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ECONOMIC FEASIBILITY ANALYSES OF COAL-BASED ACTIVATED CARBON PLANT IN INDONESIA

ANALISIS KELAYAKAN EKONOMI PABRIK KARBON AKTIF BERBAHAN BAKU BATUBARA SKALA KOMERSIAL DI INDONESIA

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ABSTRACT

Technology to make activated carbon from coal has been developed from laboratory to pilot plant scales with capacity of 1 ton/day. The results of previous experiments showed that the quality of coal activated carbon has complied with the standard of quality activated carbon from coconut shell (SNI). In addition, the result of coal utilization process showed that activated carbon can be used for water purification on hatchery, and waste water treatment in textiles and rubber industries. Although the technology and the quality have been reached, but for the production it still needs economic feasibility analysis. Economic feasibility analysis is necessary for coal-based activated carbon plant at commercial scale by giving an indication about economic value of the project. The indicators used in the analysis are Net Present Value (NPV), Return on Investment (ROI), Internal Rate of Return (IRR) and Payback Period. Calculation of financial indicators for the activated carbon project produced Rp 49.17 billion NPV, 50% ROI, 68,25% IRR and 1 year 4 months Payback Period. Based on that calculation, it can be concluded that the coal-based activated carbon plant would be economically feasible under certain operational scenarios. This study is expected to become an economic reference material and can attract investors to construct the commercial plant.

Keywords: coal, activated carbon, economic feasibility, commercial plant

SARI

Teknologi pembuatan karbon aktif berbahan baku batubara telah dikembangkan mulai skala laboratorium hingga skala pilot yang berkapasitas 1 ton/hari. Hasil dari percobaan diperoleh karbon aktif dengan kualitas sesuai persyaratan kualitas karbon aktif tempurung kelapa yang ditetapkan oleh SNI 1987, dan dari hasil uji coba pemanfaatan sangat baik digunakan untuk penjernihan dan pemurnian air seperti budidaya udang maupun limbah cair dari industri tekstil dan industri karet. Meskipun secara teknologi dan kualitas telah tercapai, namun dari sisi keekonomian masih perlu analisa kelayakan ekonomi. Analisis kelayakan ekonomi diperlukan untuk mengetahui kelayakan pabrik karbon aktif pada skala komersial dengan memberikan gambaran nilai keekonomiannya. Indikator finansial yang digunakan adalah Net Present Value (NPV), Return on Investment (ROI), Internal Rate of Return (IRR) dan Payback Period. Hasil perhitungan keempat indikator tersebut menghasilkan nilai NPV sebesar Rp 49,17 miliar, ROI sebesar 50%, IRR sebesar 68,25% dan tingkat pengembalian modal selama 1 tahun dan 4 bulan. Berdasarkan hasil perhitungan tersebut maka dapat disimpulkan bahwa pabrik karbon aktif berbahan baku batubara skala komersial adalah layak secara ekonomi dalam kondisi operasional yang ditetapkan dalan studi ini. Hasil kajian ini juga diharapkan selain sebagai bahan acuan keekonomian hasil litbang juga dapat menarik minat investor untuk membangun pabrik komersial.

Kata kunci: batubara, karbon aktif, kelayakan ekonomi, pabrik komersial

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INTRODUCTION

The new paradigm of coal as a source of energy and capital development has become critical issues, it replaces old paradigm that coal was only considered as a commercial commodity that government simply sell coal to overseas. In order to support this new paradigm, the Government issued Law No. 4 of 2009 (Anonymous, 2009) on Mineral and Coal Mining in particular article 102 and article 103 and Government Regulation No. 23 Year 2010 on Implementation of Activity Mineral and Coal Mining Enterprises that are expected to push the government to further maximize coal processing in the country. Therefore, coal processing technology becomes more important and needed to be developed in Indonesia either by government, universities or private researchers. One of the coal processing technology currently be developed was activated carbon making from coal.

