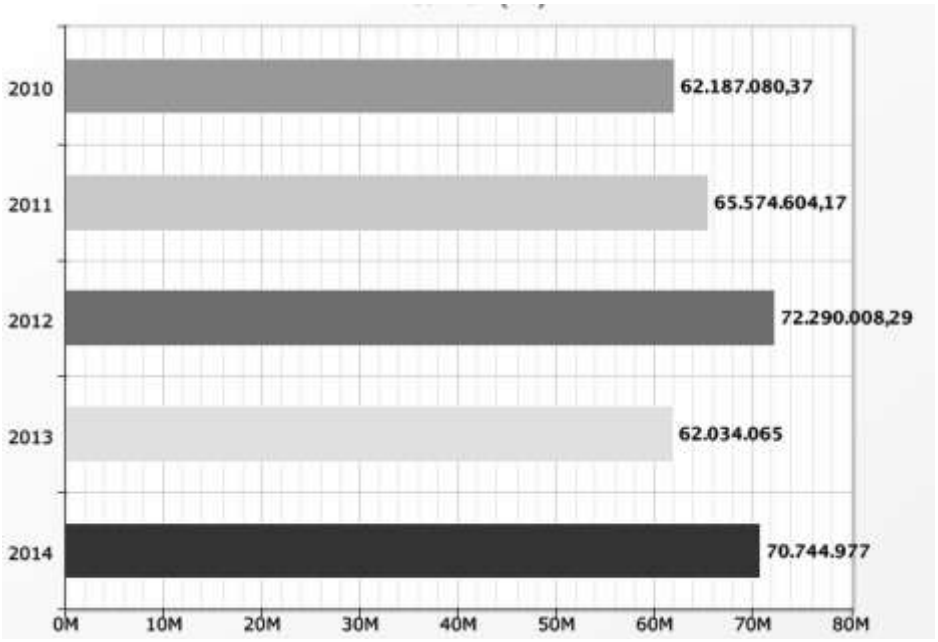
CHAPTER I
INTRODUCTION

1.1. Background

The increasing of petroleum price since 2003 caused by decreasing of petroleum production. Most people said that decreasing caused by American invension to Iraq where Iraq is the highest petroleum source number tree after Saudi Arabia and Iran. But the more influential factor is the increasing of petroleum request from big country and developing country where the consumption of energy relatively increase every year like a lifestyle (Pimentel D et al, 2009). The increasing of fossil energy consumption which relatively high especialy in transportation also can increase green house gas emision too (Amela A & R Haasp, 2010)

Inspite of increased price of fossil fuel, Indonesian petroleum consumption still high, it can be seen on the figure bellow.



(BPS, 2016)

Figure 1.1. Fossil Fuel Consumption in Indonesia (in KL)

Inspite of slow production growth especially in oil production, Indonesian energy consumption keep increase.

The fact is :

1. Local energy consumption increase twice in last 16 years, cause by fossil fuel growth.
2. Indonesian energy production growth only 1.4% lowest since 1988.
3. Oil production still decrease until the lowest level since 1969.

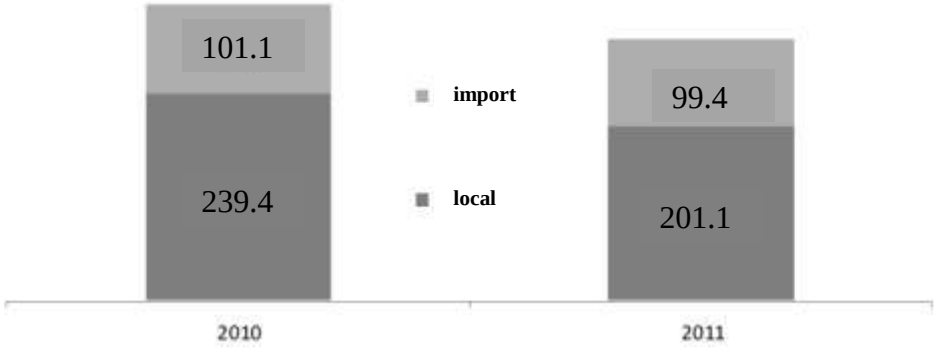
All of fact before can be describe bellow :

