

# Feasibility Study for Production of Zeolite A based on Kaolin

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**Abstract.** In industry, kaolin is widely employed as an additive to paper, rubber and ceramics, among other uses, and can be synthesized into zeolite. Zeolites have been hydrothermally synthesized using alumina and silica based on deposits (kaolin) sampled from region in Bangka-Belitung. The synthesis of Zeolite A based on kaolin through several process stages such as drying, grinding and sieving prior to the hydrothermal process. It is then calcined into metakaolin, followed by the addition of NaOH solution, heating, filtration and washing to obtain the synthesis. This study examines how assessment models can be built and used for financial, technical, and marketing feasibility analysis of synthesized Zeolite A from kaolin. A new optimization method used to estimate financing requirements of investment products is presented, as well as a new method to predict the optimal year to sell the product. The conclusion is that Net Present Value with a positive value, Pay Back Period, Internal Rate of Return 30.78% higher than the interest rate set at 12%, and marketing aspects show that the process is feasible.

## 1 Introduction

Geologically, Indonesia's territory has the world's largest kaolin deposits; it has many kaolin producing regions, which not only meet domestic demand, but also make it possible to export the product of kaolin. Bangka-Belitung is a newly developed region, with high natural resource potential, such as tin. Beside tin, Bangka-Belitung is also a producer of kaolin, with 2,250 ha of land yielding the potential for 4,095,000 tons of kaolin.

In industry, kaolin is widely used as an additive to paper, paint, ink, rubber, ceramics and plastics. In addition, it can be synthesized into zeolite. Zeolite is an alumina silica crystal that has a three-dimensional frame structure. It is formed by tetrahedral silica ( $\text{SiO}_4^{4-}$ ) and alumina ( $\text{AlO}_4^{5-}$ ) with cavities filled with metal ions, usually alkaline or alkaline earth, and water molecules. With the chemical formula  $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$  kaolin is a rock composed of clay minerals with low iron content [1]. It is generally white and most of the components contained in it are silica and alumina. The high silica and alumina content in kaolin can be used as the basic materials for the synthesis of zeolite. Based on this, this study will test the utilization of kaolin as the basic material in the synthesis of zeolite A.

The type of zeolite produced depends on the initial composition and conversion method. The most commonly used method is a hydrothermal alkali treatment which heats mixture with an alkaline solution (KOH, NaOH, etc). Direct hydrothermal zeolite production has a shorter stage than the smelting or extraction method, although the purify level is still much lower when compared to the two methods [2].

Ayele et al. successfully optimized the synthesis parameters of zeolite A from Ethiopian kaolin. All the above optimized conditions resulted in the synthesis of zeolite A with high crystallinity of about 90%, cubic crystal of zeolite A with rounded edge, Si/Al=1, high thermal stability and cation exchange capacity of 295  $\text{CaCO}_3/\text{g}$  of anhydrous zeolites. These results show that the work done here produced zeolite A suitable for the use in detergents formulation [3].

The feasibility study is procedure to predict outcome of an assessment of a planned scheme along with possible gain [4]. These studies allow proper evaluating any production and also on the essential requirement to commence the project. A feasibility studies are important and essential to evolute the any proposed project is feasible or not. There are two main motivations regarding this area location assessment of the desire project and cost expectation [5]. This study also helps to see viability of the particular idea which gives the fruitful deliverable from the project within optimal cost, time, resources, and also justifying the factors like technical and economical of raw material availability from kaolin which is efficient and has a good sales value both domestically and overseas. In general, zeolite both natural zeolite and synthetic zeolite have high economic value. Like natural zeolites, synthetic zeolites such as zeolite A can also be optimized for use [6].

## 2 Materials and Areas of Project Feasibility

### 2.1 Materials

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The raw material used to synthesis the zeolite was kaolin, since its major components are silica and alumina, consisting of 60.49%-83.02% SiO<sub>2</sub> and 10.63%-24.19% alumina Al<sub>2</sub>O<sub>3</sub> thus allowing the kaolin to be synthesized into zeolite. The kaolin used came from the Bangka-Belitung region with a high percentage chemical characterization (SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub>), as required in the raw material for the synthesis of zeolite A. Bangka Belitung kaolin quality is almost the same as that from Ranong and China, but Ahoko kaolin contains a higher level of SiO<sub>2</sub> [7].

