, planning the commercialization of the UBC process can be applied as an accurate reference in this study. The commercial UBC plant is targeted to run with a capacity of 5,000 tons/day or 1,500,000 tons/year with 300 workdays.

In accordance with the plant site that has been determined, then the brown coal which is used as a raw material is mined brown coal from PT. Bukit Asam. In terms of quantity, brown coal is widely spread in South Sumatra. Meanwhile, the feedstock from PT Bukit Asam which is be used are the brown coal with the lowest calorific value, 4.000 to 4.200 kcal/kg. The detail ultimate and proximate analysis of this type of coal can be seen in the Appendix B-1. This type of brown coal is considered suitable for the UBC technology which has been run in the UBC pilot and demonstration plant.

4.1.3 UBC Process Consideration

The UBC process applied in this study is similar to the process described in the UBC demonstration plant as previously, where it is divided into 5 sections [43]:

1. Section #100 : Coal preparation or coal crushing
2. Section #200 : Slurry dewatering
3. Section #300 : Coal-oil separation
4. Section #400 : Oil recovery
5. Section #500 : Coal briquetting.

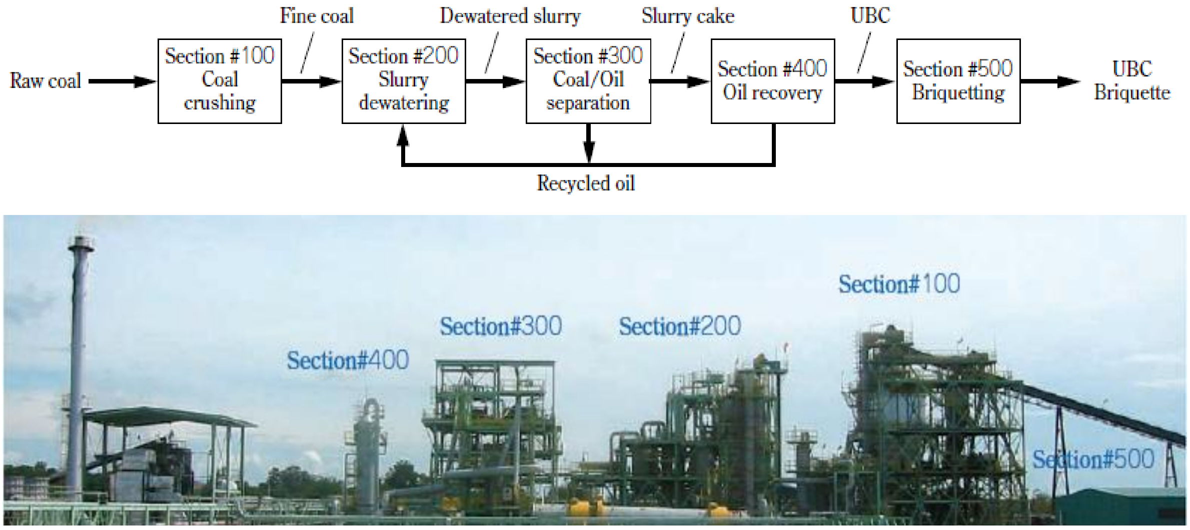


Figure 4.2 Block Flow Diagram and Full View of UBC 600 tons/day Plant

1) Coal crushing

Coal crushing is a part of brown coal preparation in UBC process. This step includes taking in raw coal, preliminarily rough-crushed to 50 mm or smaller in size, and crushing the raw coal to 5 mm or smaller using a grinding mill.

2) Slurry dewatering

This step includes mixing the pulverized high-moisture low-rank coal with circulating oil (normally light petroleum oil), and then laced with heavy oil (such as asphalt) in a slurry preparation tank to prepare the coal slurry. During this stage, the coal slurry heated in a shell and tube-type evaporator at a temperature from 130 to 160°Cand under a pressure of 400 to 450 kPa, then generating a mixed vapor consisting of water and light oil. Low-rank coal also contains numerous pores and the moisture within them is removed in the course of evaporation. The moisture is recovered as water vapor. Then it is sent to the shell side of the evaporator, after being pressurized by a compressor, to use the waste-heat as a heating source, providing substantial energy savings during the dewatering stage.

3) ***Solid/liquid separation***

This solvent recovery step includes transferring the dewatered coal slurry to a continuous centrifugal separator (decanter) to separate the slurry cake from the light oil. The separated light oil is returned to an oil recirculation tank and is reused as the light oil for slurry preparation.

4) ***Oil recovery***

Most of the recycled solvent is recovered from the dewatered slurry by a decanter. The recycled solvent remaining in the pores of the upgraded coal is recovered by a tubular steam dryer. Vaporizing and drying the oil contained in the slurry cake through indirect heat exchange with high temperature steam to recover UBC in powder form (UBC powder). The oil vapor, contained in the circulating gas (mainly consisting of nitrogen) passing through the dryer, is condensed in a cooling tower and is separated from the nitrogen.The separated light oil is fed back to a circulating oil tank and is reused as the light oil for slurry preparation.

5) ***Briquetting***

In this step, the UBC powder is fed into a briquetting machine of the double roll type. The apparatus comprises a pair of rolls, rotating in opposite directions, each roll having a roll surface provided with pockets.

Considering the product evaluation, it was confirmed that the UBC product provided good solid fuel with low moisture content and high calorific value. Total moisture of raw coal initially 33.8% could be reduced to 1.0% and stable at 6.5% after 30 days [61]. The heating value of upgraded coal, though it varies depending upon the characteristics of the coal, has been improved up to 6,000kcal/kg, and its spontaneous combustion problem has also been successfully suppressed. It has also been confirmed that briquetted upgraded-coal is similar to normal bituminous coal when it comes to ease-of-handling and re-crushing. Furthermore, upgraded coal, when combusted, quite easily burns itself out to leave almost no un-burned portion even under low- NOx combustion conditions, exhibiting excellent characteristics as a fuel [41].

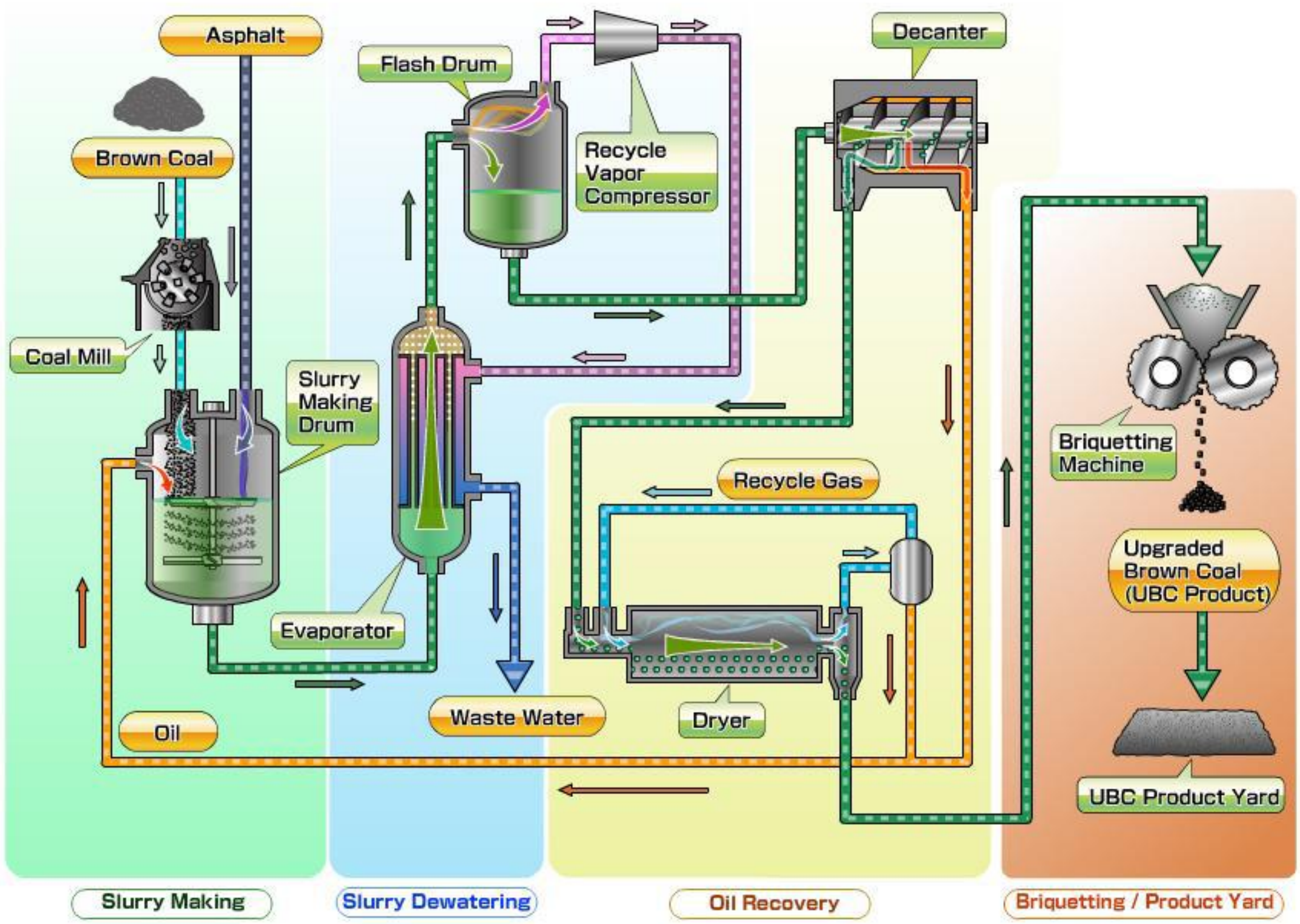


Fig 4.3 UBC Process[39]

This process, whose conditions are rather mild, is expected to resolve the issues associated with the conventional processes for dewatering low rank coal. The following describes the features of the UBC process [43].

1. Essentially no chemical reaction occurs minimizes the heat loss of the product and decreases the burden of waste water treatment.
2. The coal contains water that is vaporized into steam and separated from the coal during the dewatering in hot oil. The water steam is compressed and reused as a heat source, which makes it possible to decrease energy consumption.
3. The pores that remain in the low rank coal during the dewatering in oil absorb heavy oil, such as asphalt, which stabilizes the characteristics of the coal and prevents spontaneous combustion.

From the explanations described previously, it can be concluded that the UBC process is one of the highly efficient waysto increase the quality of coal. UBC process is free from chemical reactions which use simple an operation conditions, therefore it has a relatively low risk in the process. Based on the UBC process and journals that have published that during the process no emissions and waste produced, bringing the total emissions produced can be minimized. It is evident from the recycle system of heat generated in this process to be reused in some processes as described previously.

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4.2 Life Cycle Costing

The data calculation is useful as the basis for information needed to develop the UBC process in Indonesia, so that it can increase the amount of interested investors to invest in coal as primary energy sector. The data can be used as valuable information by GoI to stimulate the development of the UBC process in considering the future of the UBC commercial plant which is still under development and on-hold status right now, namely, PT. Upgraded Brown Coal Indonesia (UBCI) in Indonesia.

This calculation is summarized by life cycle costing analysis, which is suitable with the first objective of this study. The costs element considered in this study has been clearly described in Chapter 3 as the investment and production costs of UBC plants in Indonesia. Here is a further explanation of the life cycle costing calculation followed by an analysis of the result and suggested policy implementation for the GoI. Detail calculation for life cycle costs in the attached appendix.

4.3 Total Capital Investment Costs (C_{TCI})

Purchased landcostss, building costs, engineering costs, project management costss, procurement equipment costs (purchased equipment and electrical and Instrument costs), construction costs and commissioning costssis covered by total capital investment (C_{TCI}). The estimation of C_{TCI} was calculated by collecting data of UBC Commercial Plant Planning by a factor according to the capacity of the plant then searching for land and building costs with the suitable area (Muara Enim, South Sumatera). The planning which is used as a base has a capacity of 5,000 tons/day or 1,500,000 tons/year, while in this study estimates using capacity UBC commercial plant production by 5,000,000 tons/year. The total capital investment of this UBC process was calculated by IDR 5.96 trillion or USD 557.05 million (Appendix E-3) with breakdown costs as follow.

4.3.2 Fixed Capital Investment (FCI)

Fixed capital investment (FCI) of UBC commercial plant with capacity by 5,000,000 tons/year was calculated as IDR 5.66 trillion or USD 529.20 million. The detailed calculationsare presented in the Appendix E-1. Here are the details of FCI.

1. **Land Costs**

Based on the planning of the UBC commercial plant, then the result of the calculation of land used for the UBC commercial plant with capacity 5,000,000 tons/year was 51.43 ha or 514,287 m^2. The comparison of the total area used in the UBC commercial planning in this study and the detailed calculationsare shown in the Appendix E-1. Total land used in the commercial plant is summarised in this following table.

Table 4.1 Total Land used by UBC Plant with capacity 5,000,000 tons/year

No.	Area	Percentage [62]	Total Area
1.	Production Facilities	17.11 %	87,994 m^2
2.	General Facilities	1.59 %	8,177 m^2
3.	Others Facilities	30.99 %	159,378 m^2
4.	Lay Down	11.92 %	61,303 m^2
5.	Stockpile	10.52 %	15,002 m^2
6.	Total Area Used	72.13%	331,845 m^2
7.	Total Area not Used	27.87 %	182,433 m^2
Total Area		**100 %**	514,287 m^2

The area thatwas not used was prepared as a saving area, if there is a scaling up of the plant production capacity. The price per area was obtained from average price in the selected location, IDR 100,000,000/ha or USD 9,346.76/ha. The land area used is multiplied by the expenses for land per hectare. Then, the land costs in this study were found to be IDR 5.14 billion or equal to USD 480,691.38.

2. Plant and Building Costs

Plant / technology costsare based on UBC commercial plant planning. This planning was calculated in 2007 with the Price Index Data for Chemical Factory Japan as basic for scale up method. Based on the planning, the investment costswere including technology, construction, building, utility systems and other facilities costs. One of the utility system constructions is the construction of power plant as utilities facilities with solid fuel (coal), capacity 14.6 MW (Coal & Energy Project, 2002). The detailed calculation can be seen in Appendix E-1. The totalplant and building costsswere found to be IDR 5.66 trillion or USD 528.72 million.

4.3.2 Working Capital (WC)

The working capital of the UBC plant of the company can be calculated byEquation (3.5).The detailedare shown inAppendix E. The estimation of working capital of UBC plant in this study is IDR 297.99 billion or equal to USD 27.85 million (Appendix E-2).

4.4.3 Estimation of Total Capital Investment Costs (TCI)

This calculation is obtained by the average of the exchange rate of the dollar against the rupiah 2013 – 2014, which amounted to IDR 10,698.90 of USD 1.Total capital investment calculation was annualized, and then divided by the total production of the UBC product per year. This calculation was performed to calculate the costs of investment incurred per tons of UBCproduct. The final calculation for the investment costsof UBC commercial plant with a capacity of 5,000,000 tons/year of IDR/year 584.62 billion or USD/year 54.64 million or IDR/ton UBC product 116,923.66 or USD/ton UBC product 10.93 (Appendix E-4).

Table 4.2 Total Capital Investment (C_{TCI})

No.	Elements	Costs (IDR)	Costs (USD)
1.	Fixed Capital Investment (FCI)	5,661,891,786,197.45	529,203,169.13
	1) Land Costs	5,142,869,000.00	480,691.38
	2) Plant and Building Costs	5,656,748,917,197.45	528,722,477.75
	a) Procurement Equipment Costs Total purchased equipments (80%) Electrical & instrument costs (20%)	3,394,049,350,318.47 2,715,239,480,254.78 678,809,870,063.69	317,233,486.65 253,786,789.32 63,446,697.33
	b) Construction costs Building costs	1,445,692,667,129.24 251,332,008,030.00	135,125,355.61 23,491,387.72
	c) Engineering Costs	226,269,956,687.90	21,148,899.11
	d) Project Management Costs	226,269,956,687.90	21,148,899.11
	e) Commissioning Costs	113,134,978,343.95	10,574,449.55
2.	Working Capital (WC)	297,994,304,536.71	27,852,798.38.
	Total Capital Investment	**5,959,886,090,734.16**	**557,055,967.50**

4.5 UBC Plant Production Costss

After the calculation of the incurred UBC investment costs, then the calculation of the life cycle costing is followed by the calculation of the production costss to be incurred for the UBC plant. As described in chapter 3 that the production costs are the costsincurred for raw material costs, operating costss, general expenses and transportation costs, such as the costs estimate with details below.

4.5.1 Feedstock Costss (C_F)

In the process of upgrading brown coal (UBC), feedstock used in the form of brown coal was supplied by PT. Bukit Asam in Muara Enim Area. PT. Bukit Asam has been produced coal with a variety of characteristics that indicate that the quality of coal as well as determining the selling price of the coal. By PT. Bukit Asam, it was obtained thedata that the selling price of coal for domestic purposes equal to the selling price for the export activity, which is in accordance with the Indonesian Coal Index. This data was updated in every two weeks [63].

In this study, the average prices of feedstock costs in years 2010 - 2014 was selected, IDR/tons476,998.11 or USD/ton 44.58 with the historical details of the brown coal price was shown in Appendix F. The highest recorded price of brown coal in February 2011, i.e. 620,750.18 IDR/tonor equal to 58.02USD/ton. Then the lowest price of brown coal was recorded at IDR/ton392,863.61 or USD/ton36.72 on March 2014. The price of brown coal may change in the future or in other locations; therefore, it needs to be noted that the feedstock costs in this study is valid only in the time interval considered (2010 – 2014) and the selected location (Muara Enim / South Sumatera). The value of one tons UBC product was divided with the price per tons of brown coal as usual as feedstock in order to calculate the price of feedstock per tons of UBC product.