Activated carbon, an amorphous, non-graphitic form of carbon, is characterized by a large specific surface area of 300–2 500 m^2/g. Activated carbon can be manufactured from any cellulosic or lignocellulosic materials. Sub-bituminous coal is one of these types of materials that can be used to produce activated carbon. Other precursors that have been proven successful are agricultural wastes, coconut shells, pecan nut shells and even broiler manure. The activation of the raw material in order to prepare activated carbon can be carried out on two ways: chemical and physical activation. Chemical activation is where the raw material is treated using any dehydrating agent that dissolves cellulosic components (Campbell et al., 2012). Hsu and Teng (2000) prepared activated carbon from bituminous coal via chemical activation ($ZnCl_2$, H_3PO_4, and KOH), after which the sample was carbonized in nitrogen at various temperatures. It was found that $ZnCl_2$ and H_3PO_4 were not suitable for preparing high-porosity carbons from bituminous coal, while KOH can produce carbons with high porosity. Mineral matter content can affect the adsorptive capacity of an activated carbon that the samples with lower ash content yielded higher micropore volumes. Besides, activated carbons were prepared using the combination of chemical and activation. For example, meso porosity of lignite and bituminous is developed by coal modification using Ca-and Fe-exchange, and reported a 20–25% increase of meso pore volume (Lorenc et al, 2004).

Physical activation is when the carbonaceous material is first devolatilized for an extended period of time (1–48 hours), and then the formed char is treated with any oxidizing agent such as carbon dioxide or steam. The oxidizing agent reacts with the carbon to form gaseous products, which results in pores and channels being created (Campbell et al., 2012). Steam activation, is generally used for activation of carbon from peat, coal, coconut shell and wood. When coal is used as material in steam activation, it always consists of small graphite-like plate. Some of carbon are converted into gas, and leave pores (empty space). For long period of steam blowing, more carbon turn to gas and leave empty space. In the beginning micro pores will be formed, when the process continues, the surrounding carbon also turns into gas and the pores developed into meso pores. If the process is kept further, macro pores will be obtained. Activated carbon based on low rank coal has many meso pores of 1-4 nm in size (Paul, 2002).

Activated carbon using Indonesian sub-bituminous coal has been produced using rotary kiln and steam for activation process. The capacity was 1 ton/day and the quality of activated carbon produced by pilot plant has met almost all the requirement of Standard National Indonesia except hardness and ash content. It can be seen in Table 1 the comparison between the quality of activated carbon from the experiment at pilot plant and Standard National Indonesia (SNI) 1995 for activated carbon from coconut shell.

Until now, the quality standard (SNI) for activated carbon from coal hasn't been made. Therefore it will follow the SNI for activated carbon from coconut shell. Activated carbon specification really depends on its utilization. Although the hardness and methylene blue number of activated carbon from coal are low and below the SNI especially for hardness but it still can be used for specific purpose. Meanwhile the ash content is higher than SNI. The usage of activated carbon could be affected by the hardness and ash content. For some utilizations, it needs high hardness and low ash content because the process uses filtering system with pressurized condition. But for fisheries such as shrimp pond or water purification, the hardness is not important because the process does not require high pressure and temperature. Also, the content of ash could be reduced by washing. Therefore the product can be utilized for

Table 1. Comparison of activated carbon specification

No	Parameter	Unit	Activated carbon from pilot plant	Activated carbon (SNI,1995)/commercial
1	Missing part from heating 950°C	%	6	15-25
2	Water	%	10	4-15
3	Ash	%	15	2-10
4	Iodine number	mg/g	500-750	750-1200 (200-1200)*
5	Pure activated carbon	%	75	60-80
7	Methylene blue number	mg/g	60	60-120
8	Density	g/ml	0,52	0,30-0,55
9	Hardness		60	80

*Activated carbon with iodine number 200-400 mg/gr was sold in the market

water purification and room deodorizer (Monika and Suprapto, 2011). Regarding methylene blue number, it defines the absorption capability of the activated carbon. Even though the methylene blue number is low but coal-based activated carbon was effective in absorbing inorganic matters because the iodine number was adequate. Iodine number is defined as the absorption capability of each gram of activated carbon in absorbing per milligram iodine. From direct survey conducted in the market, it revealed that activated carbon with iodine number 200-400 mg/gr, has been sold and used in fisheries, specially ornamental fish. Based on the direct survey and compared with SNI's qualification, it can be concluded that activated carbon produced, was qualified to be sold in the market. Therefore, the pilot plant could be expanded into bigger scale even up to commercial scale.

In an attempt to attract investors to build a commercial plant, an economic feasibility analysis is required to give an indication about the economic value of the project. The purpose of the this research is to calculate financial indicators in order to determine the feasibility of coal-based activated carbon plant at commercial scale.