1. Indonesian energy consumption increase 3.1% at 2014, and increase twice in last 16 years.
2. The increasing of coal 5.3%, natural gas 5.1%, renewable energy 2.2%, and oil 1%, but there are decreasing in hydro 12%.
3. Oil still be the main energy 42.3% from total Indonesian energy needs, followed by coal 34.8%, gas 19.8%, hydro 1.9%, and renewable energy 1.3%.
4. Coal consumption growth 3.2 milion mtoe in 2014, slower than the peak number 7.4 milion mtoe at 2011.
5. Natural gass become normally until 1.9 bcm in 2014 after decrease 5.8 bcm in 2013 but its still lower about 12% than its peak in 2010.
6. Indonesia produce 56% from total oil consumption in this country, that number is the lowest proportion and seven time ratio degradation.
7. Biofuel production growth 40.4%, renewable energy growth 2.3%, coal growth 2.0%, and natural gas 1.7%, bigger than decreasing of oil 3.5% and hydro 12%.
8. Indonesia's coal production reach 458 milion ton which is the peak. The production growth 8.9 milion ton in 2014 that the smallest increasing since 2000. But that is still the big five in all around the world in 2014.

9. Natural gas production become normally in 2014 after 3 years decrease continuously, but it still lower than the peak in 2010 as much as 14%.
10. Biofuel is a fuel that have fastest growth and growth surprisely as much as 39% along the last 5 years.
11. Indonesia's CO_2 emision came from energy using increase 3.6% in 2014, its lower than the last 10 years although its twice increasing in 2013.
12. Energy intensity (the number of energy needs per unit GDP) had decrease 1.9%, almost same with the last 10 years rate as much as 1.8%.

(bp.com, 2015)

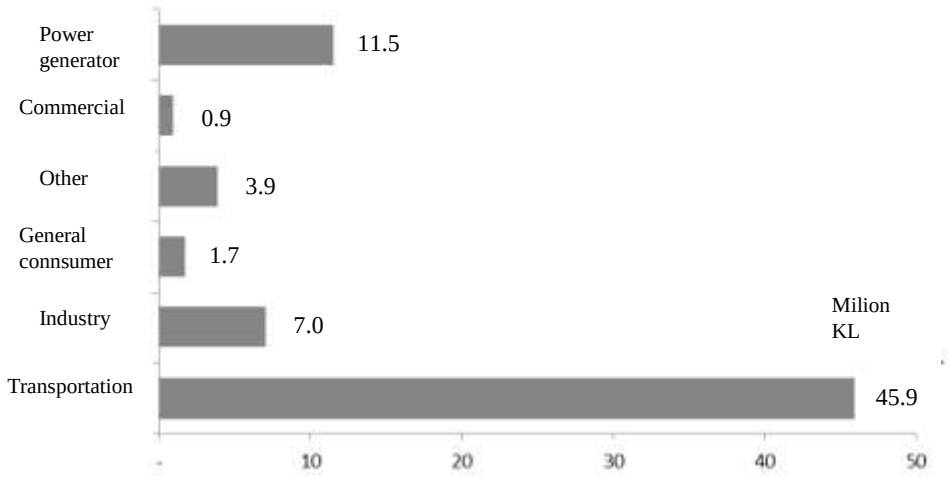
The number of crude oil need by local refinary oil in 2011 is 300.5 milion barrel per year. Compared to last year, the number decrease 40 milion barrel or 11.7 %. From that number 201.1 milion barrel from local, then 99.4 milion barrel from import. Total of crude oil need from local source, 85.5 % from goverment and the excess buy from KKKS.



(Pertamina, 2012)

Figure 1.2. Comparation of crude oil need from import and local (mil barrel)

Transportation sector used fossil fuel higher than another sector like industry or electricity. Transportation used fossil fuel about 65%, power generator 16%, industry 10%, general consumer 2%, commercial 1%, and another sector 6% from total fossil fuel consumption in 2011 that reach 70.89 milion KL. Compare to 2010, that number increase 4.04% from 68.14 miion KL.