According to the data which is obtained from the UBC demonstration plant that the UBC process has a percent yield of 82.23%. It can be used as a basic calculation for 1 tonof product UBC that requires feedstock as much as 1:22 tons of brown coal and a UBC commercial plant with a capacity of 5,000,000 tons/year would require as much as 6,080,849.19 tons of brown coal. Then, the feedstock costss was found to be IDR/year2.9 trillion or equal to USD/year271.11 million Then, the annualized of feedstock costs per ton UBC product was calculated to be IDR580,110.72or USD 54.22 (Appendix F-1).

4.5.2 Operating Costs (C_{OC})

Due to the variations of production output, Operating Costs (C_{OC}) can be classified as variable costs. The operation costs consisted of raw material, operating labor, utilities and maintenance / repairing costs. Besides the feedstock, UBC process use asphalt as raw material. Based on the demonstration plant, the price of asphalt can be calculated as IDR 68,640.00 or USD 6.42 per ton UBC product. Based on the production capacity in this study, the raw material costss per year were found to be IDR 343.2 billion or USD 3.08 million.

The estimation of utility costss can use the assumption of5% of total operating costs (include the feedstock costss). For maintenance costs, this study used the assumption 6% of fixed capital investment costs (FCI). The labor needed to operate the UBC commercial plant in this study are 199 people. Division of labor in accordance with organizational structures in UBC commercial plant and payroll earned by each worker in detail can be seen in appendix F-2. The total of operating labor costs per year is IDR 12.99 billion or USD 1.21 million. Here is the detail of the operating costs per year and per tons UBC product.

Table 4.3 Total Operating Costs (C_{OC})

No	Operating Costs	Per year		Per ton UBC product	
		IDR	**USD**	**IDR**	**USD**
1.	Raw Material Costs	343,200,000,000.00	32,078,064.10	68,640.00	6.42
2.	Operating Labor Costs	12,998,700,000.00	1,214,956.68	2,599.74	0.24
3.	Utility Costs	222,229,902,023.77	20,771,285.09	44,445.98	4.15
4.	Maintenance & Repair Costs	339,559,221,101.85	31,737,769.41	67,911.84	6.35
	Total	**918,142,109,195.62**	**85,816,496.01**	**183,628.42**	**17.16**

The total operating costss of the UBC commercial plant in this study was be IDR 918.14 billion or USD 85.82 million per year. It was equal to IDR 183,628.42 or USD 17.16 per ton UBC product (Appendix F-2).

4.5.3 General Expenses (C_{GE})

General expenses consist of administrative costss, research and development costss, product distribution and financing. As already mentioned before that, the Ministry of Energy and Mineral Resources (MEMR) Indonesia has the Agency for Research and Development co-ordinates four specialized R&D centre, one of them is *TekMira*which is related to mineral and coal technologies [9]. *TekMira* in coordination with Japan will fully support the research and development programs of the UBC process. Based on this condition, research & development costs element can be omitted in general expenses. The estimation of administrative costs can be taking the assumption for 20% of operating labor costs[57]. For distribution and financing, this study used the assumption 0.1% of total capital investment costs (TCI) [57]. Assumptions for the distribution and financing was selected at the lowest percentage with range 0-10% TCI because distribution costs incurred will be calculated in more detail on the transportation costs so that the section element is only financing costs. The summary of general expenses is shown in Table 4.4 below.

Table 4.4 General Expenses (C_{GE})

No	General Expenses (C_{GE})	Per year	
		IDR	**USD**
1.	Administrative costs	2,599,740,000.00	242,991.34
2.	Financing.	5,957,179,317.58	556,802.97
	Total	**8,556,919,317.58**	**799,794.31**

The total of the general expenses of the UBC plant in this study was calculated to be IDR 8.56 billion or USD 799,794.31 per year, and then it was equal to IDR 1,711.38 or USD 0.16 per tons UBC product (Appendix F-3).

4.5.4 Transportation Costs (C_T)

Transportation costss calculated in this study consists of two sections, costs to transport brown coal as feedstock from PT. Bukit Asam to UBC plant then transport the UBC product from UBC plant to customer. In this study, there were two kinds of transportations, namely train and truck.

PT. Bukit Asam provide data in IDR/ km (per ton) for transportation from PT. Bukit Asam (Tanjung Enim) to Kertapati Pier (Palembang) and Tarahan Port (Lampung) in the last three years (2010 – 2013). Data from PT. Bukit Asam was used in the domestic activity and exporting activity by using the train as a means of transportation. Kertapati Pier, Palembang is the last for the sale of the domestic scale. Meanwhile, the UBC product will be transported to the Tarahan Port, Lampung as the last port for export purposes.

The linear regression method was used to estimate the data in IDR/km (per ton) in 2015 (the year of plant operation in this study). The projection of transportation costs in IDR/km per tons UBC product was shown in Figure 4.4. Furthermore, that costs will be converted into the IDR/year and USD/year by multiplying the distance traveled and the total feedstock or total UBC product. Table 4.5 describes the total transportation costs in detail. Summarize of transportation costs was found to be IDR528.45 billion or USD 49.39 million per year. This costs was converted to IDR/tons UBC product or USD/ton UBC product, namely 105,690.15 and 9.88 respectively. Transportation costs calculations in detail can be shown in Appendix F-4.

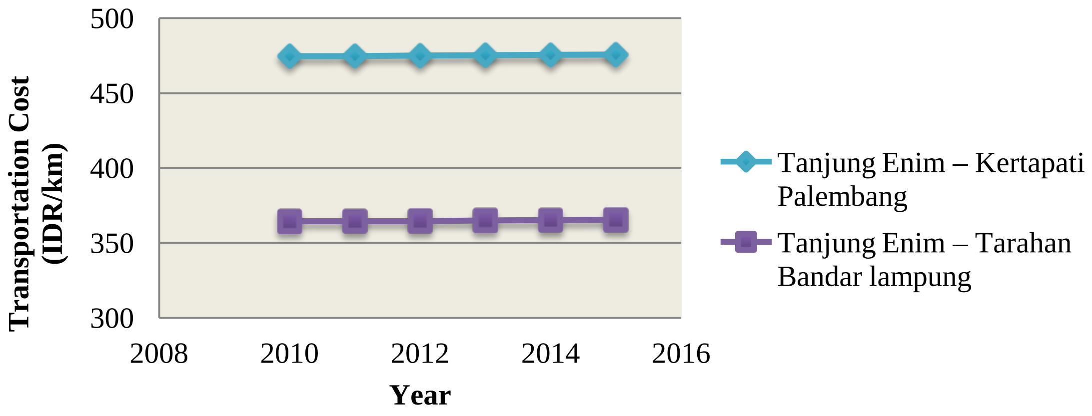


Figure 4.4 Projection of Transportation Costs in IDR/km per ton UBC Product

Table 4.5 Total Transportation Costs (C_T)

No	Transportation Costs (C_T)
1	***PT. Bukit Asam (feedstock Supplier) - UBC Plant (Process)*** Type of Transportation : Truck Distance : 3.8 km Costs : 787.71 IDR/km – per ton Total of Brown coal feed : 6,080,849.19 tons/year Total Costs : 18,155,678,300.36 IDR/year 1,696,966.82 USD/year
2	***UBC Plant (Process) - Pier (Kertapati, Palembang) : Domestic Activity*** Type of Transportation : Train Distance : 160.94 km Costs : 475.85 IDR/km – per ton Total of UBC Product : 3,250,000.00 tons/year Total Costs : 248,893,349,711.96 IDR/year 23,263,452.29 USD/year
3	***UBC Plant (Process) - Port (Tarahan, Lampung) : Exporting activity*** Type of Transportation : Train Distance : 409.52 km Costs : 365.40 IDR/km – per ton Total of UBC Product : 1.750.000,00 tons/year Total Costs : 261,401,735,000.00 IDR/year 24,432,580.45 USD/year

4.5.5 Net UBC Plant Production Costs (C_{TPC})

Table 4.6 Total Production Costs (C_{TPC})

No	Total Production Costs	Per year		Per Tons UBC product	
		IDR	**USD**	**IDR**	**USD**
1.	Investment Costs	584,618,288,519.16	54,642,840.71	116,923.66	10.93
2.	Feedstock Costs	2,900,553,581,367.29	271,107,644.84.	580,110.72	54.22
3.	Operating Costs	918,142,109,195.62	85,816,496.01	183,628.42	17.16
4.	General Expenses	8,559,626,090.73	800,047.30	1,711.93	0.16
5.	Transportation Costs	528,450,763,012.32	49,392,999.56	105,690.15	9.88
	Total	**4,940,324,368,185.13**	**461,760,028.43**	**988,064.87**	**92.35**

This table summarizes the Total Production Costss per year and per ton UBC product. Net UBC Plant Production Costs (C_{TPC}) is the total of annual investment costs, feedstock costs, operating costss, general expenses and transportation costss, which were calculated as IDR 4.94 trillion or USD 461.76 million per year. Considering the total of UBC plant capacity, its value was equal to IDR 988,064.87or USD 92.35per ton UBC product (Appendix F).

4.6 UBC Plant Production Costs Suggested Strategies

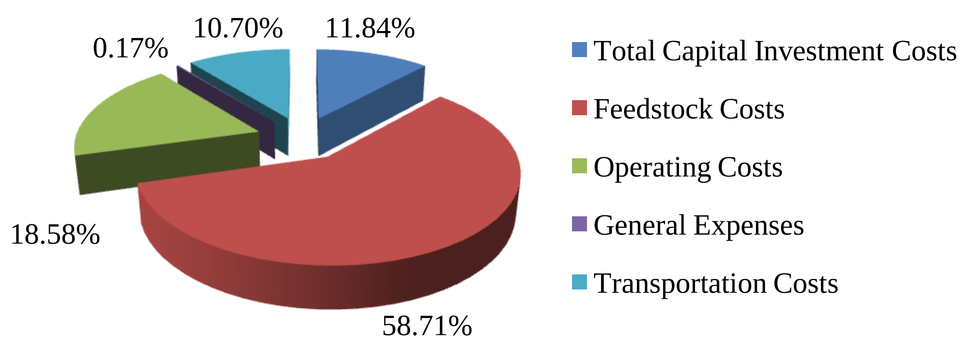


Figure 4.5 Percent Share of Net UBC Production Costs

Based on the results of the calculation, it was obvious that the price of brown coal as feedstock highly influenced, more than half the net production costss of the UBC product.

The percentage of feedstock price is 58.71%, followed by operating costss, investment costss, transportation costss and general expenses at 18.58%, 11.84%, 10.70% and 0.17% respectively.

4.6.1 Feedstock Costs Suggested Strategy

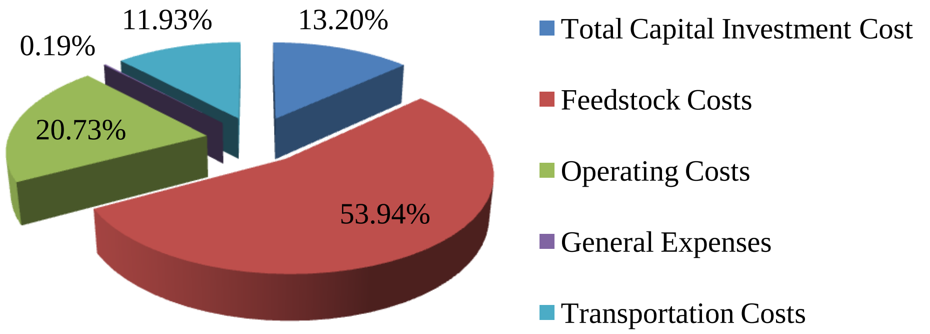


Figure 4.6 Percent Share of Net UBC Production Costs at the Lowest Feedstock Price

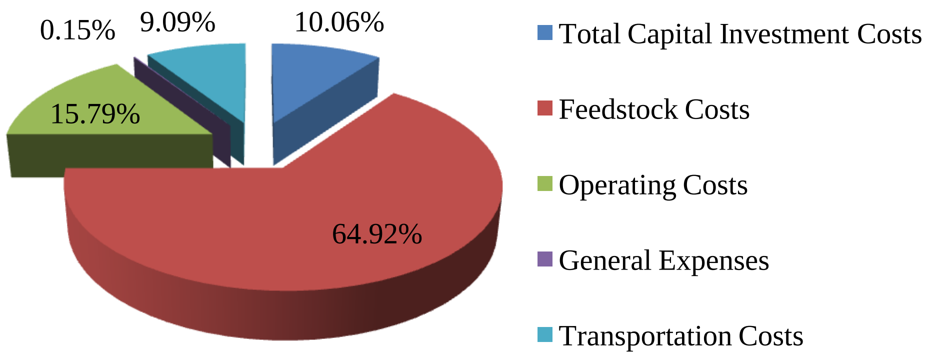


Figure 4.7 Percent Share of Net UBC Production Costs at the Highest Feedstock Price

Off the chart above, it can be seen clearly that the price of brown coal as a feedstock has affected the net UBC production costs significantly. An adequate number of brown coal in South Sumatra makes the sustainability and the development of the UBC process have a positive value. The existence of brown coal as a feedstock is highly dependent on the mining process which conducted in South Sumatra. Good mining management is indispensable in order to maximize the amount of feedstock which can be utilized in the UBC process.

Judging from the spread of Indonesian coal resources in Table 1.3, the amount of coal in South Sumatra is much more than in South Kalimantan and East Kalimantan, which has been known as a major supplier of coal. The existence of PT. Bukit Asam in South Sumatra as the largest state-owned companies in the field of coal mining make the mining process can be controlled. Therefore, PT. Bukit Asam is also expected to be a supervisor and the owner of the flow standards for domestic coal sales and export activities.

At the last, the government should allocate funding support to introduce the mining practice and training and consultation center in the prospect mining area. This program is necessarily needed to improve the coal mining productivity in Indonesia especially in South Sumatera.

4.6.2 Operating Costs Suggested Strategy

Considering the costs elements accounted, among other costs elements, raw material costs and utility costs are the potential elements that can contribute to lower total manufacturing costs. Asphalt used as raw material in this process comes from Pertamina which is a state-owned company. This makes opportunities of GoI in terms of energy policy to provide subsidies to reduce the price of asphalt so that the raw material can be reduced at a lower cost.

4.6.3 Transportation Costs Suggested Strategy

(a) **(b)**

Figure 4.8 (a) Kertapati Pier, Palembang; **(b)** Tarahan Port, Lampung

Just as PT. Bukit Asam, the UBC plant also applies on FOB (Free on Board) system for UBC product distribution process. This shows that the UBC product will be distributed to the loading pier/port. Therefore, the land or sea transportation after pier/port is provided by the customers. By adopting a system that has been implemented by PT. Bukit Asam has also lowered the costs of transportation that must be earned by the UBC plant.The division of the loading pier or loading port as it was called before adjusting with the distribution of PT. Bukit Asam as a state-owned company that is expected to collaborate with UBC Plant being developed by the Government of Indonesia. It can reduce the total of transportation costs. In addition, the feedstock distribution for future by truck can also be minimized so that the costs can be lower than lower than had been calculated.

4.7 Economic Feasibility Analysis

4.6.1 Annual Cash Flow (ACF)

The annual cash flow of the UBC commercial plant was calculated to be IDR 669.50 billion or equal to USD 62.57 million. Since the net annual cash flow (ACF) has positive value, this UBC commercial plant is considered to be economically feasible. The detailed calculation of cash flow can be found in appendix H.

4.6.2 Net Present Value (NPV)

The net present value of the company was calculated using the assumed interest rate at 7.5% / annum (average value from 2005-2013) [52] and found to be IDR 865.38 billion or USD 80.89 million. Since the net present value has positive value, this company is considered to be economically feasible (Appendix H).

4.6.3 Internal Rate of Return (IRR)

Internal Rate of Return (IRR) of the company was calculated at 20 years of assumed plant lifetime. The IRR was found to be 9.36% (Appendix H). Based on data fromAsian Bonds Online (Asian Development Bank), the 20 years Indonesian – localcurrency bonds yield is 7.046% that means, with the similar amount of paybackperiod with the Indonesian Government Bonds [64], the investor may increase their rateof return by 2.31% by investing in this project. Therefore, it is considerably feasible to invest in this project.

Table 4.7 and Figure 4.9show the IRR calculationsof different payback periods. As can be seen from the figure, after 20 years the IRR slowly begin to convergent. This means, it is safe to assume that this project will be worth at 20 years payback period (assumed value), since prolonging the project up to 30 years only increase the IRR by 1.00%.