METHODOLOGY

Economic feasibility analysis is a pre FS focusing in financial sector. The benefit of economic feasibility analysis is to determine the investment plan by calculating the expected costs and benefits, by comparing spending and revenues, such as the availability of funds, cost of capital, the ability of the project to repay the funds within a specified time and assess whether the project will be able to continue to grow (Umar, 2001).

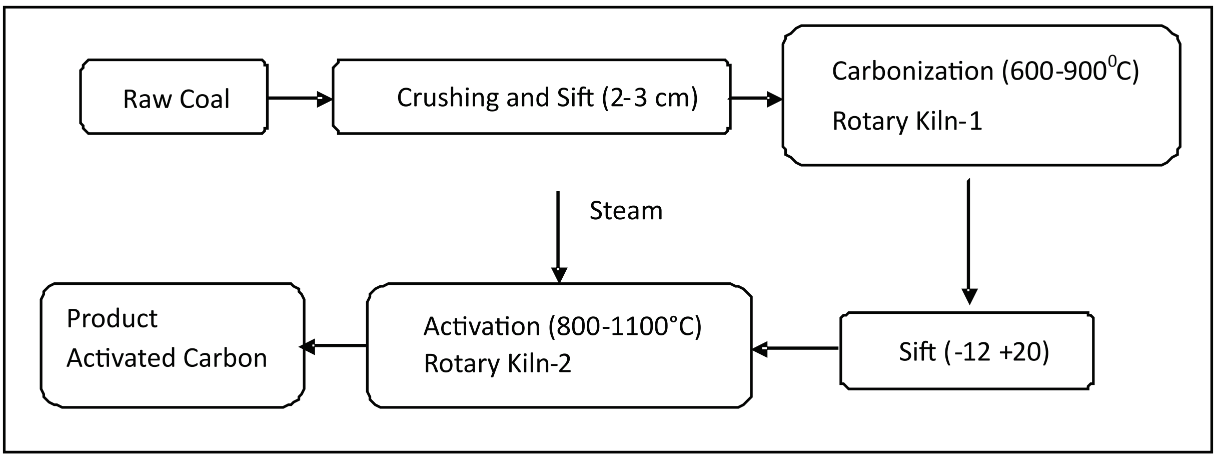

Figure 1. Flow chart of production process of coal-based activated carbon

Financial ratios used in this financial evaluation to determine the financial profitability are Net Present Value (NPV), Internal Rate of Return (IRR), Return on Investment (ROI) and Payback Period (PP) (Crundwell, 2008). There are 2 assumptions used in this analysis (Crundwell, 2008): First, the project represents the future cash flow so the costs incurred in the past are not taken into account. Second, all funds use assumed owned by the company itself (entity basis).

Net Present Value

The net present value (NPV) is the sum of all the cash flows discounted to the present using the time value of money. If the net present value is greater than zero, it is expected that value will be created for the investor. If it is less than zero, it is expected that value will be destroyed for the investor.

The net present value can be formulated as an equation in the following manner:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1 + k_t)^t}$$

where CFt is the cash flow at year t, n is the life of the investment of the engineering project and k is the discount rate.

Internal Rate of Return (IRR)

The internal rate of return (IRR), is the value of the discount rate at which the net present value is zero. This can be expressed mathematically in the following equation:

$$0 = \sum_{t=0}^{n} \frac{CF_t}{(1 + IRR)^t}$$

One method of obtaining the IRR from Equation above is by trial and error: guess a value for the discount rate, calculate the NPV, and repeat the procedure until a guess is made which satisfies equation above. Another way is to choose a range of discount rates, calculate the NPV, and then interpolate between the points on either side of the line for the point at which the NPV is equal to zero. A third way is to use a computer search algorithm, such as the secant method. A fourth method is to use built-in functions on calculators and spreadsheets, such as the “goalseek” function in MS Excel. To determine whether one project is feasible or not, it needs to compare the IRR with the IRR from other investment opportunities.

Return on Investment

Return on investment is the name for a group of similar calculations that express a ratio of profit to a measure of value. It is a measure of the profitability of the investment.

The calculation of the return on investment is shown in the following example.

- ROI is the annual profit divided by the original investment:
- ROI is the average profit divided by the average value of the assets on the balance sheet. This definition is sometimes called the average accounting return.
- ROI = (Total income – Original investment)/(Average book value)

Payback Period

The payback period determines the point in the project at which the investor gets the investment back. In other words, the payback period is the period at which the cash flow generated by the investment is equal to the cash invested in the project. The longer the investor has to wait for the project to return the initial investment, the less lucrative the project.