**Table 1.** Chemical characterization of kaolin from Bangka-Belitung and from other countries

Chemical Characterization	% Weight				
	Bangka-Belitung	Ahoko, Nigeria	Ranong, Thailand	China	Georgia
SiO <sub>2</sub>	49.86	72.46	45.63	44.21	45.30
Al <sub>2</sub> O <sub>3</sub>	30.51	18.96	35.75	37.75	38.38
Fe <sub>2</sub> O <sub>3</sub>	0.69	1.05	0.77	0.78	0.30
TiO <sub>2</sub>	0.29	-	0.04	-	1.44
CaO	1.49	-	0.02	0.45	0.05
MgO	1.07	0.13	0.04	0.08	0.25
Na <sub>2</sub> O	0.45	0.02	-	0.07	0.27
K <sub>2</sub> O	0.59	0.43	0.99	0.46	0.44
Loss on ignition	15.05	6.17	13.38	17.25	13.97

[8]

## 2.2 Areas of Project Feasibility

In this study discuss different area of the project feasibility which may be consider during the assessment of any project. The methodical study may also provide the exact respond earlier. Feasibility evaluation mainly classify in four types or categories.

### 2.2.1 Technical Feasibility

The technical study discusses how the products are to be produced, when these products are to be produced, how much will it cost to produce the products, where to produce the products and what technology to be used.

### 2.2.2 Economic Feasibility

Economic feasibility study related with price, and all kind of expenditure related with the scheme before the project start. This study also improves project reliability [9]. It is also helpful for the decision-makers to decide the planned scheme processed latter or now, depending financial condition of the organization. This evaluation process also studies the price benefits of the proposed scheme.

### 2.2.3 Operational Feasibility

Operational feasibility may employ the responsibility to examine and also decide whether the proposed methods fulfill all kind of business requirements [10]. It actions

forecast all possible schemes to recognized and resolves troubles. This studies may also examine and verify how the project planed guarantee the method development is feasible or not.

### 2.2.4 Marketing Feasibility

A market feasibility study determines the depth and condition of a particular real estate market and its ability to support a particular development. Things to include in a market feasibility study include ; current market analysis, competition, anticipated future market potential, and potential buyers and sources of revenues [11].

## 2.3 Financial Data Collection

The first data were the target prices of the raw materials. Based on the target selling price of 5.4 million from market, the market margin is equal to 73%, the total labor cost is equal to IDR 900,000, and the minimum level of company profit is equal to 15%, so the price strategy for the raw material targets a maximum of IDR 2,500,000/ton. Other data obtained included the cost of raw materials and the cost of the company. Kaolin raw material and support costs = IDR 2,400,000/ton, and NaOH = IDR 100.000/litre. Therefore, the total cost of the raw materials amounted to IDR 2,500,000/ton. The company margins were IDR 510,000, 15% of the total cost of the raw materials, and labor costs IDR 3.400.000. Calculation of the machine costs in IDR included three rotary drum dryers at IDR 600 millions, three pieces of grinder at 800 millions, three vertical crystallizers at 950 millions, three heat exchangers at 1100 millions, three create disc filter = 900 million in addition to machine import tax and shipping costs of 2319,76 million. The cost of developing new products was 435 million, so the total investment required was IDR 15,804,760,000. Engine life is 10 years, while the bank interest rate was assumed to be 12%, as applicable at the times.

## 3 Result and Discussion

Synthesis of zeolite A was developed to overcome the disadvantages of natural zeolite due to its varying mineral composition and uniform pore size. Development of synthetic zeolites can be made by adjusting the pores to allow more specific utilization. This is also supported by the high potential reserves of kaolin in the Bangka-Belitung region, which will support the effectiveness of the production of kaolin-based zeolite A.

Essentially, the synthesis of zeolite A has high economic value, and it can be utilized and processed for other functions, such as a concentrate for alcohol, olefin dryers, solid natural gas materials or air CO<sub>2</sub> cleaners. The functionality of zeolite for CO<sub>2</sub> gas adsorbents has been widely developed, including its synthesis to modify its structure and to increase the surface area and pores.

In successful project feasibility study is a critical factor. Therefore, the basic features in any feasibility

study must be ensuring are working with accurate information, exact statement, and the latest financial records [12]. The main objective of feasibility study is to evaluate three types of feasibility; technical, operational, and economic feasibility.

### 3.1 Technical Feasibility

The technical feasibility study should most essentially support the financial information of an organization. The technical analysis concern projects inputs (supplies) and outputs (production) of real goods and services. From the technical point of view, the raw material inventory amounted to IDR 2,500,000/ton, according to raw material price target of IDR 2,500,000/ton which also supported include the quality of machinery and equipment's. Synthesis of zeolite A from kaolin is using thermal activation of chemically inert crystalline kaolin to obtain a more reactive and amorphous phase, metakaolin. The resultant zeolite type and relative abundance depend on the hydrothermal conditions.