Table 4.7 Internal Rate of Return (IRR)

PBP (year)	1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
i’	-0.8877	-0.6040	-0.2577	-0.1023	-0.0231	0.0217	0.0492	0.0671	0.0791	0.0875	0.0936	0.0980	0.1012	0.1037	0.1056	0.1070
IRR (%)	-88.77%	-60.40%	-25.77%	-10.23%	-2.31%	2.17%	4.92%	6.71%	7.91%	8.75%	9.36%	9.80%	10.12%	10.37%	10.56%	10.70%

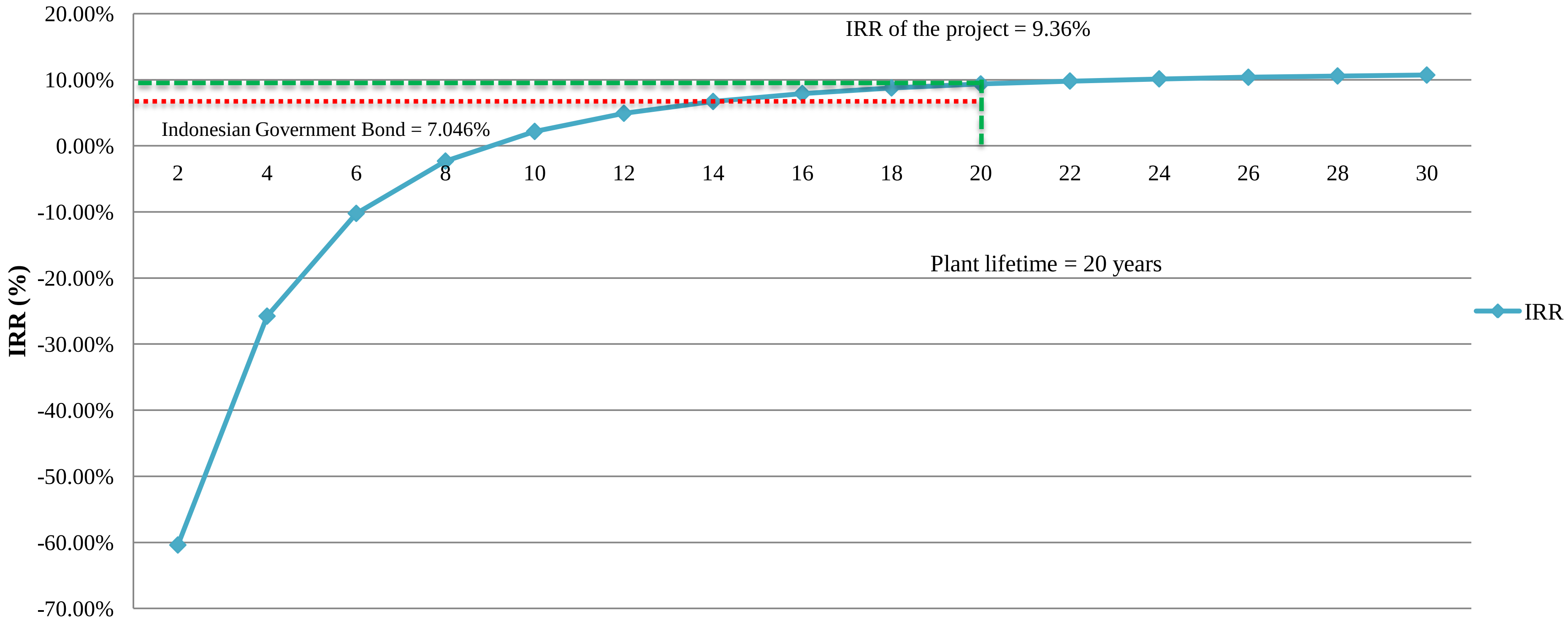


Figure 4.9 Internal Rate of Return (IRR)

4.6.4 Payback Period (PBP)

In this study, the payback period (PBP) of the UBC commercial plant was calculated using the assumed interest rate and found to be 9 years (Appendix H). The payback period was most likely to be less than half of the total project lifetime (20 years). Thus, the UBC commercial plant was considered to be economically feasible in this study.

4.7 Sensitivity Analysis

4.7.1 Effects of Brown Coal Price

The feedstock costs or brown coal price is the major cost affecting the UBC product production costs, since it is accounted for the highest costsamong the other element costs. Therefore, the sensitivity analyses were conducted in order to determine the sensitivity of production costs to the changes of variety feedstock price in the market.

Monthly Data in 2010 - 2014 showed that the lowest price of 1 ton of brown coal occurredon May 2014, with a value of USD 36.72. USD 58.02 was the highest price of brown coal reached in February 2011 (Appendix F-1). Therefore, the sensitivity of this analysis was taken from range USD 35.00 to USD 62.00 for the price of 1 ton of brown coal. The variation in the price of brown coal would show the increasing production costs to be incurred. Production costs was included investment costs, operating costs, general expenses and transportation costs as fixed variable and feedstock costs as an independent variable with the range specified above. At the end, the production costs for 1 ton of product UBC would be compared with the selling price of 1 ton of UBC product that has been determined in this study (average price of the February 2010 - May 2014). This comparison would show the range of prices that can be categorized as brown coal competitive price at the current condition (Figure 4.10).

Figure 4.10 shows clearly that the variation in the price of brown coal for USD 35.00, USD 38.00, USD 41.00 and USD 44.00 are under the coverage area of brown coal competitive prices at the current condition. This is because in the calculation of production costs, the net cash flow showed a positive value. In other words, the production costs for 1 ton of UBC product has a value below the selling price of 1 ton UBC product, USD 93.94. Meanwhile, the variations in the price of brown coal from USD 47.00, USD 50.00, USD 53.00, USD 56.00, USD 59.00 and USD 62.00 is outside the competitive category of brown coal price at the current condition after inclusion in the calculation of production costs to be incurred (Appendix I-1).

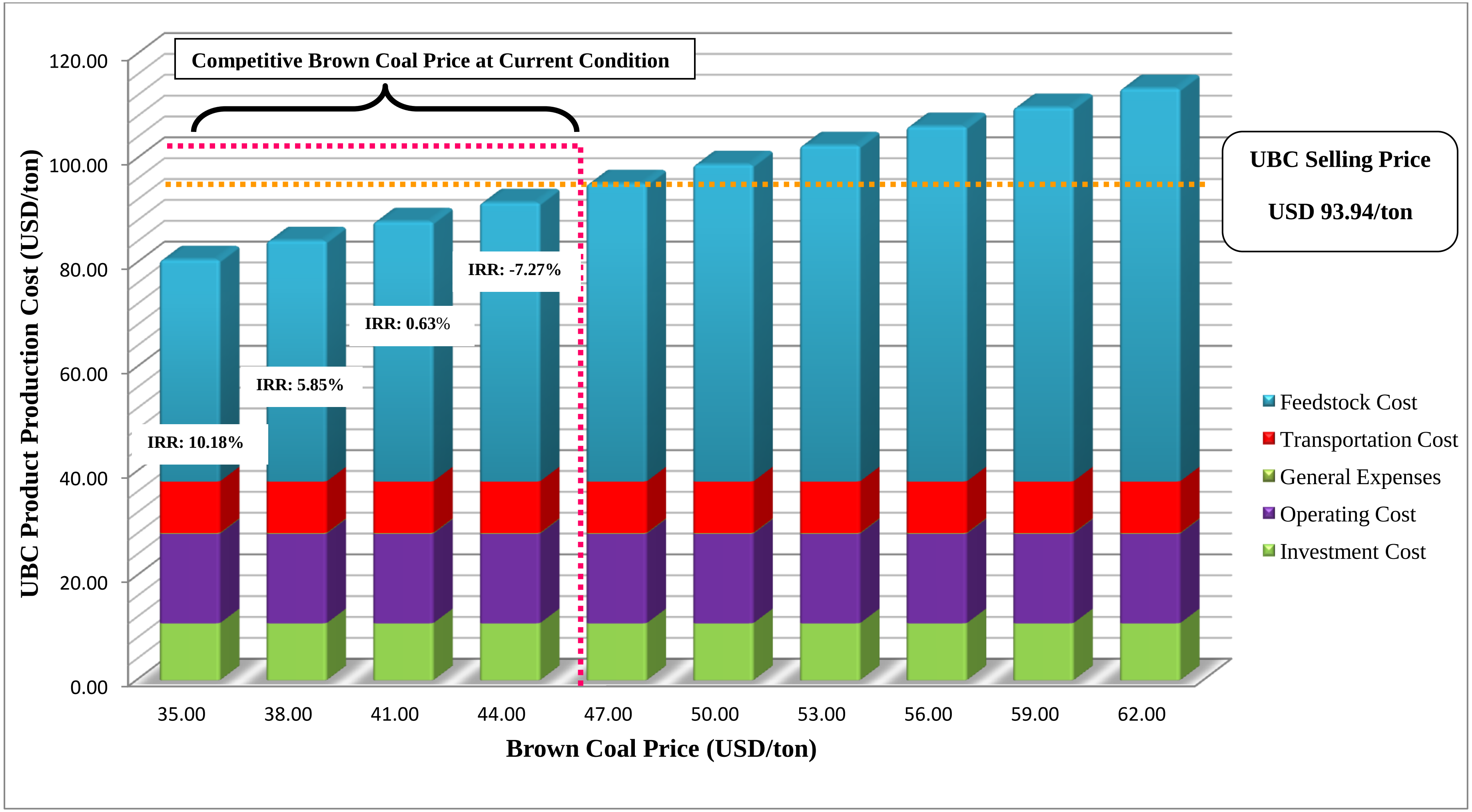


Figure 4.10 Effects of Brown Coal Price on Total Production Costs of UBC Processes

4.7.2 Effects of UBC Product Selling Price

UBC product price was categorized as sub-bituminous coal price. UBC product price was unable to follow the production costs of its prices. It must confirm to the coal price in the world market based. This price may be accessed through the ICI (Indonesian Coal Index) which can be shown the historical data from Indonesian coal price in accordance with UBC product characteristics. In ICI, UBC product can be categorized as coal Pinang 6150 (TM Base 14.5% - Ash - 5.5%, TS - 0.6% and GCV 6200 kcal/kg).

Coal prices were set based on the ICI of the Minister of Energy and Mineral Resources Regulation No. 17 of 2010 concerning the procedures for determining the benchmark price of minerals and coal sales. Regulation became effective on 23 September 2010 and must be adhered to by all mineral and coal producers in Indonesia. Coal reference price (HPB) is set to 8 main types of coal comprising:

a. Gunung Bayan I (7,000 kcal/kg GAR)
b. Prima Coal (6,700 kcal/kg GAR)
c. Pinang 6150 (6,200 kcal/kg GAR)
d. Indominco IM-East (5,700 kcal/kg GAR)
e. Melawan Coal (5,400 kcal/kg GAR)
f. Envirocoal (5,000 kcal/kg GAR);
g. Jorong J-1 (4,400 kcal/kg GAR);and
h. Ecocoal (4,200 kcal/kg GAR), then classified as brown coal.

HPB must be used as a reference price for coal companies that have permission for coal sales that were legally registered in Indonesia. On behalf of the Ministry of Energy, Director General set a benchmark price for steam (thermal) coal and cooking (metallurgical) coal per month based on a formula that refers to the average coal price index in accordance with market mechanisms and in accordance with generally accepted prices in the international market. Steam (thermal) coal price index, which is comprised of:

a. Indonesian Coal Index/ Argus Coalindo
b. New Castle Export Index
c. Platts
d. Global Coal New Castle Index

Indonesian Coal Index (ICI) / Argus Coalindoused in almost all mining companies, including PT. Bukit Asam as Indonesia's largest coal supplier. ICI is published weekly and is the average of the Argus fob Indonesia price as reported in the Argus Coal Daily

International report and the PT Coalindo Energy weekly panel system. The full database of time series data is available from 2006.

Argus uses a market appropriate methodology to assess prices in the markets it covers. Argus consults with the range of participants involved in different markets and publishes methodologies for each price report on its website. Each methodology is reviewed regularly to ensure that it always meets the needs of market participants and is in line with industry practice. Argus seeks to reflect the way markets are traded, rather than impose its own view.Formulas and methods used are described in more detail in the director general of minerals and coal regulation no.15.K / 32 / DJB / 2011 on coal benchmark pricing formula and methodology and specifications guide from Argus Media.

All methodologies are used to determine the coal's HPB based on the characteristics of UBC product with formulasand variables as follows:

a. Price marker / main HPB
b. Calorific value
c. Moisture Content
d. Sulfur Content
e. Ash Content

Then we can obtain the UBC selling price from January 2010 until May 2014 for this study.

Monthly Data from ICI in 2010 - 2014 showed that the lowest price of 1 ton of UBC product occurred in May 2014, with a value of USD 75.71. USD 125.31 was the highest UBC product price reached in February 2011 (Appendix G). Therefore, the sensitivity of this analysis was taken from the price range USD 70.00 to USD 125.00 for the price of 1 ton of UBC product. The variation in the selling price of UBC would show differences in net cash flow after deducting production costs.

Figure 4.11 shows clearly that the variance of the UBC product selling price for USD 70.00 UBC, USD 76.00, USD 82.00 and USD 88.00 showed that the negative value of the net cash flow was positive cash. While the positive net cash flow was shown by the variation in the selling price of the product UBC USD 94.00, USD 100.00, USD 106.00, USD 112.00, USD 118.00 and USD 125.00. By viewing from the concept of net cash flow, negative net cash flow which indicated that that the project included in the category was not economic feasible, while project was stated as economic feasible if it has a net positive cash flow. Therefore it can be concluded that the project would that the project would be able to work well when the price of the product UBC is above USD 89.50 per ton (Appendix I-2).