Regulations used in this research to calculate the cash flow of the project are :

- Corporate tax
  Under Article 17 of Law no. 36 in 2008, since the year 2010 tax rate was 25% mandatory body. The tax will be used in calculating cash flow of the project
- Depreciation
  Depreciation method used is straight-line method and zero residual value, the depreciation period equal to the time the project is for 10 years. This also will be used in calculating cash flow of the project.

The data are collected through literature study and from the results of the experiments. Primary data such as material balance for making activated carbon from coal was collected from the experiment’s results in pilot plant scale in Palimanan, Cirebon. Other data such as investment capital, interest rate, coal price and product’s price are collected from literature study, market or assumptions.

RESULTS AND DISCUSSION

To calculate the financial value of activated carbon project, it require data related to cash inflows and outflows. These data include: income data, expenditure data, information about the royalties and taxes. Assumptions used in the calculation of financial analysis in activated carbon projects are:

1. Cost of capital
   Activated carbon project will only utilize one source of fund by using their own capital.
   - Cost of equity is:
     Ke = Rf + · (Rm-Rf) = 16%
     Rf = return on government bonds 15 years = 10% (Anonymous , 2013a)
     · = Assumed the company was similar with other companies in Indonesia so the value of · = 1
     Rm = return on its peers (energy sector) in Indonesia per year = 16% (UBS Investment Research, 2006)
   - The discount rate is 16 %.

2. The selling price of activated carbon products
   The selling price of activated carbon from Indonesia that was exported to foreign countries will vary depending on the type and quality of activated carbon. In the period of January-May 2012, exports of activated carbon (from coconut shell) from Indonesia to the United States of America amounted to 3,629 tons with a price range of U.S. $ 1.4 - 1.9 per kg (Anonymous, 2013b). In domestic area, the selling prices are vary. Assumed that the sale price of activated carbon from coal is Rp 9.000,-/kg with reference to the selling price of activated carbon from coconut shells with almost the same quality.

3. Initial Investment
   Initial investment is an investment fund that is required to hold capital goods (machinery factory, factory buildings and warehouses, office buildings and housing for direct labor), land location, installation, test and production procurement, office tools (office machines and furnitures), and public services (electricity, water, and telephone) as well as other supporting facilities (road projects, motor vehicles, and other facilities) (Haming and Basalamah, 2010). Initial investment which required to build a commercial plant with a capacity of 15.000 kg/day is estimated to be Rp 17.9 billion (Table 2) based on pilot plant's investment cost in Palimanan, Cirebon.

4. Activated Carbon Production Costs
   To determine the cost of production of activated carbon, it uses the following assumptions:
   a. Raw materials
      Producing 15 tons of activated carbon per day or 4,950 tons per year, with a yield of 30% will need low rank coal as much as 16,500 tons per year. With coal price of Rp 400,000, -/ton then the raw material cost

Table 2. Initial investment

Million Rp

No.	Type of investment	Cost	Total cost
1	Delivering Equipment Cost (DEC)		2,540
	a. Total Purchase Equipment Cost (PEC)	2,000	
	b. Transport costs to the port (25% PEC)	500	
	c. Cost of loading and unloading, storage, transport	40	
2	Equipment Installation (43% DEC)		1,092.2
	a. Material (11%)	279.4	
	b. Labor (32%)	812.8	
3	Piping Cost (86% DEC)		2,006.6
	a. Material (49%)	1,244.6	
	b. Labor (37%)	762	
4	Instrument Cost (30% DEC)		762
	a. Material (24%)	609.6	
	b. Labor (6%)	152.4	

Table 2. Initial investment (continue)

Million Rp

No.	Type of Investment	Costs	Total Cost
5	Insulation Cost (8% DEC)		203.2
	a. Materials (3%)	76.2	
	b. Labor (5%)	127	
6	Electrical Cost (12% DEC)		304.8
	a. Material (5%)	127	
	b. Labor (7%)	177.8	
7.	Building		2,575
8	Land and Improvements		1,000
9	Total Cost of Utilities		529.4
	a. Purchase equipment cost utility	295	
	b. Transport costs to port	73.8	
	c. Cost of loading and unloading, storage, transport	1.5	
	d. Retrofitting cost	158	
10	Engineering and Construction (25% PPC (total no.1-9))		2,753.3
11	Contractors Fee (12.5% PPC)		1,376.6
12	Unexpected costs (25% PPC)		2,753.3
	Total Initial Investment		17,896.5

per year is Rp 6.6 billion.