(Kementrian ESDM, 2012)

Figure 1.3. Fossil fuel consumption in 2011

The increasing of petroleum consumption make Indonesians government want to handle this case relate to globlal petroleum price which always increase. The step that take by the government is give a subsidy (International Institute for Sustainable Development). But for a long time the petroleum price increase uncontrolly and the amount goes to rare. The rare of petroleum will make the scientist search the renewable energy source for the future (Austin G. T, 1984)

Table 1.1. Government Expanding and Subsidy (2005-2011) in Quintillion of Rupiah

	2005	2006	2007	2008	2009	2010	2011	
	LKPP	LKPP	LKPP	LKPP	LKPP	APBN-P	RAPBN	APBN
Total Expenditure	361	440	505	693	629	782	823	837
All Subsidy	121	108	150	273	201	201	185	188
Energy Subsidy	105	95	117	223	95	144	134	137
Fuel Energy	96	64	84	139	45	89	93	96
Electrical Energy	9	31	33	84	50	55	41	41
Capital Expenditure (Capital Investment)	33	55	64	73	76	95	122	136
Land	22	24	31	9	13	21	45	47
Education	29	45	51	55	85	97	82	92
Health	6	12	16	14	16	20	13	14
Public Insurance	2	2	3	3	3	4	4	5

(Kemenkeu, 2013)

Alternative energy that usually used in some country are bioethanol. Bioethanol can be produced from source that consist of sugar, carbohydrate, and cellulose, for example flour $(C_6H_{10}O_5)_n$ which hydrolize become a glucose then fermented using *Saccharomyces cerevisiae* and purified by distillation (Fessenden and Fessenden, 1999)

Bioethanol is a biofuel which consist of ethyl alcohol. In some condition and amount ethyl alcohol can mixed with gasoline for transportation energy. Biofuel become more interesting after oil crisis as liquid fossil fuel changer.the increasing of biofuel interest in las decade is contribute to the popularity of biofuel as alternative fuel (Karel J et al, 2012)

Currently, biofuel global production still low but continuously increasing following the needs of energy. This increasing based on some country that want to change some part fossil fuel with biofuel. Some country in Europe have the rule that 5.75 percent of transportation energy must use biofuel as alternative fuel (European Parliament and Council, 2003).

With developing of ethyl alcohol plant, so hopely can :

1. Decreasing the consumption of fossil fuel in Indonesia.
2. Decreasing the dependence of fossil fuel in Indonesia.
3. Comply with a request of ethyl alcohol in Indonesia.
4. Increase the country devizen by ethyl alcohol export.
5. Decreasing the amount of unemployee with adding a job vacancy.
6. Help the government program about petroleum using (Perpres Number 5 year of 2006 about National Energy Sublety and President Instruction Number 1 year of 2006 about stock and Utilization of Natural Fuel (Biofuel) as alternative energy)

1.2. The Selection of Design Capacity

The selection of ethyl alcohol plant design capacity is consider with some reason, that is :

1. The needs of ethyl alcohol in the country.
2. The roadmap of biofuel utillization.
3. The raw material available.
4. Bioethanol plant data operate.

1. The needs of ethyl alcohol in the country

   The data of ethyl alcohol needs in the country can shown on table behind in column of import volume :

Table 1.2. Ethanol (Ethyl Alcohol) Product Data

Comodity Kind	2006	2007	2008	2009	2010
Investation (US$ Million)	687.00	687.00	687.00	687.00	1,042.00
Employee (Man)	294.00	290.00	290.00	290.00	443.00
Production capacity (Ton)	990,000.00	990,000.00	990,000.00	990,00.00	660,000.00
Production price (US$ Million)	340,511.62	350,809.71	357,825.00	346,499.38	345,643.64
Production volume (Ton)	920,000.00	947,823.55	641,852.00	621,535.00	620,000.00
Import volume (Ton)	31,026.78	30,095.98	64,148.00	76,937.00	20,000.00
Import price (US$ Million)	15,483.67	14,431.00	14,431.00	14,431.00	14,431.00
Export volume (Ton)	524,814.20	543,182.70	400,000.00	414,000.00	420,000.00
Export price (US$ Million)	128,947.04	105,489.00	107,598.78	105,489.00	105,489.00
Utillity (%)	93	96	65	63	94

(BPS, 2012)

2. The roadmap of biofuel utillization

   Currently the utilization of biofuel in Indonesia increase. For 2011-2015 was predicted need about 2.78 million KL of bioethanol as a mixture of 10% gasoline (Directorate General of Oil and Gas).