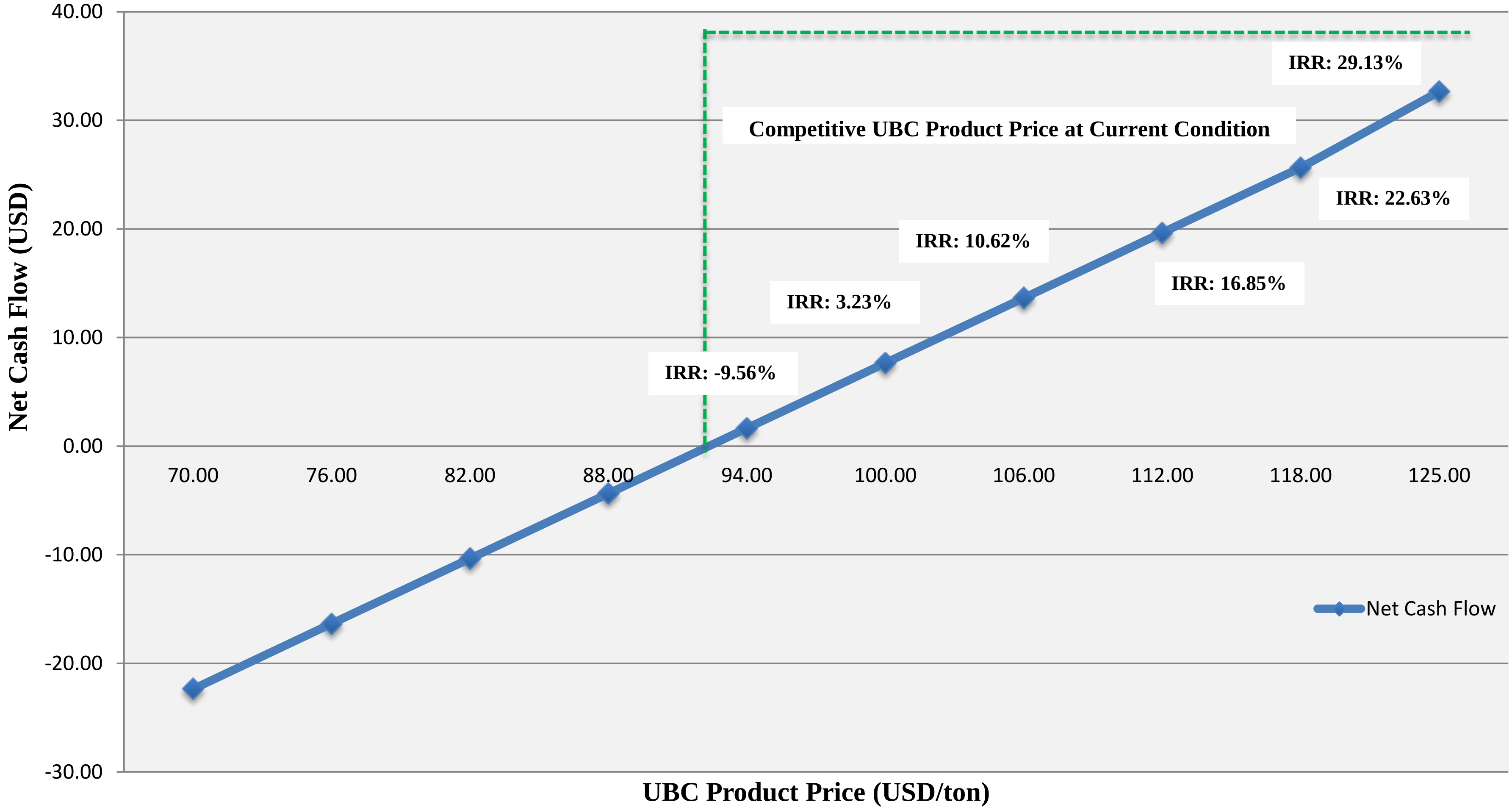


Figure 4.11 Effectsof UBC Product Selling Price to Net Cash Flow of UBC Process

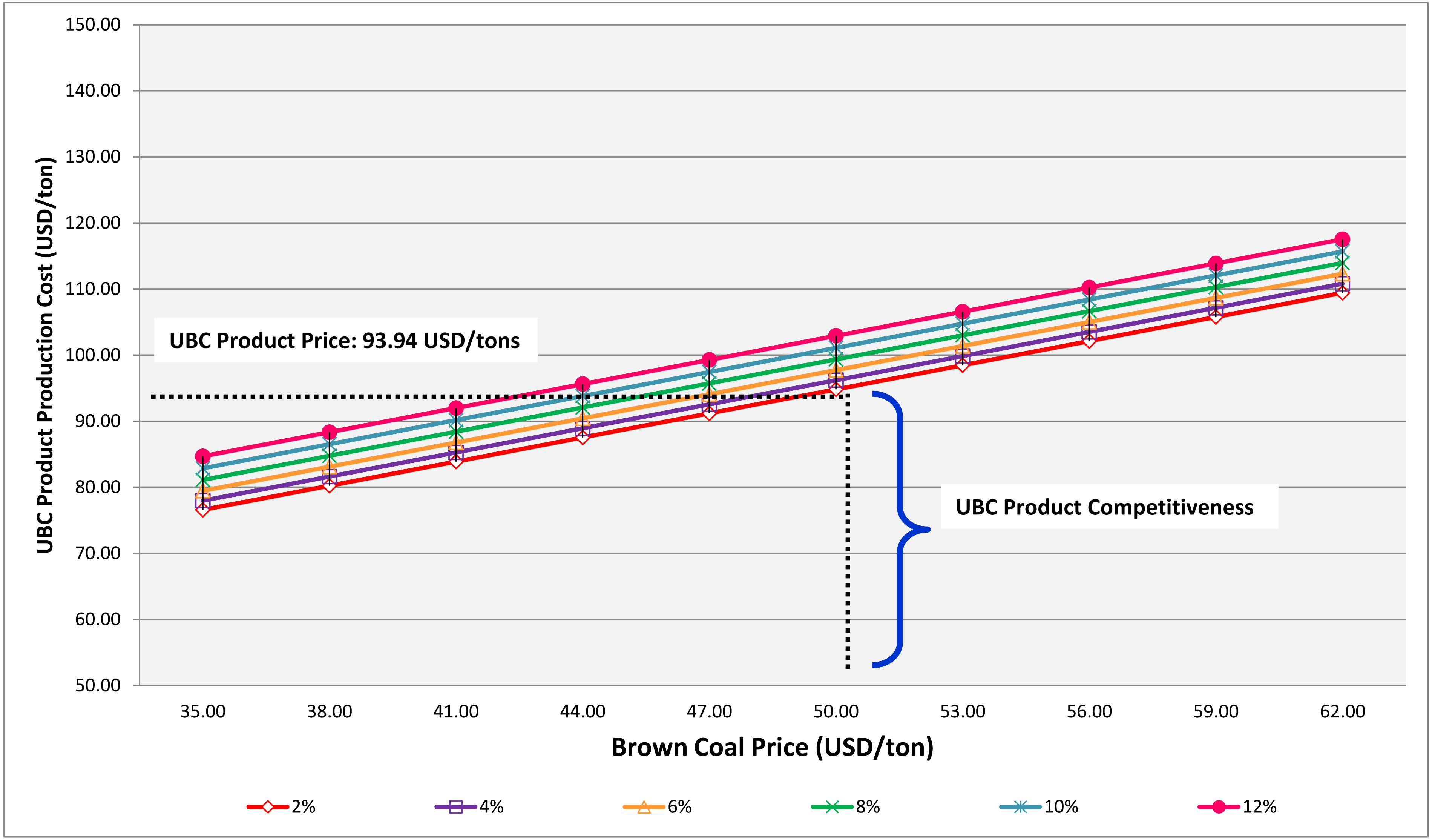


Figure 4.12 UBC Product Competitiveness

4.7.3 Effects of Interest Rate

Various brown coal prices are also the same with the first part of sensitivity analysis, which the effect of brown coal prices. The variations of the interest rate used are 2%, 4%, 6%, 8%, 10% and 12%. It is based on the lowest and the highest historical rate in Indonesia. The result of this analysis was shown in Figure 4.12 (Appendix I-3). From this figure, we can see the UBC product competitiveness based on variations that already mentioned before with UBC selling price as the standard.

4.8 Greenhouse Gas (GHG) EmissionPotential Calculations

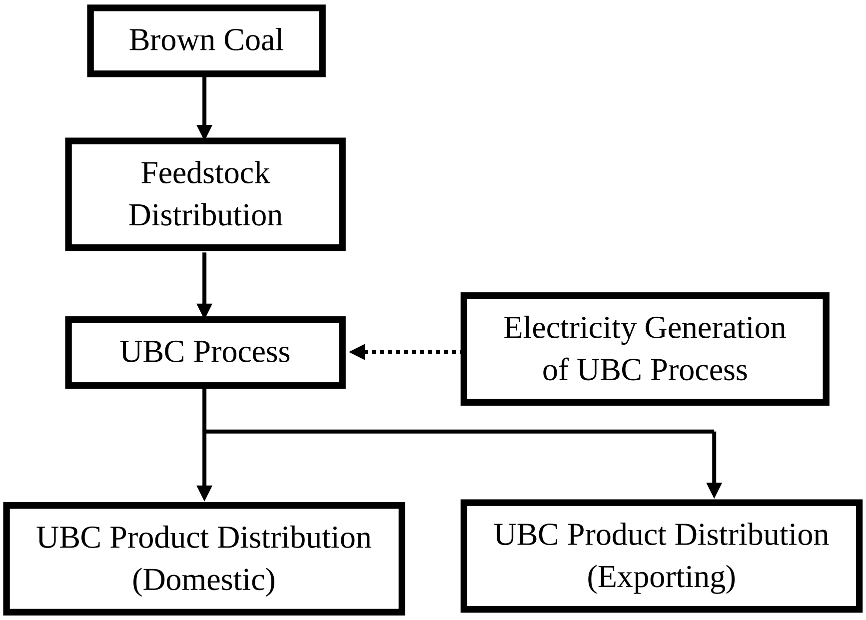


Figure 4.13 System Boundary ofGreenhouse Gas Emission Potential Calculations

Feedstock Distribution (Appendix J-1)

Type of Transportation	: Truck
Truck Capacity	: 30 tons brown coal/truck
Type of Fuel	: Diesel
Total amount of fuel	: 0.543 l
Functional Unit	: Per ton capacity
Total greenhouse gas emissions potential	: 0.059 kg CO_2-eq

UBC Process (Appendix J-2)

Capacity of Power Plant	: 48.67 MW

Type of Fuel	: Brown coal
Operational Time	: 300 days/year
Functional Unit	: Per ton capacity
Total greenhouse gas emissions potential	: 74.454kg CO2-eq

UBC Product Distribution (Appendix J-3)

a. *Domestic*

Type of Transportation	: Train locomotive CC 201
Train Capacity	: 1,050 tons UBC product
Type of Fuel	: Diesel
Total amount of fuel	: 827.232 l
Functional Unit	: Per ton capacity
Total greenhouse gas emissions potential	: 2.112kg CO_2-eq

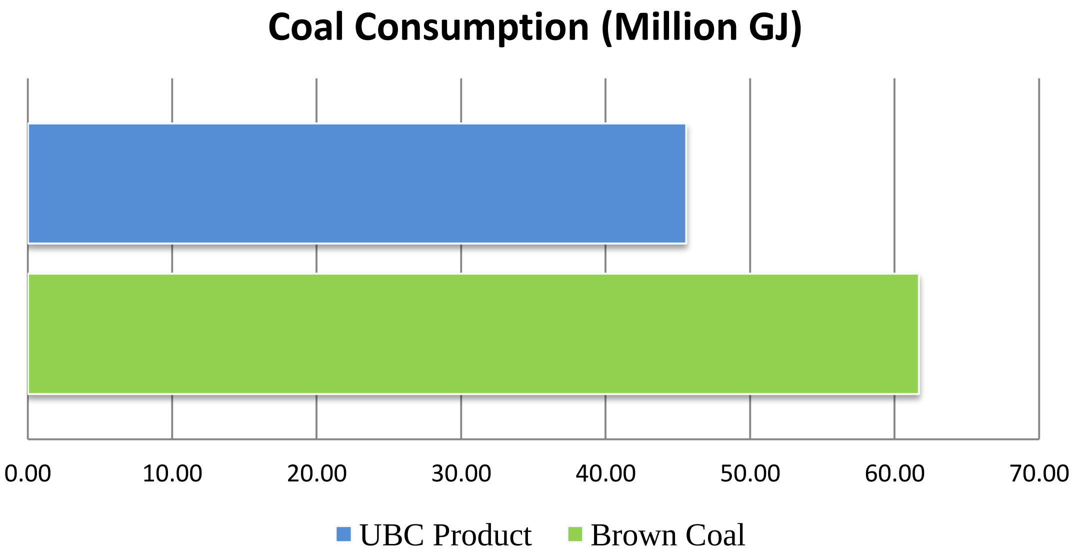
b. *Export*

Type of Transportation	: Train locomotive CC 205
Train Capacity	: 2,500 tons UBC product
Type of Fuel	: Diesel
Total amount of fuel	: 1,578.700
Functional Unit	: Per ton capacity
Total greenhouse gas emissions potential	: 1.6925kg CO_2-eq

The average efficiency of coal-fired generation in the OECD is 36% in 2002 compared with 30% in developing countries. As a result, one kilowatt-hour produced from coal in developing countries emits 20% more carbon dioxide than in industrialized countries [47]. UBC to reduce CO_2 emissions can increase the thermal efficiency of coal utilization by at least 2-3% on existing PC and possibly up to 5% [65]. The effects of an increase in efficiency from, for example, 28 % to 33 % could be a reduction in CO_2 emissions up to 15% [66]. If carried out at the mine, coal upgrading can also reduce the energy required for transportation of coal, and thus, the associated greenhouse emissions.

4.9 UBC Product Competitiveness

Brown coal and UBC product is fed to the boiler and burnt to generate steam. In this process, the moisture content of the coal contained within will determine the heat losses that occur. Its high content of moisture will cause a massive loss of heat that occurs so that the amount of coal used to generate electricity will increase. Two scenarios were applied to show the difference in the amount of coal needed to generate electricity with the same capacity, 660 MW ofpower plant. UBC product use can reduce feed consumption were used by 50% compared to the use of brown coal (Appendix K-1). This occurs because the process of UBC can lose almost 80% of the moisture contained in the brown coal so as to increase the efficiency of combustion.



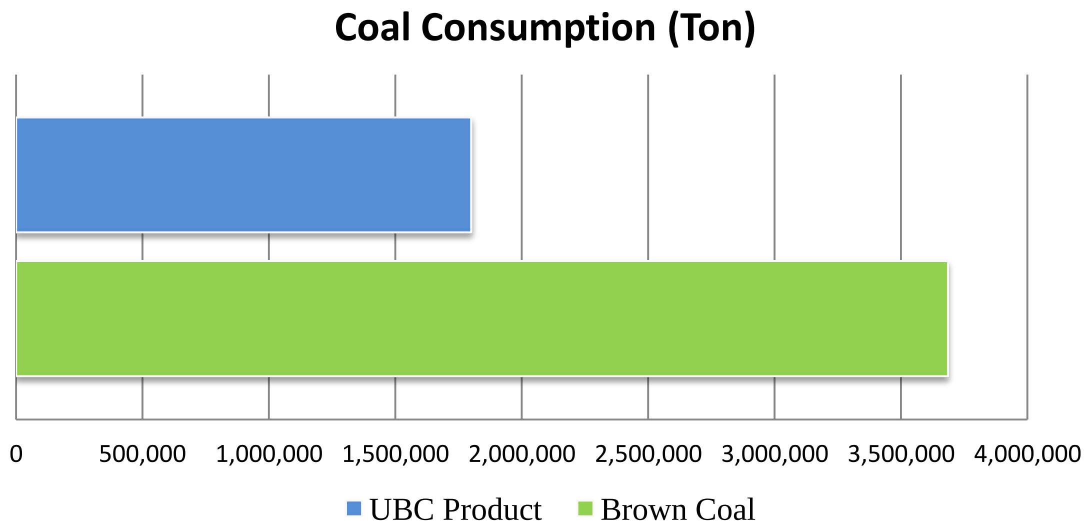


Figure 4.14 Brown Coal and UBC Product Consumption

Coal quality has a significant impact on many areas of power plant operation and performance, notably, capacity, heat rate, availability and maintenance [65]. Significant amounts of the energy in the coal are absorbed as heat to evaporate the water before any useful energy can be obtained and converted to electricity. The low quality of brown coal creates undesirable properties. Brown coal boilers need three to four times as much fuel to produce the same amount of electricity as black coal boilers. This is because of the high moisture content and low fuel value of brown coal. So the boiler plants where the coal is burnt are much larger than black coal boilers, with hundreds of kilometers of water and steam tubing [67]. Therefore, in order to generate electricity with the same amount, it would require the coal consumption as an energy input by different amounts. In addition, when viewed with the characteristics of different calorific values between brown coal and UBC product then by using of UBC product will save 50% of coal consumption in the mass basis (ton).

The upgrading of thermal coal is intended not only to improve its combustion properties, but to minimize the presence of abrasive and corrosive materials. These can affect pulverizes, classifiers, PC distribution pipes, heat exchanger tubes in the boiler and included draft fans. The presence of the mineral matter leads to fouling and slanging, cause reductions in the boiler thermal efficiency, and the possible longer-term damage to the heat exchangers [38].

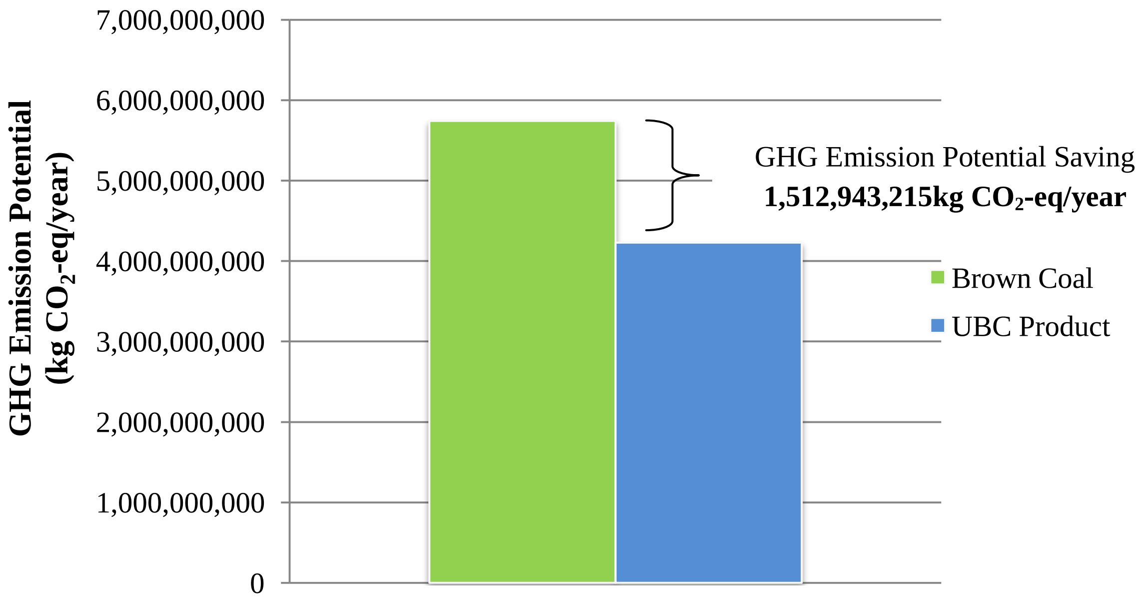


Figure 4.15 GHG Emission Potential (kg CO_2-eq/year)

Furthermore, if you will in terms of green house gas emissions potentially occur, it will be seen that the decrease of combustion of brown coal and UBC product. Net for greenhouse gas emission saving potential as calculated is equal to 1,140,674,415.29 kg CO_2-eq/year (Appendix K-2). Decrease in green house gas emission potential is often called global warming potential (GWP) does not occur with significant between combustion of brown coal or UBCproduct. This is consistent with the literature that has been mentioned previously that the UBC process will reduce green house gas emission potential of ± 5%

4.9.1 Suggested Strategies to Improve UBC Product Competitiveness

UBC product will competitive to be developed in Indonesia in the future with a record needs to be some development in the long run. As mentioned previously, if the UBC process can be developed to improve the quality of brown coal with calorific value lower than 3,500 kcal/kg, the UBC product will be much more competitive, because brown coal with a calorific value has not been widely used due to its low quality. This development will probably increase the costs of investment at the beginning but it can maintain the stability of the UBC process in the long run considering coal with calorific value above 3,500 kcal/kg already has its own market today. In addition, the development of the technology used in power plants can also improve combustion efficiency and reduce levels emissions formed. Currently GoI is being launched development of supercritical power plant in East Java that has not been commercially viable. Development and commercialization of some of supercritical power plant can be a driving force for the increased use of UBC product in Indonesia.

4.10 Energy Policy Improvements and Recommendations

Rubianto Indrayuda, the Deputy Director on Coal Mining Services in the MEMR, outlined that the key objectives of the National Coal Policy (NCP) was established by MEMR in 2004 [15]. NCP has the following principal objectives:

1. Coal production is to be increased to meet rapidly growing domestic demand
2. Coal production is also to be increased to exploit export opportunities and generate a significant and reliable flow of foreign exchange
3. Coal industry should be able to compete globally and offer an internationally competitive investment framework.
4. All quantities of coal reserves, including lower quality coals, are to be developed

5. Opportunities created by the development of the coal industry to provide economic and social development
6. An adequate supply of skilled manpower has to be ensured to staff the future expansion of the coal industry.
7. The growth of the coal industry has to be consistent with the concept of sustainable development. The environment has to be protected as well as the safety and the health of the industry labor force
8. A role of small-scale mine operators in the industry is to be maintained.