b. Labor
Activated carbon commercial plant is estimated will require permanent workforce of 25 people consisted of tiers of leadership and service levels. Total amount of salaries and allowances to be issued per year is assumed Rp 1,272 billion.

c. Operational cost utility
Kerosene needed for boiler is 10 liters / hour at a price of Rp 8,500, -/liter. Two existing cyclo burners will require fine coal as much as 30 kg/h each at Rp 1,250, -/ kg. In addition, water is also required for boiler about 200 liters per hour at a cost of Rp 1,-/liter. Total utility operating costs needed is Rp 1,268.8 billion.

Assumptions of production costs can be seen in Table 3 .

5. Working Capital Investment
Working capital is the necessary funds to finance operating activities after the project enters commercial operation phase (Haming and Basalamah, 2010). It is assumed that the working capital required is as much as 4 months of production, before any funds coming from the sale of activated carbon. Thus, the amount of working capital required is 4 months/12 months x Rp 20.84 billion equal to Rp 6.94 billion.

6. Cash Flow Projection
The projected cash flows of the company can be seen in Table 4.

7. Net Present Value (NPV)
NPV is calculated using a discount rate of 16%. The discount rate is the cost of capital weighted average of the returns on investment (16%) as the opportunity cost of investing for investors.

The result shows that the NPV is positive amounted to Rp 49.17 billion. The value of NPV is positive with big number, means that this project is profitable with robush profit.

8. Internal Rate of Return (IRR)
By using the method of trial and error, the resulting IRR is equal to 68,25%. At a discount rate of 68,25% , it obtained NPV ~ 0. The results show that this project is feasible because if compared with the cost of capital (16%) then the IRR is bigger, suggest that the possibility

Table 3. Calculation of production cost

Million Rp

No.	Type	Costs	Total Cost
	Direct Costs		
1	Raw materials	6,600	
2	Labor	1,272	
3	Supervision (15% of labor)	190.8	
4	Maintenance (6% of cost initials)	1,073.8	
5	Royalties and patents (2% of the sales price of the product per year)	891	
6	Operating materials utilities	1,268.8	
	Total Direct Costs		11,457.4
	Indirect Costs		
1	Indirect labor costs (15% of labor)	190.8	
2	Laboratory (15% of labor)	28.62	
3	Indirect factory costs (50% of labor)	536.9	
4	Packing and shipping (1% for sales)	445.5	
5	Insurance (1% initial cost)	179	
	Total Indirect Costs		1,380.8
	Direct and Indirect Costs		12,838.2
	General Costs		
1	Administrative (5% of the sales price a year)	2,227.5	
2	Cost of sales (5% of the sales price a year)	2,227.5	
3	Research costs (3% of the sales price a year)	1,336.5	
4	Financial costs (10% of the initial investment and working capital)	2,213.7	
			8,005.2
	Total Cost of Production		20,843.4

Table 4. Cash flow projection

Billion Rp

Description	Year										
	0	1	2	3	4	5	6	7	8	9	10
Revenue		44.550	44.550	44.550	44.550	44.550	44.550	44.550	44.550	44.550	44.550
Production costs (up 5%/yr)		20.843	21.885	22.979	24.128	25.335	26.602	27.932	29.328	30.795	32.334
Gross profit		23.707	22.665	21.571	20.422	19.215	17.948	16.618	15.222	13.755	12.216
Depreciation		1.790	1.790	1.790	1.790	1.790	1.790	1.790	1.790	1.790	1.790
Profit before tax		21.917	20.875	19.781	18.632	17.425	16.158	14.828	13.432	11.965	10.426
Income tax		5.479	5.219	4.945	4.658	4.356	4.040	3.707	3.358	2.991	2.606
Profit after Tax		16.438	15.656	14.835	13.974	13.069	12.119	11.121	10.074	8.974	7.819
Depreciation		1.790	1.790	1.790	1.790	1.790	1.790	1.790	1.790	1.790	1.790
Initial investment	17.896										
Working capital	6.948										
Cash flow	24.844	18.228	17.446	16.625	15.764	14.859	13.909	12.911	11.864	10.764	9.609

for the project to be chosen was higher.