### 3.2 Economic Feasibility

#### 3.2.1 Pay Back Period Analysis

Calculation by the Pay Back Period Analysis method is shown in table 2.

**Table 2.** Payback period analysis (PP)

Month	Net Cash Flow (IDR)	Cumulative Cash Flow (IDR)
0	-15804760000	-15804760000
1	1020000000	-14784760000
2	1020000000	-13764760000
3	1020000000	-12744760000
4	1020000000	-11724760000
5	1020000000	-10704760000
6	1020000000	-9684760000
7	1020000000	-866476000
8	1020000000	-7644760000
9	1020000000	-6624760000
10	1020000000	-5604760000
11	1020000000	-4584760000
12	1020000000	-3564760000
13	1020000000	-2544760000
14	1020000000	-1524760000
15	1020000000	-504760000
16	1020000000	515240000

$$PP = 15 + (16 - 15) \times \frac{515.240.000}{515.240.000 - (-504.760.000)}$$

$PP = 15.505 \text{ months}$

#### 3.2.2 Internal Rate of Return (IRR)

Calculation by the Internal Rate of Return method is shown in table 3.

**Table 3.** Internal rate of return (IRR)

Month	Net Cash Flow (IDR)	(r) 2,5%	Net Value	(r) 2,75%	Net Value
0	-15804760	1.0000	-15804760	1	-15804760
1	10200000	0.9756	995112	0.9732	992664
2	10200000	0.9518	970836	0.9472	966144

3	1020000	0.9286	947172	0.9218	940236
4	1020000	0.9060	924120	0.8972	915144
5	1020000	0.8839	901578	0.8372	853944
6	1020000	0.8623	879546	0.8498	866796
7	1020000	0.8413	858126	0.8270	843540
8	1020000	0.8207	837114	0.8049	820998
9	1020000	0.8007	816714	0.7834	799068
10	1020000	0.7812	796824	0.7624	777648
11	1020000	0.7621	777342	0.7420	756840
12	1020000	0.7436	758472	0.7221	736542
13	1020000	0.7254	739908	0.7028	716856
14	1020000	0.7077	721854	0.6840	697680
15	1020000	0.6905	704310	0.6657	679014
16	1020000	0.6736	687072	0.6479	660858
17	1020000	0.6572	670344	0.6305	643110
18	1020000	0.6412	654024	0.6137	625974
19	1020000	0.6255	638010	0.5972	609144
20	1020000	0.6103	622506	0.5813	592926
Total			96224		-272914

$$IRR = 0,025 + (0,0275 - 0,025) \times \frac{96.224}{96.224 - (-272.914)}$$

$$IRR \text{ in a year} = 2,56\% \times 12$$

$$= 30.78\%$$

#### 3.2.3 Net Present Value (NPV)

Calculation by the Net Present Value method is shown in table 4.

**Table 4.** Net present value (NPV)

Month	Net Cash Flow	Discount Factor (1%)	Net Present Value
0	-15804760	1.0000	-15804760
1	1020000000	0.9901	1009902000
2	1020000000	0.9803	999906000
3	1020000000	0.9706	990012000
4	1020000000	0.9610	980220000
5	1020000000	0.9515	970530000
6	1020000000	0.9420	960840000
7	1020000000	0.9327	951354000
8	1020000000	0.9235	941970000
9	1020000000	0.9143	932586000
10	1020000000	0.9053	923406000
11	1020000000	0.8963	914226000
12	1020000000	0.8874	905148000
13	1020000000	0.8787	896274000
14	1020000000	0.8700	887400000
15	1020000000	0.8613	878526000
16	1020000000	0.8528	869856000
17	1020000000	0.8444	861288000
Net Present Value			68684000

### 3.3 Operational Feasibility

#### 3.3.1 Forecasting of needs with constant forecasting

Calculation of assumptions with the constant forecasting method is shown in table 5.

**Table 5.** Constant Forecasting of Kaolin Needs

Year	T	d	d'	d-d'	(d-d') <sup>2</sup>
2018	1	82000	95275	-13275	176225625

2019	2	90500	95275	-4775	22800625
2020	3	110200	95275	14925	222755625
2021	4	98400	95275	3125	9765625
Quantity	10	381100		(-)	431547500

2019	2	90500	-1	-90500	0	0	102707	-12207	149022160
2020	3	110200	0	0	-1	-110200	106424	3776	14260480
2021	4	98400	1	98400	0	0	110140	-	137825875
Qty	10	381100	0	7900	0	-28200	418262	-37162	589810468

$$d' = \frac{\sum d}{n} \tag{1}$$

$$d' = \frac{381100}{4} = 95.275$$

From the calculation of forecasting requirements above a Standard Error of Estimate (SEE) was obtained, as follows:

$$SEE = \sqrt{\frac{\sum(d-d')^2}{n-1}} \tag{2}$$

$$SEE = \sqrt{\frac{431.547.500}{3}}$$

$$SEE = 11.994$$

### 3.3.2 Forecasting of needs with linear forecasting

Calculation of assumptions with the linear forecasting method is shown in table 6.