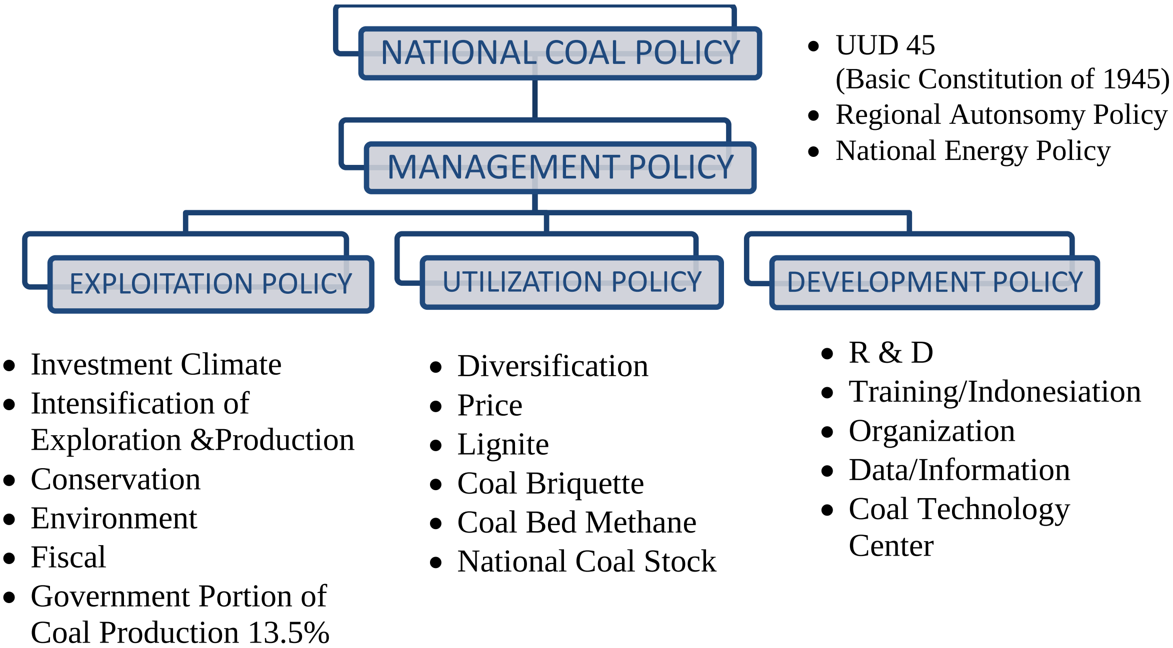


Figure 4.16 National Coal Policy (NCP)

UBC is one of the implementations to add the value of coal. The added value is one of the considerations taken in the Law No. 4/2009 concerning mineral and coalmining. Article 102 outlines that the holders of mining permit (IUP) and a special mining permit (IUPK), are required to increase the added value ofmineral resources and / or coal in the implementation of mining,processing and refining, as well as utilization of mineral and coal; Article 103 paragraph (1) and (2) explains that holders of mining permit(IUP) and a special mining permit (IUPK) required to process and refinethe results of its mine in the country, and can perform processing andrefining of other IUP and IUPK [68]. These tell us that how the important the increasing addedvalue is in coal mining business today and the future.

Several years ago, brown coal did not have a wide market due to high moisture content, low calorific value and tendency to generate greater total emissions. The high amount of using coal as an energy source during has led the high demand of coal, including brown coal so that coal with calorific value below 5000 cal/g starts to have its own market nowadays.

The mining that frequently occur nowadays is currently more focused on earning profits quickly even with small amounts, so that the coal that is obtained is directly sold without going through the added value process. A number of mining processes that should be controlled and owned by GoI goes poorly. GoI has regulation for coal mining in accordance with this, namely the President Regulation No.1 in 2014. In accordance with the foundation of government in the Constitution of 1945 Article 33, paragraph 3, which reads " *Earth, water and natural resources contained therein is controlled by the GoI and used for the prosperity of the people in Indonesia*" , if it can run properly then the mining process can be optimized and precisely target. Unfortunately, the implementation was not going well due to lack of supervision. Closer scrutiny of the mining that occurs is the key factor in increasing the possibility of direct sales of brown coal to the low price, then it can be enhanced its quality by the UBC process.

If the GoI could impose a more detailed policy, the mining companies would not exporting brown coal directly and increase the added value in accordance with the NCP above. It will be able to develop UBC process in the future. In addition, cooperation with PT. Bukit Asam as brown coal supplier also becomes very important. Cooperation between UBC plants with brown coal suppliers so as to obtain brown coal (feedstock) with cheaper price compared to its market price. The government's role as a link both of the two companies could generate an agreement that can give benefits to both companies.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

UBC process production costs with capacity 5,000,000 tons per year was found to be USD 92.35per ton UBC product or equal to USD 461.76 million per year. At that price, the UBC product is still competitive if we compare to the UBC selling price during 2010 – 2014. The UBC selling price was taken from sub bituminous coal which has same characteristics, USD 93.94 per ton. If seen briefly, the difference in production costs and the selling price per tons was very small. This is different after adjusting plant capacity and calculation of the economic feasibility of UBC plant itself.Annual Cash Flow (ACF) and Net Present Value (NPV) showed the positive value. Internal Rate of Return (IRR) was 9.36 %or 2.31% higher than Indonesian Government Bonds, which indicates that the ethanol plant is most likely economically feasible. Then, payback period (PBP) of this project was found to be 9 years of 20 years of lifetime project.

The feedstockcosts of brown coal and UBC selling price are the most important costs elements in the economic feasibility analysis. Both parts can be seen on the Indonesian Coal Index (ICI) as historical data from 2010 to 2014. From the sensitivity analysis it can be seen that the Brown Coal Competitive Price at Current Condition can be achievedat the current price of brown coal under USD 47.00. In terms of UBC selling price, it can be concluded that the project would that the project would be able to work well when the price of the product UBC is above USD 89.50 per ton. In this study, it was determined that the conversion of brown coal into UBC product is 82.23%. This conversion was expected that can be upgraded until 92%, then UBC process production costs may be reduced up to 6.44% than the estimated production costs.

The total green house gas emission potential that occurs in the transport section is divided into two UBC feedstock distribution and product distribution for both the domestic and export sales, 0.05914 kg CO_2-eq, 2.11160 kg CO_2-eq and 1.69252 kg CO_2-eq respectively. While at UBC process, emissions that occur during the process of power generation as energy source to run the process at UBC 74.45376kg CO_2-eq. The UBC process itself takes place in close and recycle system so it can be assumed almost no emissions formed during the process. In terms of product competitiveness UBC, BAU scenario (brown coal) and UBC scenario were applied to show the difference in the amount of coal needed to generate electricity with the same capacity. UBC product use can reduce feed consumption by 50% Compared to the use of brown coal. Furthermore, when compared with the greenhouse gas emission potential (GEP) which occurs between the two scenarios is the importance of the number 1,512,943,215 kg CO_2-eq as saving and CO_2-eq kg 1,140,674,415.29 as net saving.

The Government of Indonesia should pay attention to the mining sector and UBC process development sector to support the Energy Mix Targetby 2025. Only by the reduction in feedstock price, improvement in the UBC product conversion and also the prevention direct sales of brown coal, UBC process can be developed so that Indonesia can benefit greater in the long term.

5.2 Recommendations

Indonesia, which has large amounts of coal, greatly affects the selling price of coal on the world market. Currently GoI launched a more concentrated allocation policy to meet the needs of domestic compared to export to other countries. It was expected to maintain the stability of coal price and UBC product selling price itself. The quantity of goods with a large number of course would lead to decrease in the in the selling price of the item itself. A large amount of coal exported to other countries indirectly was lead to decrease the selling price of coal and gave impact on the selling price of the UBC product. This could reduce the sustainability of the development of the UBC process in Indonesia. It is expected that the long-term brown coal can be enhanced and improved selling prices to then maintain the stability of coal prices in the world market.

Assertiveness from the Government of Indonesia (GoI) is necessary in order to implement a coal policy that prohibits the direct export of low quality coal (brown coal) in order not to bring down the price of coal on the global market. Moreover, a tighter supervision in sales of coal is also sorely needed.

UBC development process is urgently needed for the sustainability of this process in the long term. One of them is to increase the yield of the generated UBC product be above 82%. Going forward, UBC process is expected to be applied to improve the quality of brown coal with less than 3,500 cal/g of calorific value which does not exis in international market.

UBC technology development can also reduce the production costs in the long term. UBC technology can be further developed to improve the quality of coal with a calorific value below 3,500 cal/g considering the price of brown coal with that quality that is much lower than the feedstock which is used in this study, 4,000 cal/g. Currently, coal with a calorific value below 3,500 cal/g is still very rarely used for domestic purposes and does not have a role in the international market yet.Therefore, cooperation and commitment that has been constructed together by the Indonesian Ministry of Energy and Mineral Resources (MEMR) and Kobe Steel Ltd has to be developed better in the future.

5.2 Recommendationsfor Future Studies

This study only represents a specific time interval, location, technology, feedstock and capacity. A further study needs to be conducted since this study has limited data based on the scopes of research work. This is due to the lack UBC commercial plant in the world. There was also some asks and equations of handbook to support the calculations in this study. In 2016, UBC commercial plant targeted has been running in Indonesia. Therefore, further studies are expected in order to get the actual commercial-scale plant for the data to count the costs of the life cycle of the plant UBC.The data can also be used to calculate demolish costs of UBC commercial plant which is not included in the scope of this study in order to get the all aspects of life cycle costs analysis as well.

A variation in capacity may change the investment and production costs of a UBC plant. By investigating a wide range of investment and production costs based on capacity, one may found the optimum capacity for a UBC plant that can be considered economically feasible and produce lower price.In addition, further studies are expected to include the salvage value of land used in the UBC plant so as to enhance revenue at the end of the UBC commercial plant project.

The amount of the added value of brown coal is being developed at this time is also expected to be a consideration for future studies. Life cycle costs are calculated can be compared with other technologies that are being developed primarily in developing countries that have the same standards. Different technologies or improvements may change the quality of added value processin the future.

In accordance with previous recommendations, the UBC process is expected to be developed to increase the value added to the brown coal with a heating value less than 3,500 cal/g. The differences in the characteristics of the feedstock will certainly result in differences UBC process itself. Therefore, the life cycle cost of the new technology applied to brown coal with lower quality is expected to be done in future studies.

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APPENDICES

APPENDIX A-1 Resources of Coal per Province in Indonesia in 2012 [16]

No.	Island	Province	Resources (million tons)				
			Hypothetical	Estimated	Designated	Measured	Total
1	Java	Banten	5.47	5.75	4.85	2.72	18.80
		Central Java	-	0.82	-	-	0.82
		East Java	-	0.08	-	-	0.08
2	**Sumatera**	Aceh	-	345.35	13.89	90.40	450.64
		North Sumatera	-	7.00	-	19.97	26.97
		Riau	12.79	216.19	626.38	896.48	1,751.84
		West Sumatera	20.41	294.50	231.16	249.45	795.52
		Jambi	494.04	765.37	698.66	424.63	2,382.70
		Bengkulu	-	2.12	118.81	71.14	192.07
		South Sumatera	**19,439.95**	**13,279.59**	**14,667.06**	**10,155.61**	**57,541.96**
		Lampung	-	106.95	-	0.94	107.89
3	Kalimantan	West Kalimantan	2.06	477.69	6.85	4.70	491.30
		Central Kalimantan	197.58	2,129.66	869.41	919.04	4,115.69
		South Kalimantan	-	3,692.82	3,349.75	3,377.18	10,619.76
		East Kalimantan	12,677.60	13,796.79	5,683.92	8,422.53	57,541.96
4	Sulawesi	South Sulawesi	-	48.81	129.22	53.09	231,12
		Central Sulawesi	-	1.98	-	-	1,98
5	Maluku	North Maluku	6.69	-	-	-	6.69
6	Papua	West Papua	93.66	32.82	-	-	126.48
		Papua	-	2.16	-	-	2.16
Total			***32,950.25***	***35,206.95***	***26,399.96***	***24,687.88***	***119.245.04***

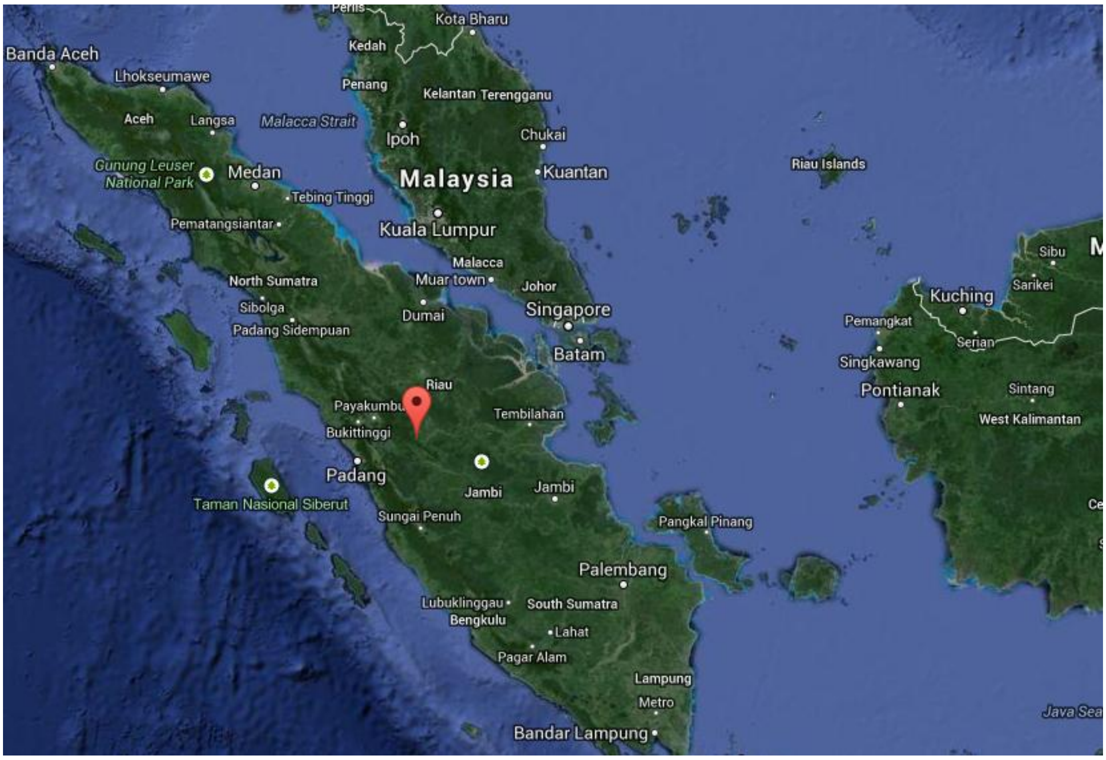
Source: Geological Agency of the Republic of Indonesia (2012)

APPENDIX A-2 Production of Mineral and Quarrying Materials by Commodity and Location in Sumatera Selatan Province, 2007 – 2011

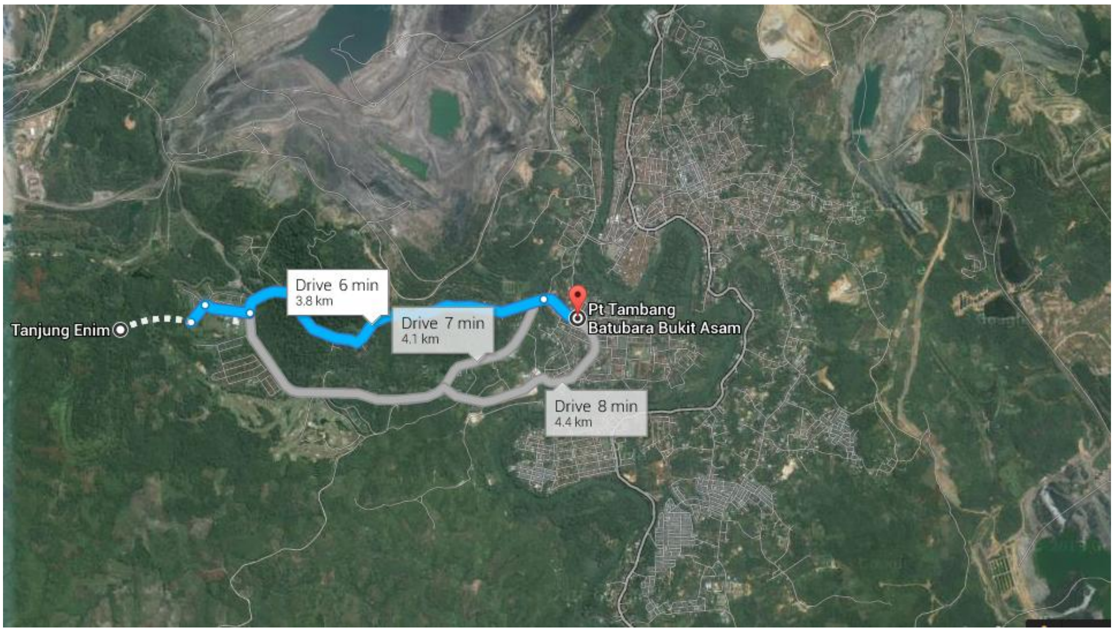
No	Commodity and Location	Unit	Production				
			2007	**2008**	**2009**	**2010**	**2011**
1.	*Crude Oil* Prabumulih, M.Enim, Muba, Lahat, OKU	10^3 Barel	28,340.05	27,933.07	20,716.76	25,407.06	12,130.04
2.	*Natural Gas* Prabumulih, M. Enim, Muba, Lahat, OKU	10^3 MMBTU	365,648.20	434,108.64	389,731.97	569,538.18	578,581.04
3.	***Coal*** **Tanjung Enim, M.Enim & Lahat**	**Tons**	**9,276,391**	**10,310,772**	**10,869,870**	**15,365,659.29**	**20,020,669.41**
4.	*Andesit* M.Enim, Lahat, OKU Timur, Linggau	M^3	188,020.00	25,697,95			
5.	*Clay* Muba, OKI, M.Enim, Lahat, OKU, Linggau	M^3	727,460.00	186,155.50			
6.	*Lime Stonse* OKU	Tons	450,829.00	638,874			
7.	Sand Muba, Ogan Ilir, OKI, M.Enim, Lahat, OKU, Linggau	M^3	539,344.00	471, 555.30			
8.	*Embankment* Muba, OKI, M.Enim, OKU, Linggau	M^3	177,199.00	1,332,672.90			
9.	*Stonse* Muba, OKI, M.Enim, Lahat, OKU, Linggau	M^3	108,520.00	59,163.90			
10.	*Sand Embankment* Muba & OKU Selatan	Tons	72,107.60	46,776.80			
11.	*Stonse* M.Enim & OKU Selatan	M^3	112,412.00	247,528.80			
12.	*Coral* M.Enim, OKU Selatan, Linggau	M^3	187,922.00	103,699.10			
13.	*Gravel* OKU Selatan	Tons	31,354.00	16,989.00			
14.	*Quart Sand* OKU	M^3		10,189.96			
15.	*Crushed Stonse* OKI & OKU Timur,	M^3	41,314.00	226,152.90			