3. The raw material available

   In this plant design used mollasses as a raw material. Mollases got from sugar industry. In this plant design the source of mollasses needs comes from some PTP Nusantara IX sugar industry around Surakarta and Semarang area with the amount industry is about 13 units with the

capacity of mollasses about 99,580 ton (PT. Karisma Pemasaran Bersama)

4. Bioethanol plant data operate

Table 1.3. Data of Ethyl Alcohol plant

Plant Name	Location	Capacity (KL/Year)
Salim Group	South Sumatra	70,000
PT. Indo Acidatama Tbk	Central Java	61,875
Molindo Raya	East Java	50,000
PT. PS Madukismo	Yogyakarta	18,480
Anugrah Kurnia Abadi	Lampung	2,500

Depend on four consideration before, in this ethyl alcohol plant design choose the capacity about 40,000 ton per year or about 50,000 KL per year.

1.3. The Selection of Plant Location

The selection of plant location is a one main factor that have a part to determine the successes and the live of the plant. There are several thing that must be considered in the selection of plant location. So before the plant build there are some factor considered to the live of the plant. That factor is :

1. Raw material availability
2. Electrical and energy source availability
3. Water availability
4. Transportation
5. Employee and labor

With some consideration before, the plant location placed in Sukoharjo, Central Java, with some reason that is:

1. Raw material availability

   The plant location choose because near to the raw material source so can decrease the transportation cost and loosing raw material along transportation. Mollasses are got from sugar industry around Surakarta, Semarang, and Yogyakarta.

2. Electrical and energy source availability

   For electrical and energy source can fill with prepare own generator of electricity. If there are any interuption happen because of PLN problem, the plant doesn't have a lose out because the stoping of electricity.

3. Water availability

   Sukoharjo through by Bengawan Solo River, the water needs for process are available.

4. Transportation

   Transportation must be available appropiate with plant needs. Transportation here consist of raw material transportation, product transportation, and operational transortation. The location that near from raw material source and near ring road it can be reach easily by the source, so can minimalize the time needs. It's also happen to product transportation, because relate to the distribution of the product. The last is operational transportation needs to support the operational on that plant can do well.

5. Employee and labor

   For employee factor, as possible as get from people surrounding the plant. It can be good relationship between plant industry and society. Except the specialist labor maybe got from another place depend on their speciality skills. Specialist labor can get from society surround the plant if they can fill the skill needs, but if there are anyone can filled it, it can be give some job vacancy to help the government decrease the number of unemployee.

1.4. Theory

1.4.1. Type of process

There are many kind of ethyl alcohol production process, that is:

1. Ethylene hydration

Synthesis ethyl alcohol can be produced from ethylene absorption in sulphuric acid which produce ethyl sulphate that hydrolized become ethyl alcohol and thin sulphuric acid. (Faith et all, 1975). Ethanol for industrial stock is usually made from petro chemical by acid catalyzed hydration of ethylene, represented by the chemical equation (Roberts et all, 1977)

Reaction:

$$CH_2 = CH_2 + H_2O \rightarrow C_2H_5OH \quad \ldots(1.1)$$

The catalyst most commonly use phosporic acid that adsorbed onto a porous support like silica or diatomaceus earth (Naim et all 2005). The reaction which now almost entirely absolete, ethylene was hydrated indirectly by reacting with concetrated level of suphuric acid to produce ethyl sulphate which was hydrolized to yield ethanol regenerate the sulphuric acid (Streiweister et all, 1976).

$$CH_2 = CH_2 + H_2SO_4 \rightarrow C_2H_5OSO_4H \quad ...(1.2)$$

$$C_2H_5SO_4H + H_2O \rightarrow C_2H_5OH + 2\ H_2SO_4 \quad ... (1.3)$$

2. Ethylene cataytic hydration

Synthesis ethyl alcohol generally processes from direct ethylenen hydration using sulphuric acid as catalyst (Faith et all, 1975). The current process of involves the ethylene dirrect hydration with the amount of catalytic agent of sulphuric acid (Figure.1). The temperature is around 300^oC to 400^o C with pressure about 1000 Psi (James G, 2002)