**Table 6.** Linear forecasting of kaolin needs

Year	T	d	dt	t <sup>2</sup>	d'	d-d'	(d-d') <sup>2</sup>
2018	1	82000	82000	1	34025	47975	2301619815
2019	2	90500	181000	4	35458	55042	3029665798
2020	3	110200	330600	9	36890	73310	5374297452
2021	4	98400	393600	16	38323	60077	3609221898
Quantity	10	381100	987200	30	144696	236404	14314804963

From the above calculation, the values of a and b can be obtained, as follows:

$$a = \frac{\sum d \sum t^2 - \sum t \sum dt}{n \sum t^2 - (\sum t)^2} \tag{3}$$

$$d' = 78.050 + 6.890(t) \tag{4}$$

From the calculation of forecasting requirements above, a Standard Error of Estimate (SEE) was obtained, as follows:

$$SEE = \sqrt{\frac{\sum(d-d')^2}{n-2}} \tag{5}$$

$$SEE = \sqrt{\frac{14.314.804.963}{2}}$$

$$SEE = 84.601$$

### 3.3.3 Forecasting of needs with cycle forecasting

Calculation of assumptions with the cycle forecasting method is shown in table 7.

**Table 7.** Cycle forecasting of kaolin needs

Year	t	D	cos	dcos	sin	dsin	d'	d-d'	(d-d') <sup>2</sup>
		90t	90t	90t	90t				
2018	1	82000	0	0	1	8200	98991	-16991	288701953

$$d' = a + u \cdot \cos \frac{2\pi}{N} \cdot t + v \cdot \sin \frac{2\pi}{N} \cdot t \tag{6}$$

$$d' = 95.275 + 3.950 \cdot \cos 90 \cdot t - 14.100 \cdot \sin 90 \cdot t$$

From the calculation of forecasting requirements above, a Standard Error of Estimate (SEE) was obtained, as follows:

$$SEE = \sqrt{\frac{\sum(d-d')^2}{n-2}} \tag{7}$$

$$SEE = \sqrt{\frac{589.810.468}{1}}$$

$$SEE = 24.286$$

Based on the calculation of the Standard Error of Estimate (SEE) value of the three forecasting methods employed, the constant forecasting method was chosen to forecast kaolin needs.

### 3.4 Marketing Feasibility

Market analysis is an extremely important step after completing identifying the investment opportunities, and the initial feasibility study. From the results of the needs forecasting of kaolin-based zeolite A synthesis of 7,940 tons per month, and of a product sales plan of 2,000 tons per month, this means that the product will capture 25% of the existing market share (Constant SEE=11994). This is feasible, because customer behavior with regard to the synthesis of zeolite A-based commercial kaolin is not loyal towards a specific brand. As long as quality, price and distribution can be met, it will be well received by the market. In terms of marketing, the cost of raw materials that matches the target marketing will make the selling price of the kaolin products competitive.

The quality and accuracy of the collected data and information on the variables of market analysis of the proposed business leads to the safety and accuracy of decision making on either proceed further on establishing the business. The demand analysis refers to the organized processes aiming at exploration of a certain variable behavior (demand) in future, based on a systematic study of the existing historical data. Demand, in itself, is an economical term indicating the volume or quantity of the commodities and/or services demanded within a certain period, at a certain price level, and from a certain market. The demand will be analyzed both in the past and future through the use of the mathematical methods so as to predict the actual demand on the commodity or service in future.

Price is one of the important variables in the market analysis process, because price affect the demand on the products and the way they are introduced into the markets. Price also have their strong influence upon the production processes, such as methods or means of production, as well as other effects of prices. From

consumer's point of view, price expresses the cost of getting the product. Competition plays an important role in market analysis, and is deemed the party that offers similar or typical products of the proposed investment business of both the same current and anticipated consumer segments [13].

## 4 Conclusion

Basically it is a predictable project that demonstrate conclusion of the assessment, examine, and evaluation of a designed method and terminate if this method is accurately feasible, profitable, and productive. Based on the analysis and discussion it can be concluded from the results of the product feasibility study that the market and marketing aspects are feasible. The financial aspects are also considered feasible, when reviewed from the financial analysis of PP 15,505 months lower than the economic value of machine 10 years, IRR 30.78% which is higher than the interest set 12% and the positive value of NPV IDR 68,857,400.

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