Source: Representative Officer of Department of Mining and Energy in Sumatera Selatan Province

APPENDIX A-3 View of Plant Site Selection



South Sumatera



Plant Site Selection: Tanjung Enim

(15.8 km from PT. Bukit Asam as Brown Coal / Feedstock Supplier)

APPENDIX B-1 Specifications of Brown Coal Feedstock From Coal Mine Brand Production in PT. Bukit Asam

(Mine Brand TE 55 Minus)

No.	PARAMETER		RANGE	AVERAGE
1.	Total Moisture	(%, arb)	27.45 – 45.59	36.00
2.	Proximate Analysis			
	• Inherent Moisture	(%, adb)	15.30 – 17.40	16.10
	• Ash Content	(%, adb)	5.50 – 9.70	7.60
	• Volatile Matter	(%, adb)	37.80 – 40.00	38.89
	• Fixed Carbon	(%,adb)	37.80 – 39.90	37.90
3.	Calorific Value (CV)			
	• Gross Calorific Value	(kcal/kg, arb)	Max 5,200	4,000
4.	Total Sulfur (TS)	(%, arb)	0.37 – 1.01	0.57
5.	Ultimate Analysis	(%,adb)		
	• Carbon	(C)	53.39 – 58.09	56.91
	• Hydrogen	(H)	4.60 – 4.97	4.85
	• Nitrogen	(N)	0.53 – 0.62	0.59
	• Oxygen	(O)	27.72 – 30.99	28.98
6.	Ash Analysis (by weight)	(%,adb)		
	• Silicon Dioxide	(SIO_2)	53.70 – 67.60	61.37
	• Aluminum Oxide	(Al_2O_3)	11.58 – 23.63	18.26
	• Iron Oxide	(Fe_2O_3)	4.93 – 18.26	10.12
	• Calcium Oxide	(CaO)	1.48 – 7.26	4.07
	• Magnesium Oxide	(MgO)	0.58 – 2.90	1.51
	• Titanium Dioxide	(TiO_2)	0.75 – 0.84	0.81
	• Potassium Oxide	(K_2O)	0.56 – 0.65	0.60
	• Phosphorus Pentaoxide	(P_2O_5)	0.01 – 0.03	0.02
	• Sodium Oxide	(Na_2O)	0.18 – 0.68	0.39
	• Manganese Dioxide	(Mn_3O_4)	0.15 – 0.66	0.36
	• Sulfur Trioxide	(SO_3)	1.22 – 2.97	2.10
7.	Ash Fusion Temperature (reducing / Oxidizing)	^oC		
	• Deformation		1,065 – 1,341	1,210
	• Spherical		1,143 – 1,385	1,339
	• Hemisphere		1,155 – 1,391	1,347
	• Flow		1,225 – 1,413	1,390
8.	Hardgrave Grindability		45 – 48	46

Source: Keputusan Direksi PT.Bukit Asam (PERSERO) Tbk No.277/KEP/Int-0100/PR.08/2012, 2012

APPENDIX B-2 Specifications of Bituminous Coal from Coal Mine Brand Production in PT. Bukit Asam

(Mine Brand TE 63)

No.	PARAMETER		RANGE	AVARAGE
1.	Total Moisture	(%, arb)	19.47 – 28.52	25.00
2.	Proximate Analysis			
	• Inherent Moisture	(%, adb)	9.80 – 13.54	11.67
	• Ash Content	(%, adb)	2.58 – 6.27	4.43
	• Volatile Matter	(%, adb)	39.61 – 42.76	41.18
	• Fixed Carbon	(%,adb)	41.29 – 44.08	42.72
3.	Calorific Value (CV)			
	• Gross Calorific Value	(kcal/kg, arb)	6,001 – 6,400	6,174
4.	Total Sulfur (TS)	(%, arb)	0.28 – 1,87	0.67
5.	Ultimate Analysis	(%,adb)		
	• Carbon	(C)	51.78 – 68.29	62.56
	• Hydrogen	(H)	2.08 – 6.68	4.45
	• Nitrogen	(N)	0.16 – 0.95	0.64
	• Oxygen	(O)	23.56 – 33.40	27.25
6.	Ash Analysis (by weight)	(%,adb)		
	• Silicon Dioxide	(SIO_2)	35.54 – 68.29	44.24
	• Aluminum Oxide	(Al_2O_3)	15.85 – 37.31	28.82
	• Iron Oxide	(Fe_2O_3)	1.76 – 10.80	5.63
	• Calcium Oxide	(CaO)	0.43 – 7.08	3.62
	• Magnesium Oxide	(MgO)	0.34 – 3.63	1.67
	• Titanium Dioxide	(TiO_2)	0.69 – 1.46	1.05
	• Potassium Oxide	(K_2O)	0.25 – 0.41	0.34
	• Phosphorus Pentaoxide	(P_2O_5)	0.10 – 0.78	0.38
	• Sodium Oxide	(Na_2O)	0.78 – 6.15	3.16
	• Manganese Dioxide	(Mn_3O_4)	0.02 – 0.03	0.025
	• Sulfur Trioxide	(SO_3)	0.01 – 5.02	1.39
7.	Ash Fusion Temperature (reducing / Oxidizing)	^oC		
	• Deformation		1,118 – 1,502	1,310
	• Spherical		1,324 – 1,515	1,400
	• Hemisphere		1,358 – 1,535	1,435
	• Flow		1,402 – 1,535	1,477
8.	Hardgrave Grindabillity		48 – 55	52

Source: Keputusan Direksi PT.Bukit Asam (PERSERO) Tbk No.277/KEP/Int-0100/PR.08/2012, 2012

APPENDIX B-3 Coal Quality

(Brown Coal vs. UBC Coal)

DESCRIPTION		**Brown Coal**	**UBC COAL**
TOTAL MOISTURE	AR	36.0 %	8.3 %
PROXIMATE ANALYSIS			
Inherent Moisture	ADB	20.5 %	9.4 %
Ash Content	ADB	5.5 %	4.0 %
Volatile Matter	ADB	38.0 %	44.0 %
Fixed Carbon	ADB	36.0 %	42.6 %
PROXIMATE ANALYSIS			
Ash Content	AR	4.4 %	4.0 %
Volatile Matter	AR	30.6 %	44.5 %
Fixed Carbon	AR	29.0 %	43.2 %
CALORIFIC VALUE	AR		
Gross Calorific Value	ADB	5,031	5,979
Gross Calorific Value	AR	4,050	6,052
Total Sulfur (TS)	AR	0.57	0.58
ASH FUSION TEMPERATURE			
Reducing Atmosphere	°C	1,150	1,160
Initial Deformation	°C	1,170	1,170
Spherical	°C	1,200	1,180
Hemispherical	°C	1,230	1,220
Flow			
ASH FUSION TEMPERATURE			
Oxidizing Atmosphere			
Initial Deformation	°C	1,190	1,220
Spherical	°C	1,210	1,230
Hemispherical	°C	1,210	1,240
Flow	°C	1,240	1,270

Source: UBC Demonstration Plant, Satui, South Kalimantan

APPENDIX C-1 UBC Technology Overview

Source: UBC Demonstration Plant, Satui, Kalimantan

APPEDIX C-2 Equipment and Utility System of UBC Plant in Detail

Production Equipment of UBC Plant :

6. Section #100 – Coal Preparation
   Grinding mill (Coal crushing Process)

7. Section #200 – Slurry Dewatering
   Shell and tube-type evaporator at a temperature from 130 to 160°Cand under a pressure of 400 to 450 kPa

8. Section #300 – Coal-oil separation
   Continuous centrifugal separator (decanter)

9. Section #400 – Recycled Solvent (Coal-oil separation)
   Rotary steam tube dryer or Tubular steam dryer

10. Section #500 – Coal briquetting.
   The double roll type of briquetting machine

Utility Equipment of UBC Plant :

1. Equipment for treating raw water
2. A boiler (steam generation)
3. Equipment for cooling water
4. Equipment for producing nitrogen, for compressing air
5. Air compressor
6. Equipment for treating wastewater
7. A tank yard for storing light oil and heavy oil (asphalt)
8. Fire-fighting equipment.
9. Generator
10. Control System

Source: UBC Demonstration Plant, Satui, Kalimantan

APPENDIX D

INDONESIAN CURRENCY EXCHANGE PER USD

	2013	2014
January	9,763.2	12,165.0
February	9,662.5	11,578.5
March	9,612.5	11,240.0
April	9,722.5	11,555.0
May	9,795.0	11,430.5
June	9,925.0	
July	10,278.0	
August	11,254.5	
September	9,612.5	
October	11,272.5	
November	11,869.0	
December	12,160.5	

Average

1 USD = IDR 10,698.90 (Selected for calculation in this study)

Highest

1 USD = IDR 12,165.00 (January, 2014)

Lowest

1 USD = IDR 9,612.50 (September, 2013)

APPENDIX E
INVESTMENT COSTS OF UBC COMMERCIAL PLANT CALCULATION

E-1 Total Fixed Capital Investment Costs

Data from UBC Plan Commercial Plant (planning) in Indonesia:

Include with the construction of power plant with solid fuel (coal), capacity 14,6 MW (Coal & Energy Project, 2002)

<u>Data 2002 [A]</u>

1. Capacity of UBC plant: 1,500,000 tons/year
2. Exchange rate: USD 1 = IDR 9,200.00
3. Price Index (PI): 94.20 *(Price Index Data for Chemical Factory Japan)**
4. Plant Costs: USD 101,100,000.00 or IDR 930,120,000,000.00
   (Technology, construction, building, utility systems and other facilities costs)
5. The material to be used for construction from domestic (discount 15%), so that :
   Plant Costs: USD 85,935,000.00 or IDR 790,602,000,000.00

<u>Data 2007 [A]</u>

- Price Index (PI): 139.20 *(Price Index Data for Chemical Factory Japan)**
- Rate of Price index Increasing: 9.00

**Source: Japan Machinery Center for Trade and Investment, 2007*

<u>UBC Plant Investment Calculation:</u>

1. Capacity of UBC plant: 5,000,000 tons/year
2. Exchange rate: USD 1 = IDR 10,698.90
3. Price Index (PI): 202.20
   (Assumption that the Increasing of Price Index (PI) is equal with the increasing among 2002 – 2007)
4. Plant Costs: USD 622,026,444.41 or IDR 6,654,998,726,114.65
   (Technology, construction, building, utility systems and other facilities costs)

$$FCI = \left(\frac{PI\ (2015)}{PI\ (2002)} xFCI\ (2002)\right) x \left(\frac{UBCCapacity\ (2015)}{UBCCapacity\ (2002)}\right)$$

$$FCI = \left(\frac{202.20}{94.20} xUSD101{,}100{,}000.00\right) x \left(\frac{5{,}000{,}000 ton/year}{1{,}500{,}000 \text{ tons/year}}\right)$$

5. The material to be used for construction from domestic (discount 15%), so that :
   Plant Costs:USD 528,722,477.75 or IDR 5,656,748,917,197.45
6. Based on the older calculation that this fixed costsdoes not include the land costs. In detail this costs includes :

Plant Costs Elements	Percentage	IDR	USD
1. Engineering Costs	4%	226,269,956,687.90	21,148,899.11
2. Project Management Costs	4%	226,269,956,687.90	21,148,899.11
3. Procurement Equipment Costs a. Total equipment costs (80%) b. Electrical and Instrument costs (20%)	60%	3,394,049,350,318.47	317,233,486.65
4. Building and Construction Costs	30%	1,697,024,675,159.24	158,616,743.32
5. Commissioning Costs	2%	113,134,978,343.95	10,574,449.55
Total	**100%**	**5,656,748,917,197.45**	**528,722,477.75**

note

1) Procurement Equipment Costs
   a. Total equipment costs (80%) : USD 253,786,789.32 or IDR 2,715,239,480,254.78
   b. Electrical & Instrument costs (20%) : USD 63,446,697.33 or IDR 678,809,870,063.69
2) Building and Construction Costs
   a. Building costs : USD 23,491,387.72 or IDR 251,332,008,030.00
   (Detail building costs will describe below)
   Construction costs : USD 135,125,355.61 or IDR 1,445,692,667,129.24

$$TotalBuildingArea = GeneralFacility + OtherFacility$$

$$TotalBuildingArea = 8{,}177\ m^2 + 159{,}378\ m^2$$

$$TotalBuildingArea = 167.555 m^2$$

The land price is IDR 1,500,000.00 per m^2 since the plant is built in sub-urban area

$TotalLandCost = \ 167.555 m^2 x IDR 1{,}500{,}000.00$

$TotalLandCost = \ IDR\ 251{,}332{,}008{,}030\ or USD\ 23{,}491{,}387.72$

7. Land Costsing

   Data from another UBC Commercial Plant (Planning)

   Capacity of UBC plant : 1,000,000 tons/year

   Total Area Used : 10.29 ha or 102,875 m^2

$$TotalArea = \ \left(\frac{UBCCapacity\ (2015)}{UBCCapacity\ (planning)}\right) xTotalAreaUsed\ (Planning)$$

$$TotalArea = \ \left(\frac{5{,}000{,}000\ tons/year}{1{,}000{,}000\ tons/year}\right) x102{,}875\ m^2$$

$$TotalArea = \ 514{,}287\ m^2 or\ 51.43\ ha$$

   The land price is IDR 100,000,000.00 per ha since the plant is built in a sub-urbanarea

   $TotalLandCost = \ 51.43\ haxIDR\ 1{,}000{,}000.00$

   $TotalLandCost = \ IDR 5{,}142{,}869{,}000.00$ or USD 480,691.38

8. Total Fixed Capital Investment Costs (FCI)

   $FCI = PlantCost + LandCost$

   $FCI = USD\ 528{,}722{,}477.75 + \ USD\ 480{,}691.38$

   $FCI = USD\ 529{,}203{,}169.13\ orIDR\ 5{,}661{,}891{,}786{,}197.45$

E-2 Working Capital

WC = 5 % TCI

= USD 27,852,798.38 or IDR 297,994,304,536.71

E-3 Total Capital Investment Costs (TCI)

TCI = FCI + WCI

= 529,203,169.13 + 27,852,798.38

TCI = USD 557,055,967.50 or IDR 5,959,886,090,734.16

E-4 Annual Total Capital Investment

$$\boldsymbol{A = P\left[\frac{i(1+i)^n}{(1+i)^n-1}\right]}$$

Where, P (TCI) : USD 557,055,967.50

i (interest rate) : 7.5 %

n (year) : 20.00 years

A = 54,642,840.71 USD/year or 584,618,288,519.16 IDR/year

A= 10.93 USD/ton UBC product or 116,923.66 IDR/ton UBC product

APPENDIX F
UBC PLANT PRODUCTION COSTS CALCULATION (C_{TPC})

F-1 Feedstock Costs (C_F)

Feedstock is brown coal from PT. Bukit Asam with range of Calorific value of less than 5,200 kcal/kg(average 4,000 - 4,200). This follows is the historical data of brown coal price per tons from (2010 - 2013) IDR/ ton from ICI (Indonesian Coal Index). ICI reflects the spot price of five key grades of Indonesian coal — 6,500 (ICI 1), 5,800 (ICI 2), 5,000 (ICI 3), 4,200 (ICI 4) and 3,400 (ICI 5) kcal/kg GAR.

Table F-1 Brown Coal / Feedstock Historical Prices

	2010	**2011**	**2012**	**2013**	**2014**
January	-	51.74	52.02	42.72	40.28
February	42.15	58.02	53.01	43.05	39.66
March	41.64	56.04	53.56	43.79	38.18
April	41.61	57.48	50.45	43.13	37.24
May	44.03	55.59	48.95	41.75	36.72
June	46.29	56.20	46.61	41.55	
July	44.99	55.86	42.71	40.19	
August	44.21	55.42	41.45	38.05	
September	42.16	55.01	42.13	38.13	
October	43.28	56.29	42.05	38.00	
November	44.50	55.18	40.08	38.66	
December	47.88	53.47	40.22	39.60	

The minimum Brown Coal price : 392,863.61 IDR/tons or 36.72 US$/ton
The maximum Brown Coal price : 620,750.18 IDR/tons or 58.02 US$/ton
The average Brown Coal price : 476,998.11 IDR/tons or 44.58 US$/ton

The average brown coal price was selected as the feedstock price. Since yield of UBC product is 82.23%, so total feedstock price was found to be 580,110.72 IDR/tons UBC product or 54.22 USD/tons UBC product. Regarding to the capacity of UBC plant, total feedstock costs was calculated as 2,900,553,581,367.29 IDR/year or 271,107,644.84 USD/year.

F-2 Operating Costs (OC)

1. Raw Material Costs (RMC)

a) Asphalt was selling for 200 liter per drum with IDR 2,400,000 per drum. There was a cash back, IDR 1,000,000 per 5 drum asphalt.

b) Based on the UBC pilot plant in Palimanan, 0.006 tons / 6.24 liter / 0.03 drum asphalt was needed in order to produce 1 tons UBC product.

c) Then the raw material costs to produce 1 tons UBC product was found to be IDR 68,640.0 or USD 6.42.

d) Regarding the capacity of UBC Plant, 5,000,000 tons/year, so that the total raw material costs per year was calculated as IDR 343,200,000,000.00 or USD 32,078,064.10.