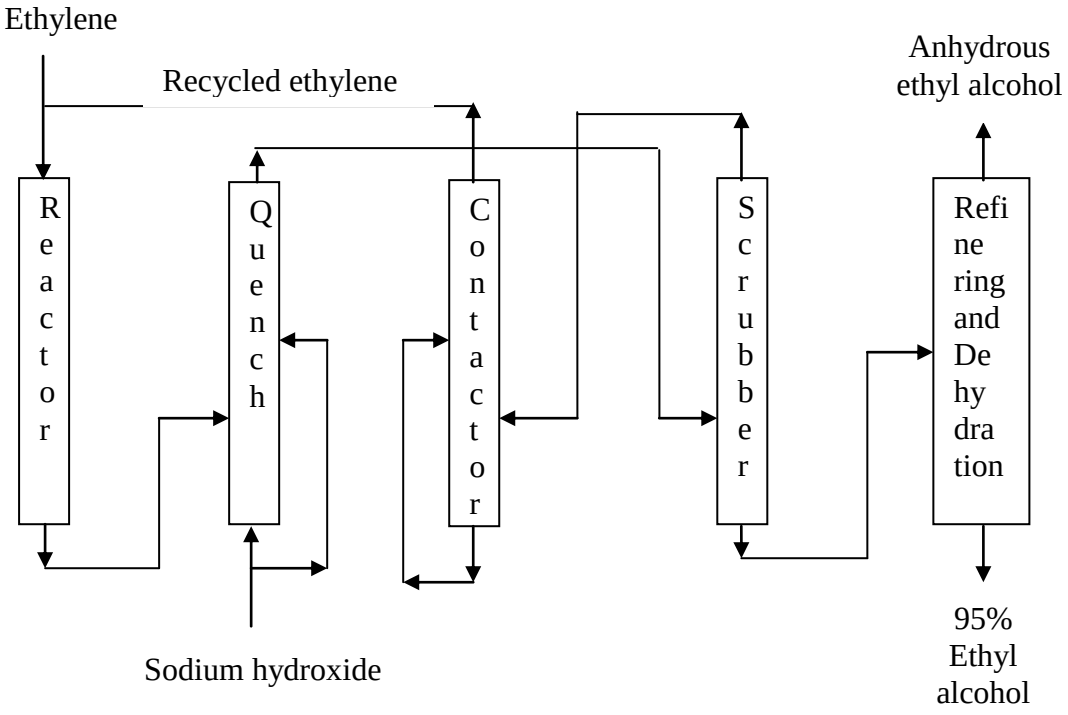


Figure. 1.4 Production of ethyl alcohol

$$CH_2 = CH_2 + H_2O \rightarrow CH_2CH_2OH \quad \ldots(1.4)$$

Only 4% of ethylene is converted to alcohol per pass but this cyclic process eventually gives a net yield of 97 %.

In direct hydration process, acid catalyst is usually used. The factors that may infuence is temperature, pressure, water ratio, and ethylene puruty. And then there are some by product found, one of side reaction is the dehydration of ethyl alcohol into diethyl ether :

$$2\ CH_2CH_2OH \rightarrow (C_2H_5)_2O + H_2O \quad \ldots (1.5)$$

3. Fermentation

Some of ethyl alcohol produced by fermentation, when the yeast reduced in oxygen produce ethyl alcohol and carbon dioxide. The chemical equation can be written to summarize the convertion behind (Morais et all, 1996).

$$C_6H_{12}O_6 \rightarrow 2\ CH_3CH_2OH + 2\ CO_2 \quad \text{... (1.6)}$$

$$C_{12}H_{22}O_8 + H_2O \rightarrow 4\ CH_3CH_2OH + 4\ CO_2 \quad \text{... (1.7)}$$

Fermentation here is yeast culturization process under favorable thermal condition to make an ethyl alcohol. The process happen on temperature around $35^oC - 40^o$ C.

1.4.2. Product Usability

There are some using of ethyl alcohol, that is:

1. Important raw material industry and has wide spread use as a raw chemical material for other organic compound.
2. Medical wipes and most common antibacterial hand sanitizer gels at a concentration of about 62% v/v as an antiseptic.
3. Treatment for poisoning by other alcohol.
4. Ethyl alcohol is miscible with water and is a good general purpose solvent.
5. Ethyl alcohol was commonly used as fuel.

1.4.3. General Theory

The production of ethyl alchol or ethanol from mollasses is used fermentation process by the helping of the yeast. The characteristic of this reaction process is exothermic reaction. The process generally done on fermentor reactor at temperature of 35^oC with pressure about 1 atm and pH around 4.8 to 5 with the long of process about 48 hours. Ethyl alcohol made from mollasses fermentation in some steps, that is :

1. Raw material purification step
2. Hydrolysis step
3. Fermentation step
4. Product purification step
5. Ethyl alcohol separation step

Where each step will clearly explain in the next chapter.

In fermentation process the product result is ethyl alcohol, CO_2 gas, water, and other materials as a slurry. After the fermentation process finished, then the product be purified with distillation until reach the concentration around 95-95.6% of mass.