9. Return on Investment (ROI)
   To calculate the ROI, it can be seen in Table 5.

   Table 5 shows that the ROI of this project from year 1 until year 10 is larger than the cost of capital (16%). It means that the investor would gain profit every year from this project.

10. Payback Period
    Table 6 shows that the payback period for this project of activated carbon made from coal is 1 year 4 months. It means that the investor would obtain all of the investment back in very short time compared to the life time of this project of around 10 years.

11. Review
    The review of all financial indicator calculations for commercial plant of activated carbon made from coal can be seen in Table 7.

CONCLUSION

Calculation of financial indicators for the project of activated carbon plant produces 16% discount rate, NPV of Rp 49.17 billion, IRR of 68.25%, ROI of 50% and a payback period of 1 year 4 months. The overall financial indicators show that the project is economically very feasible, however until today there are no investor interested in activated carbon technology. Further research is needed to identify the reasons. Hopefully this technology would attract investors and in the end will increase the consumption of coal domestically.

Table 5. ROI calculations

Million Rp

Description	Year										
	0	1	2	3	4	5	6.	7.	8	9	10
Profit after Tax		16.438	15.656	14.835	13.974	13.069	12.119	11.121	10.074	8.974	7.819
Initial investment	17,896										
Working capital	6948										
Total investment	24,844										
ROI value		66%	63%	60%	56%	53%	49%	45%	41%	36%	31%

Table 6. Calculation of payback period

Billion Rp

Description	Year										
	0	1	2	3	4	5	6.	7.	8	9	10
Total investment	24,84										
Cash flow		18.228	17.446	16.625	15.764	14.859	13.909	12.911	11.864	10.764	9.609
Total cash flow		18.23	35.67	52.3	68.06	82.92	96.83	109.74	121.61	132.4	142

Table 7. Review of financial indicators

No.	Parameter	Calculation Results	Criteria Worth	Decision
1	NPV	Rp 49.17 billion	NPV> 0	Feasible
2	IRR	68.25%	IRR> 16%	Feasible
3	ROI	50%	ROI> 16%	Feasible
4	PP	1 year 4 months	PP <10 years	Feasible

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REFERENCES

Anonymous, 2009. *Law No. 4 of 2009 on Mineral and Coal Mining*, Jakarta.

Anonymous, 2010. *Government Regulation No. 23 : Operations Implementation of Mineral and Coal*, Jakarta.

Anonymous, 2013a. *Level Coupon Bonds of Bank Indonesia*, http://www .bi.go.id/web/id/Moneter2 / Interest Rate + / + State Bonds /.

Anonymous, 2013b. *Market of Activated Carbon, Coconut Market Information Center*, http://www.coconutmic.com/en/component/content/article/50-research-articles/ 172-market-of-activated-carbon.

Campbell, Q.P., Burnt J.R., Kasaini, H., Kruger, D.J, 2012. The Preparation of activated carbon from South African coal. *The Journal of The Southern African Institute of Mining and Metallurgy*, vol. 112, p. 37-44.

Crundwell, FK, 2008. *Finance for engineers*. Springer-Verlag London Limited, England.

Haming, M., and Basalamah, S., 2010. *Studi kelayakan investasi proyek dan bisnis*. Bumi Aksara, Jakarta, 668 p.

Hsu,L. and Teng., H. 2000, Influence of different chemical reagents on the preparation of activated carbons from bituminous coal. *Fuel Processing Technology*, vol. 64, p. 155–166.

Lorenc-G, E., Gryglewicz, G. and Gryglewicz, S. 2004. Development of mesoporosity in activated carbons via coal modification using Ca- and Fe-exchange. *Microporous and Mesoporous Materials*, vol. 76, 2004. p 193-201.

Monika, I. and Suprapto, S., 2011. Production of activated carbon from subbituminous coal using rotary kiln and cyclone burner. *Indonesian Mining Journal*, vol 14 number 1, February, p 30-37.

UBS Investment Research, 2006. *Indonesia Analyser*, UBS, p 3, 26.

Umar, H., 2001. *Studi kelayakan bisnis Edisi 2*. Gramedia Pustaka Utama, Jakarta, 301 p.

Paul, P.J., 2002. *Value added products from gasification activated carbon*. Combustion Gasification and Propulsion Laboratory, Department of Aerospace Engineering, Indian Institute of Science, Bangalore.