2. Operating Labor Costs

Table D-2 Estimated Total Employees in UBC Plant

POSITION	PERSON
President Director	1
Secretary of President Director	1
A. Engineering and Production Director	1
Secretary of Engineering and Production Director	1
1. Chief of Processing and Production	1
a. Section Head Process	1
▪ Control Operator	20
▪ Field Operator	40
b. Section Head Utility	1
▪ Control Operator	10
▪ Field Operator	15
2. Chief of Engineering and Maintenance	1
a. Section Head Maintenance and Workshop	1
▪ Workshop Staff	3
b. Section Head Instrument	1
▪ Instrument Operator	3
3. Chief of Research and Development	1
a. Section Head of Planning	1

▪ *Staff*	2
b. Section Head of Research and Development	1
▪ *Staff*	2
c. Section Head of Laboratory	1
▪ *Staff*	2
▪ Analyst	5
B. Marketing and Finance Director	1
Secretary of Marketing and Finance Director	1
1. Chief of Financial Officer	1
a. Section Head of Financial	1
▪ *Staff*	3
b. Section Head of Administration	1
▪ *Staff*	3
2. Chief of Marketing	1
a. Section Head of Sales	1
▪ *Staff*	3
b. Section Head of Promotion	1
▪ *Staff*	3
c. Section Head of Warehousing	1
▪ Warehouse Labor	5
C. General and Public Relations Director	1
Secretary of General Director	1
1. Chief of Human Resources and Public Relations	1
a. Section Head of Public Relations	1
▪ *Staff*	3
b. Section Head of Human Resources	1
▪ *Staff*	3
c. Section Head of Education and Training	1
▪ *Staff*	3
1. Chief of General Services	1
a. Section Head of Public Health	1
▪ Doctor	2
▪ Nurses	4

▪ *Staff*	3
b. Section Head of General Administration	1
▪ *Staff*	3
c. Section Head of Transportation	1
▪ Driver	8
d. Section Head of Security and Safety	1
▪ Firefighters	5
▪ Security	12
Total Employees	199

The following table describes the total operating labor costs in the UBC plant.

Table F-3 Estimated Salaries of UBC Plant staff

No.	Position	Person	Salary / month (IDR)	Total salary / month (IDR)
1	President Director	1	25,000,000.00	25,000,000.00
2	Director	3	20,000,000.00	60,000,000.00
4	Secretary of President Director	1	4,000,000.00	4,000,000.00
5	Secretary of Director	3	3,200,000.00	9,600,000.00
6	Chief	7	15,000,000.00	105,000,000.00
7	Section Head	19	13,500,000.00	256,500,000.00
9	Instrument Operator	3	4,000,000.00	12,000,000.00
10	Control Operator	30	5,000,000.00	150,000,000.00
11	Field Operator	55	3,000,000.00	165,000,000.00
12	Analyst	5	3,000,000.00	15,000,000.00
13	Doctor	2	6,000,000.00	12,000,000.00
14	Nurses	4	3,200,000.00	12,800,000.00
15	Staff	33	3,000,000.00	99,000,000.00
16	Workshop Staff	3	2,500,000.00	7,500,000.00
17	Warehouse Labor	5	2,500,000.00	12,500,000.00
18	Firefighters	5	2,800,000.00	14,000,000.00
19	Driver	8	2,000,000.00	16,000,000.00
20	Security	12	2,000,000.00	24,000,000.00
	Total	**199**		**999,900,000.00**

3. Utility Costs

UC = 5 % TPC

= 20,771,285.09 USD/year or 222,229,902,023.77 IDR/year

= 4.15 USD/ton UBC product or 44,445.98 IDR/ton UBC product

4. Maintenance and Repair Costs

MRC = 6 % FCI (Fixed Capital Investment)

= 6 % 529,203,169.13 USD

= 31,752,190.15 USD/year or 339,713,507,171.85 IDR/year

= 6.35 USD/ton UBC product or 67,942.70 IDR/ton UBC product

F-3 General Expenses (C_{GE})

1. Administrative costs (20% OL) = 242,991.34 USD/year

   (20 – 30% Operating Labor)

   = 2,599,740,000.00 IDR/year

2. Financing (0.1% TCI) = 557,055.97 USD/year

   (0 – 10% Total Capital Investment)

   = 5,959,886,090.73 IDR/year

Total General Expenses (GE) = 800,047.30 USD/year

= 8,559,626,090.73 IDR/year

F-4 Transportation Costs (C_T)

1. The location of the UBC plant is near the PT. Bukit Asam, so that truckscan be used to transport brown coal feed stock to the UBC plant

2. Train is used to transport the UBC product from UBC plant to port
3. Method in transportation is adopted from PT. Bukit Asam, which uses FOB (Free on Board) basis. Customers have their own truck or boat to transport UBC product in domestic or export. UBC plant only transport UBC product until the port or last terminal.

1. Transportation Costs Historical Data From PT. Bukit Asam (per ton coal)

Tanjung Enim – Kertapati Palembang. (±160.94 KM) / Pier (Domestic Activity)

2010	:	420	IDR/km	2011	:	472	IDR/km
2012	:	493	IDR/km	2013	:	515	IDR/km

By using the linear regressionmethod:

X	Y	X2	X.Y
2010	420	4,040,100	844,200
2011	472	4,044,121	949,192
2012	493	4,048,144	991,916
2013	515	4,052,169	1,036,695
8046	1,900	16,184,534	3,822,003

Slope (A) = 0.236170324 intercept (B) = -0.037737795

With this equation, y=Ax+B. Then, the data in 2015 was found to be 475.85 IDR/km

Tanjung Enim – Tarahan Bandar Lampung(± 409.52 KM) / Port (Exporting Activity)

2010	:	335	IDR/km	2011	:	344	IDR/km
2012	:	383	IDR/km	2013	:	397	IDR/km

By using the linear regression method:

X	Y	X2	X.Y
2010	335	4,040,100	673,350
2011	344	4,044,121	691,784
2012	383	4,048,144	770,596
2013	397	4,052,169	799,161
8046	1,459	16,184,534	2,934,891

Slope (A) = 0.181353024 intercepts (B) = -0.027738811

With this equation, y=Ax+B. Then, the data in 2015 was found to be 365.40 IDR/km

2. PT. Bukit Asam (feedstock supplier) - UBC Plant (Process)

Type of Transportation : Truck

Distance : 3.8 km

1 lt diesel fuel prices : IDR 5,500 for ±7 km

Costs (IDR/km/ton) : 787.71 IDR/km – per ton

Costs (IDR/ton) : $Cost\left(\frac{\frac{IDR}{km}}{ton}\right)xDistance$

: $787.71\ \left(\frac{\frac{IDR}{km}}{ton}\right)x\ 3.8\ km$

: 2,985.71 IDR/ton

Total Brown coal feed : 6,080,849.19 tons/year

Total Costs : $Cost\left(\frac{IDR}{ton}\right)xTotalbrowncoalfeed\left(\frac{ton}{year}\right)$

: $2{,}985.71\ \left(\frac{IDR}{ton}\right)x6{,}080{,}849.19\left(\frac{ton}{year}\right)$

: 18,155,678,300.36 IDR/year or
1,696,966.82 USD/year

3. UBC Plant (Process) - Pier (Kertapati,Palembang) : Domestic Activity

Type of Transportation : Train

Distance : 160.94 km

Costs (IDR/km/ton) : 475.85 IDR/km – per ton
(Calculation was shown in above)

Costs (IDR/ton) : $Cost\left(\frac{\frac{IDR}{km}}{ton}\right)xDistance$

: $475.85\ \left(\frac{\frac{IDR}{km}}{ton}\right)x160.94\ km$

: 76,582.57 IDR/ton

Total UBC Product : $65\%\ x\ 5{,}000{,}000\frac{ton}{year}$ (total product)

: 3,250,000.00 tons/year

Total Costs : $Cost\left(\frac{IDR}{ton}\right)xTotalbrowncoalfeed\left(\frac{ton}{year}\right)$

: $76{,}582.57\left(\frac{IDR}{ton}\right)x3{,}250{,}000.00\left(\frac{ton}{year}\right)$

: 248,893,349,711.96 IDR/year
23,263,452.29 USD/year

4. UBC Plant (Process) - Port (Tarahan, Lampung) : Exporting activity

Type of Transportation : Train

Distance : 409.52 km

Costs (IDR/km/ton) : 365.40 IDR/km – per ton

(Calculation was shown in above)

Costs (IDR/ton) : $Cost\left(\frac{\frac{IDR}{km}}{ton}\right)xDistance$

: $365.40\ \left(\frac{\frac{IDR}{km}}{ton}\right)x409.52\ km$

: 149,372.42 IDR/ton

Total UBC Product : $35\%\ x\ 5{,}000{,}000\frac{ton}{year}$ (total product)

: 1,750,000.00 tons/year

Total Costs : $Cost\left(\frac{IDR}{ton}\right)xTotalbrowncoalfeed\left(\frac{ton}{year}\right)$

: $149{,}372.42\left(\frac{IDR}{ton}\right)x1.750.000{,}00\ \left(\frac{ton}{year}\right)$

: 261,401,735,000.00 IDR/year

24,432,580.45 USD/year

5. Total Transportation Costs (C_T)

C_T = Feedstock transportation + Domestic Activity + Exporting Activity

= IDR 18,155,678,300.36 + IDR 248,893,349,711.96 + IDR 261,401,735,000.00

= 528,450,763,012.32 IDR/year

C_T = Feedstock transportation + Domestic Activity + Exporting Activity

= USD 1,696,966.82+ USD 23,263,452.29+ USD 24,432,580.45

= 49,392,999.56 USD/year

Then, the total transportation costsequals 105,690.15IDR/ton UBC product or 9.88 USD/ton UBC product

APPENDIX G
UBC PRODUCT SELLING PRICES

The UBC product is close to bituminous coal with calorific value greater than 6,000 cal/kg. This following is the historical data of coal price per ton from (2010 - 2013) IDR/ ton from ICI (Indonesian Coal Index). Based on the characteristics appendix B, ICI was categorized that UBC product as almost the same with Coal Pinang 6150 (Basis TM 14.5% - Ash - 5.5%, TS - 0.6% and GCV (GAR) 6200 Kcal/kg)

Table G-1 Historical Coal Prices with Selected Characteristics

	2010	2011	2012	2013	2014
January	-	111.32	109.56	88.82	83.43
February	87.86	125.31	111.75	89.58	82.03
March	86.74	120.89	112.98	91.24	78.76
April	86.69	121,71	109.56	89.78	76.77
May	91.92	117.50	102.72	86.70	75.71
June	96.84	118.86	97.50	86.26	-
July	96.30	118.11	88.82	83.23	-
August	94.56	117.12	86.05	78.46	-
September	90.00	116.21	87.54	78.65	-
October	92.51	119.06	87.38	78.38	-
November	95.21	116.59	82.99	79.83	-
December	102.75	112.79	83.29	81.91	-

The minimum coal price : 810,013.72 IDR/ton or 75.71 USD/ton
The maximum coal price : 1,340,679.16 IDR/ton or 125.31 USD/ton
The average coal price : 1,005,042.32 IDR/ton or 93.94 USD/ton

The average coal price was selected as the UBC product price. This price was multiplying with capacity of UBC plant (5,000,000 tons/year) in order to calculate total income. The total income of this company was calculated as 5,025,211,605,576.92 IDR/year or 469,694,230.77 USD/year.

APPENDIX H. Net Cash Flow Analysis, Net Present Value, Internal Rate of Return and Payback Period

Costs Elements (USD)	**Construction Period**	**Operational Period**			
	0	**1**	**2**	**3**	**4**
Investment Costs					
Initial Investment	557,055,967.50				
Feedstock Costs (F)		271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84
Operating Costs (OC)		85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01
Raw Material		32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10
Operating Labors		20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09
Utilities		6,504,526.51	6,504,526.51	6,504,526.51	6,504,526.51
Maintenance		31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15
General Expenses (GE)		800,047.30	800,047.30	800,047.30	800,047.30
Administrative Costs		242,991.34	242,991.34	242,991.34	242,991.34
Financing		557,055.97	557,055.97	557,055.97	557,055.97
Transportation Costs (T)		49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56
Total Expenses	557,055,967.50	407,117,187.72	407,117,187.72	407,117,187.72	407,117,187.72
Total Income	0.00	469,694,230.77	469,694,230.77	469,694,230.77	469,694,230.77
Net Cash Flow	-557,055,967.50	62,577,043.05	62,577,043.05	62,577,043.05	62,577,043.05
Net Present Value (NPV)	**USD 80,885,157.17**				
Internal Rate of Return (IRR)	**9.36 %**				
Payback Period (PP)	**9 years**				

APPENDIX H. Net Cash Flow Analysis, Net Present Value, Internal Rate of Return and Payback Period (Cont')

Costs Elements (USD)	Operational Period				
	5	6	7	8	9
Investment Costs					
Initial Investment					
Feedstock Costs	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84
Operating Costs	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01
Raw Material	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10
Operating Labors	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09
Utilities	6,504,526.51	6,504,526.51	6,504,526.51	6,504,526.51	6,504,526.51
Maintenance	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15
General Expenses	800,047.30	800,047.30	800,047.30	800,047.30	800,047.30
Administrative Costs	242,991.34	242,991.34	242,991.34	242,991.34	242,991.34
Financing	557,055.97	557,055.97	557,055.97	557,055.97	557,055.97
Transportation Costs	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56
Total Expenses	407,117,187.72	407,117,187.72	407,117,187.72	407,117,187.72	407,117,187.72
Total Income	469,694,230.77	469,694,230.77	469,694,230.77	469,694,230.77	469,694,230.77
Net Cash Flow	62,577,043.05	62,577,043.05	62,577,043.05	62,577,043.05	62,577,043.05

APPENDIX H. Net Cash Flow Analysis, Net Present Value, Internal Rate of Return and Payback Period (Cont')

Costs Elements (USD)	Operational Period				
	10	11	12	13	14
Investment Costs					
Initial Investment					
Feedstock Costs	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84
Operating Costs	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01
Raw Material	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10
Operating Labors	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09
Utilities	6,504,526.51	6,504,526.51	6,504,526.51	6,504,526.51	6,504,526.51
Maintenance	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15
General Expenses	800,047.30	800,047.30	800,047.30	800,047.30	800,047.30
Administrative Costs	242,991.34	242,991.34	242,991.34	242,991.34	242,991.34
Financing	557,055.97	557,055.97	557,055.97	557,055.97	557,055.97
Transportation Costs	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56
Total Expenses	407,117,187.72	407,117,187.72	407,117,187.72	407,117,187.72	407,117,187.72
Total Income	469,694,230.77	469,694,230.77	469,694,230.77	469,694,230.77	469,694,230.77
Net Cash Flow	62,577,043.05	62,577,043.05	62,577,043.05	62,577,043.05	62,577,043.05

APPENDIX H. Net Cash Flow Analysis, Net Present Value, Internal Rate of Return and Payback Period (Cont')

Costs Elements (USD)	Operational Period					
	15	16	17	18	19	20
Investment Costs						
Initial Investment						
Feedstock Costs	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84
Operating Costs	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01
Raw Material	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10
Operating Labors	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09
Utilities	6,504,526.51	6,504,526.51	6,504,526.51	6,504,526.51	6,504,526.51	6,504,526.51
Maintenance	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15
General Expenses	800,047.30	800,047.30	800,047.30	800,047.30	800,047.30	800,047.30
Administrative Costs	242,991.34	242,991.34	242,991.34	242,991.34	242,991.34	242,991.34
Financing	557,055.97	557,055.97	557,055.97	557,055.97	557,055.97	557,055.97
Transportation Costs	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56
Total Expenses	407,117,187.72	407,117,187.72	407,117,187.72	407,117,187.72	407,117,187.72	407,117,187.72
Total Income	469,694,230.77	469,694,230.77	469,694,230.77	469,694,230.77	469,694,230.77	469,694,230.77
Net Cash Flow	62,577,043.05	62,577,043.05	62,577,043.05	62,577,043.05	62,577,043.05	62,577,043.05

APPENDIX I-1 UBC Product Production Costs Based on the Variation of Brown Coal Price

Costs Elements (USD/year)		Brown Coal Price / Feedstock Price (USD/ton)				
		35.00	**38.00**	**41.00**	**44.00**	**47.00**
1	**Investment Costs**	54,642,840.71	54,642,840.71	54,642,840.71	54,642,840.71	54,642,840.71
2	**Feedstock Costs**	212,829,721.70	231,072,269.28	249,314,816.85	267,557,364.43	285,799,912.00
3	**Operating Costs**	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01
	Raw Material	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10
	Operating Labors	1,214,956.68	1,214,956.68	1,214,956.68	1,214,956.68	1,214,956.68
	Utilities	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09
	Maintenance	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15
4	**General Expenses**	800,047.30	800,047.30	800,047.30	800,047.30	800,047.30
	Administrative Costs	242,991.34	242,991.34	242,991.34	242,991.34	242,991.34
	Financing	557,055.97	557,055.97	557,055.97	557,055.97	557,055.97
5	**Transportation Costs**	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56
6	**Total Production Costs (USD/year)**	403,482,105.30	421,724,652.87	439,967,200.44	458,209,748.02	476,452,295.59
7	**UBC Product Capacity (ton/year)**	5,000,000.00				
8	**Net Production Costs (USD/ton UBC Product)**	80.70	84.34	87.99	91.64	95.29
9	**UBC Selling Prices (USD/ton)**	93.94				

APPENDIX I-1 Product Production Costs Based on the Variation of Brown Coal Price (Cont')

Costs Elements (USD/year)		Brown Coal Price / Feedstock Price (USD/ton)				
		50.00	**53.00**	**56.00**	**59.00**	**62.00**
1	**Investment Costs**	54,642,840.71	54,642,840.71	54,642,840.71	54,642,840.71	54,642,840.71
2	**Feedstock Costs**	304,042,459.58	322,285,007.15	340,527,554.72	358,770,102.30	377,012,649.87
3	**Operating Costs**	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01
	Raw Material	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10
	Operating Labors	1,214,956.68	1,214,956.68	1,214,956.68	1,214,956.68	1,214,956.68
	Utilities	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09
	Maintenance	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15
4	**General Expenses**	800,047.30	800,047.30	800,047.30	800,047.30	800,047.30
	Administrative Costs	242,991.34	242,991.34	242,991.34	242,991.34	242,991.34
	Financing	557,055.97	557,055.97	557,055.97	557,055.97	557,055.97
5	**Transportation Costs**	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56
6	**Total Production Costs (USD/year)**	494,694,843.17	512,937,390.74	531,179,938.32	549,422,485.89	567,665,033.47
7	**UBC Product Capacity (ton/year)**	5,000,000.00				
8	**Net Production Costs (USD/ton UBC Product)**	98.94	102.59	106.24	109.88	113.53
9	**UBC Selling Prices (USD/ton)**	93.94				

APPENDIX I-2 Net Cash Flow Based on the Variation of UBC Product Selling Prices

No	Costs Elements (USD/year)	UBC Product Selling Prices (USD/ton)				
		70.00	**76.00**	**82.00**	**88.00**	**94.00**
1	**Investment Costs**	54,642,840.71	54,642,840.71	54,642,840.71	54,642,840.71	54,642,840.71
2	**Feedstock Costs**	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84
3	**Operating Costs**	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01
	Raw Material	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10
	Operating Labors	1,214,956.68	1,214,956.68	1,214,956.68	1,214,956.68	1,214,956.68
	Utilities	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09
	Maintenance	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15
4	**General Expenses**	800,047.30	800,047.30	800,047.30	800,047.30	800,047.30
	Administrative Costs	242,991.34	242,991.34	242,991.34	242,991.34	242,991.34
	Financing	557,055.97	557,055.97	557,055.97	557,055.97	557,055.97
5	**Transportation Costs**	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56
6	**Total Production Costs (USD/year)**	461,760,028.43	461,760,028.43	461,760,028.43	461,760,028.43	461,760,028.43
7	**UBC Product Capacity (Ton/year)**	5,000,000.00				
8	**Total Production Costs (USD/ton UBC Product)**	89.50				
9	**Net Cash Flow (USD)**	-22.35	-16.35	-10.35	-4.35	1.65

APPENDIX I-2 Net Cash Flow Based on the Variation of UBC Product Selling Prices (Cont')

No	Costs Elements (USD/year)	UBC Product Selling Prices (USD/ton)				
		100.00	**106.00**	**112.00**	**118.00**	**125.00**
1	**Investment Costs**	54,642,840.71	54,642,840.71	54,642,840.71	54,642,840.71	54,642,840.71
2	**Feedstock Costs**	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84	271,107,644.84
3	**Operating Costs**	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01	85,816,496.01
	Raw Material	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10	32,078,064.10
	Operating Labors	1,214,956.68	1,214,956.68	1,214,956.68	1,214,956.68	1,214,956.68
	Utilities	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09	20,771,285.09
	Maintenance	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15	31,752,190.15
4	**General Expenses**	800,047.30	800,047.30	800,047.30	800,047.30	800,047.30
	Administrative Costs	242,991.34	242,991.34	242,991.34	242,991.34	242,991.34
	Financing	557,055.97	557,055.97	557,055.97	557,055.97	557,055.97
5	**Transportation Costs**	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56	49,392,999.56
6	**Total Production Costs (USD/year)**	461,760,028.43	461,760,028.43	461,760,028.43	461,760,028.43	461,760,028.43
7	**UBC Product Capacity (Ton/year)**	5,000,000.00				
8	**Total Production Costs (USD/ton UBC Product)**	89.50				
9	**Net Cash Flow (USD)**	7.65	13.65	19.65	25.65	32.65

APPENDIX I-3 Production Costs of UBC Product Based on the Variation of Interest Rate

Costs Elements (USD/year)		Brown Coal Price / Feedstock Price (USD/ton)									
		35.00	38.00	41.00	44.00	47.00	50.00	53.00	56.00	59.00	62.00
Interest Rate : 2%											
1	Investment Costs	6.81	6.81	6.81	6.81	6.81	6.81	6.81	6.81	6.81	6.81
	Feedstock Costs (F)	42.57	46.21	49.86	53.51	57.16	60.81	64.46	68.11	71.75	75.40
	Operating Costs (O)	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16
	General Expenses (GE)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	Transportation Costs (T)	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88
	Total Production Costs (USD/ton UBC product)	**76.58**	**80.23**	**83.88**	**87.53**	**91.18**	**94.82**	**98.47**	**102.12**	**105.77**	**109.42**
	UBC Selling Prices (USD/ton)	**93.94**									
	Net Cash Flow (USD)	**17.36**	**13.71**	**10.06**	**6.41**	**2.76**	**-0.88**	**-4.53**	**-8.18**	**-11.83**	**-15.48**
Interest Rate : 4%											
2	Investment Costs	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20
	Feedstock Costs (F)	42.57	46.21	49.86	53.51	57.16	60.81	64.46	68.11	71.75	75.40
	Operating Costs (O)	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16
	General Expenses (GE)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	Transportation Costs (T)	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88
	Total Production Costs (USD/ton UBC product)	**77.97**	**81.61**	**85.26**	**88.91**	**92.56**	**96.21**	**99.86**	**103.51**	**107.15**	**110.80**
	UBC Selling Prices (USD/ton)	**93.94**									
	Net Cash Flow (USD)	**15.97**	**12.33**	**8.68**	**5.03**	**1.38**	**-2.27**	**-5.92**	**-9.57**	**-13.21**	**-16.86**

APPENDIX I-3 Production Costs of UBC Product Based on the Variation of Interest Rate (Cont')

Costs Elements (USD/year)		Brown Coal Price / Feedstock Price (USD/ton)									
		35.00	38.00	41.00	44.00	47.00	50.00	53.00	56.00	59.00	62.00
Interest Rate : 6%											
3	Investment Costs	9.71	9.71	9.71	9.71	9.71	9.71	9.71	9.71	9.71	9.71
	Feedstock Costs (F)	42.57	46.21	49.86	53.51	57.16	60.81	64.46	68.11	71.75	75.40
	Operating Costs (O)	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16
	General Expenses (GE)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	Transportation Costs (T)	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88
	Total Production Costs (USD/ton UBC product)	**79.48**	**83.13**	**86.78**	**90.43**	**94.08**	**97.72**	**101.37**	**105.02**	**108.67**	**112.32**
	UBC Selling Prices (USD/ton)	**93.94**									
	Net Cash Flow (USD)	**14.46**	**10.81**	**7.16**	**3.51**	**-0.14**	**-3.78**	**-7.43**	**-11.08**	**-14.73**	**-18.38**
Interest Rate : 8%											
4	Investment Costs	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35
	Feedstock Costs (F)	42.57	46.21	49.86	53.51	57.16	60.81	64.46	68.11	71.75	75.40
	Operating Costs (O)	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16
	General Expenses (GE)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	Transportation Costs (T)	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88
	Total Production Costs (USD/ton UBC product)	**81.12**	**84.76**	**88.41**	**92.06**	**95.71**	**99.36**	**103.01**	**106.65**	**110.30**	**113.95**
	UBC Selling Prices (USD/ton)	**93.94**									
	Net Cash Flow (USD)	**12.82**	**9.18**	**5.53**	**1.88**	**-1.77**	**-5.42**	**-9.07**	**-12.71**	**-16.36**	**-20.01**

APPENDIX I-3 Production Costs of UBC Product Based on the Variation of Interest Rate (Cont')

	Costs Elements (USD/year)	Brown Coal Price / Feedstock Price (USD/ton)									
		35.00	38.00	41.00	44.00	47.00	50.00	53.00	56.00	59.00	62.00
Interest Rate : 10%											
5	Investment Costs	13.09	13.09	13.09	13.09	13.09	13.09	13.09	13.09	13.09	13.09
	Feedstock Costs (F)	42.57	46.21	49.86	53.51	57.16	60.81	64.46	68.11	71.75	75.40
	Operating Costs (O)	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16
	General Expenses (GE)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	Transportation Costs (T)	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88
	Total Production Costs (USD/ton UBC product)	**82.85**	**86.50**	**90.15**	**93.80**	**97.45**	**101.10**	**104.75**	**108.39**	**112.04**	**115.69**
	UBC Selling Prices (USD/ton)	**93.94**									
	Net Cash Flow (USD)	**11.09**	**7.44**	**3.79**	**0.14**	**-3.51**	**-7.16**	**-10.81**	**-14.45**	**-18.10**	**-21.75**
Interest Rate : 12%											
6	Investment Costs	14.92	14.92	14.92	14.92	14.92	14.92	14.92	14.92	14.92	14.92
	Feedstock Costs (F)	42.57	46.21	49.86	53.51	57.16	60.81	64.46	68.11	71.75	75.40
	Operating Costs (O)	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16	17.16
	General Expenses (GE)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
	Transportation Costs (T)	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88
	Total Production Costs (USD/ton UBC product)	**84.68**	**88.33**	**91.98**	**95.63**	**99.28**	**102.93**	**106.57**	**110.22**	**113.87**	**117.52**
	UBC Selling Prices (USD/ton)	**93.94**									
	Net Cash Flow (USD)	**9.26**	**5.61**	**1.96**	**-1.69**	**-5.34**	**-8.99**	**-12.63**	**-16.28**	**-19.93**	**-23.58**

APPENDIX J
GREENHOUSE GAS EMISSION (GHG) CALCULATION

J-1 Feedstock Distribution

Type of Transportation	: Truck
Truck Capacity	: 30 tons brown coal/truck
UBC product yield	: 82%
Type of Fuel	: Diesel
Amount of Fuel	: 0.143 l/km
Distance	: 3.8 km
Total amount of fuel	: 0.543 l
	: 0.022 l (per ton UBC product)
Functional Unit	: Per ton capacity
Diesel Density	: 0.840 kg/l
Net Calorific Values (NCV)	: 43.000.00 TJ/Gg
	: 0.043 TJ/ton

Table J-1.1 Emission Factors for Road Transportation (Diesel) [A]

No	Substances	Emission Factors	Sources
1.	CO_2	74,100 kg/TJ	IPPCC Emission Factor Database (EFDB,vol1)
2.	CH_4	3.9 kg/TJ	EEA (2005a)
3.	N_2O	3.9 kg/TJ	EEA (2005a)

Based on Equation 3.13, we can conclude that tthe total emissions are as follows:

Table J-1.2 Total Emissions

No	Substances	Emissions
1.	CO_2	0.059kg CO_2
2.	CH_4	0.000kg CH_4
3.	N_2O	0.000kg N_2O

Table J-1.3 Greenhouse Gas Emission Potential

No	Substances	Impact Categories (IPCC, 2007)	Total kg CO_2 eq
1.	CO_2	1 kg CO_2-eq/kg	0.059
2.	CH_4	25 kg CO_2-eq/kg	0.000
Total			**0.059**

J-2 UBC Process

UBC Plant Capacity : 5,000,000 tons
Capacity of Power Plant : 48.67 MW
Fuel : Brown coal
Operation Time : 300 days/year
: 7,200 hr/years
Power : 315,360.00 MWh
315,360,000.00 kWh

Table J-2.1 Greenhouse Gas Emission Potential with LEAP program

	Coal Consumption (Million Giga Joule)	**CO_2** (Thousand metric ton)	**SO_2** (Thousand metric ton)	**N_2O** (Metric ton)	**No_x** (Thousand metric ton)
Brown Coal	4.00	370.60	0.14	5.60	1.20

Table J-2.2 Total Emissions

	CO_2 (Thousand metric ton)	**SO_2** (Thousand metric ton)	**N_2O** (Metric ton)	**No_x** (Thousand metric ton)
Brown Coal	370,600,000.00	141,000.00	5,600.00	1,200,000.00

Table J-2.3 Greenhouse Gas Emission Potential for Brown Coal

No	Substances	Impact Categories (IPCC, 2007)	Total kg CO_2-eq
1.	CO_2	1 kg CO_2-eq/kg	370,600,000
2.	N_2O	298 kg CO_2-eq/kg	1,668,800
Total			**372,268,800**
74.454kg CO_2-eq/ton UBC product			

J-3 UBC Product Distribution

c. Domestic

Type of Transportation : Train locomotive Seri CC 201
Amount of Carriage : 35 carriage/train
Carriage Capacity : 30 tons UBC product/carriage
Train Capacity : 1,050 tons UBC product
Type of Fuel : Diesel
Amount of Fuel : 5.14/km
Distance : 160.940 km
Total amount of fuel : 827.232 l
: 0.788 (per ton UBC product)
Functional Unit : Per ton capacity
Density Diesel : 0.840 kg/l
Net Calorific Values (NCV) : 43.000.00 TJ/Gg
: 0.043 TJ/ton

Table J-3.1 Emission Factors for Locomotives (Diesel) [A]

No	Substances	Emission Factor	Sources
1.	CO_2	74,100 kg/TJ	IPPCC Emission Factor Database (EFDB,vol1)
2.	CH_4	4.15 kg/TJ	EEA (2005a)
3.	N_2O	28.6 kg/TJ	EEA (2005a)

Based on Equation 3.13, we can conclude that the total emissions are as follows:

Table J-3.2 Total Emissions

No	Substances	Emissions
1.	CO_2	2.109kg CO_2
2.	CH_4	0.000kg CH_4
3.	N_2O	0.000kg N_2O

Table J-3.3 Greenhouse Gas Emission Potential

No	Substances	Impact Categories (IPCC, 2007)	Total kg CO_2 eq
1.	CO_2	1 kg CO_2-eq/kg	2.109
2.	CH_4	25 kg CO_2-eq/kg	0.003
Total			**2.112**

d. Export

Type of Transportation : Train locomotive Seri CC 205

Amount of Carriage : 50 carriages /train

Carriage Capacity : 50 tons UBC product/carriage

Train Capacity : 2,500 tons UBC product

Type of Fuel : Diesel

Amount of Fuel : 3.855/km

Distance : 409.520km

Total amount of fuel : 1,578.700

: 0.631 (per ton UBC product)

Functional Unit : Per ton capacity

Density Diesel : 0.840 kg/l

Net Calorific Values (NCV) : 43.000.00 TJ/Gg

: 0.043 TJ/ton

Table J-3.4 Emission Factors for Locomotives (Diesel) [A]

No	Substances	Emission Factor	Sources
1.	CO_2	74,100 kg/TJ	IPPCC Emission Factor Database (EFDB,vol1)
2.	CH_4	4.15 kg/TJ	EEA (2005a)
3.	N_2O	28.6 kg/TJ	EEA (2005a)

Based on Equation 3.13, we can conclude that the total emissions are as follows:

Table J-3.5 Total Emissions

No	Substances	Emissions
1.	CO_2	1.690kg CO_2
2.	CH_4	0.000kg CH_4
3.	N_2O	0.001kg N_2O

Table J-3.6 Greenhouse Gas Emission Potential

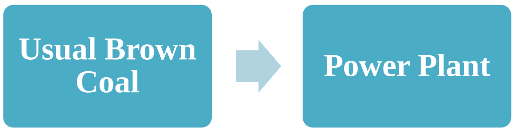
No	Substances	Impact Categories (IPCC, 2007)	Total kg CO_2-eq
1.	CO_2	1 kg CO_2-eq/kg	1.690
2.	CH_4	25 kg CO_2-eq/kg	0.002
Total			**1.692**

APPENDIX K

UBC PRODUCT COMPETITIVENESS CALCULATION

Capacity of Power Plant	: 660 MW
Operation Time	: 365 days/year
	: 8,760 hr/year
Power	: 5,203,440.00 MWh
	: 5,203,440,000.00 kWh

1. *BAU (Business as Usual) Scenario*



2. *UBC Process Scenario*

By using the LEAP Program:

Table K Brown Coal and UBC Product

	Coal Consumption (Million Giga Joule)	**CO_2** (Thousand metric ton)	**SO_2** (Thousand metric ton)	**N_2O** (Metric ton)	**No_x** (Thousand metric ton)
Brown Coal	61.68	5,714.14	43.51	86.35	18.50
UBC	45.58	4,222.85	12.62	13.67	13.67

K-1 Total Emissions

Table K-1 Total Emissions

	CO_2 (Thousand metric ton)	**SO_2** (Thousand metric ton)	**N_2O** (Metric ton)	**No_x** (Thousand metric ton)
Brown Coal	5,714,135,450.89	43,512,754.09	86,349.65	18,503,496.50
UBC	4,222,849,454.67	12,615,004.31	13,674.42	13,674,418.60

Table K-2 Greenhouse Gas Emission Potential for Brown Coal

No	**Substances**	**Impact Categories (IPCC, 2007)**	**Total kg CO_2-eq**
1.	CO_2	1 kg CO_2-eq/kg	5,714,135,450.89
2.	N_2O	298 kg CO_2-eq/kg	25,732,195.80
Total			**5,739,867,647.70**
1.103 kg CO_2-eq/kWh			

Table K-2 Greenhouse Gas Emission Potential for UBC Product

No	**Substances**	**Impact Categories (IPCC, 2007)**	**Total kg CO_2-eq**
1.	CO_2	1 kg CO_2-eq/kg	4,222,849,454.67
2.	N_2O	298 kg CO_2-eq/kg	4,074,976.74
Total			**4,226,924,431.41**
0.812 kg CO_2-eq/kWh			

GHG emission potentialsavings: 1,512,943,215 kg CO2-eq/year

Nett Greenhouse Emissions Potential Savings

= GEP saving- GEP to run UBC Process

= 1,140,674,415.29 kg CO2-eq/year

K-2 Coal Consumption

Table K-2 Brown Coal and UBC Product Consumption of 660 MW Power Plants

	Gross Calorific Value kcal/kg	**Coal Consumption** (Million Giga Joule)	**Coal Consumption** Ton
Brown Coal	4,000	61.68	3,685,368.17
UBC	6,052	45.58	1,800,101.61
Coal Consumption Differences			**1,885,266.56**