Economic Feasibility Analysis of Hydrogen Production from Raw Materials of Oil Palm Empty Fruit Bunches

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Abstract. The potential of hydrogen as a fuel for the future has been discussed as a part of the energy agenda for decades. Many research projects led by academics and engineers are directed by the future use of hydrogen in the energy supply chain for road transport, and power generation for energy storage. Economy base hydrogen is a long period for many countries being sustainable energy system. The policy maker also learn the implementation and challenges an economy change based on carbon doesn't sustainable to be economy sustainable hydrogen. Challenge in build infrastructure discussed from perspective planning for the economy of hydrogen production feasibility. In this study, the economic feasibility of hydrogen production was calculated from raw oil palm empty fruit bunches in North Sumatra. Assessment of several factors in getting results BEP production value is 175.965 kg with a value of Rp37,684,532,764 NPV, IRR of 13.976%, and PBP during 6 years, 5 months.

1. Introduction
The palm oil industry in Indonesia is growing rapidly and place Indonesia to be the number one in the whole world. The total area of oil palm plantations is around 9 (nine) million hectares, and production crude palm oil (CPO) reaches 25 (twenty five) million tons per year. [1] [2] But a few years ago, the oil palm plantation industry in Indonesia has been in the spotlight from the other countries because the environmental impact caused by biomass which damages the environment and it is necessary to reprocess oil palm biomass.

Oil palm biomass consists of shells, fibers and empty palm oil bunches (EFB). EFB has the highest biomass potential. The process of processing FFB into oil palm produces waste in the form of empty bunches the amount of palm oil reaches 22-23% of raw material for FFB[3]. Efforts to utilize EFB waste who prospects to be developed well easily applied by people in the region this includes the use of EFB as an alternative energy namely hydrogen. Hydrogen in the industry generally produced with use Steam Methane Reforming (SMR) method from natural gas resulting from pyrolysis and gasification methods. The use of Steam Methane Reforming is more efficient than before at a low cost by the pyrolysis process and gasification [4][5].

Indonesia, which consists of many islands, has the challenge of stable supplier and low-cost energy for each island especially in the latest energy such as hydrogen fuel. Asia especially Indonesia is one
of the places rich in renewable power [6]. Resources, security factors, better ability to accept the public, and government often affect orientation application of hydrogen energy in the country.[7] A hydrogen-based economy is a long-term view of many countries for sustainable energy system. The main goal of a hydrogen-based economy is to replace the existing energy sources used today (methane gas to produce energy heat and electricity, liquid fuels for the transportation sector) with hydrogen[8][9].

There is a research on the application of hydrogen in fuel cell technology, especially in countries development. However, adoption of alternative vehicle technology, in particular using hydrogen fuel cells is a good thing [10]. Hydrogen is the lightest and most abundant element in universe. Hydrogen does not exist in the free element but in the form of compounds. Hydrogen is also a high-quality energy which store and transmit forms of energy electricity produced from various resources and as a product from chemical processes [11].

In a short term, hydrogen production which is distributed through natural gas reform or by electrolysis will be the most potential approach to introducing hydrogen technology and the beginning to build a hydrogen infrastructure. Although in the long term, large-scale hydrogen production centralization facilities based on hydrogen production through coal gasification and by biomass gasification will benefit the economic scale and needed to meet the needs of hydrogen and in the future will have a positive effect on the national economy [12][13].

Calculation of investment criteria is to find out how far the planned business idea or project can provide benefits, both from the financial benefits and social benefits. Other factors tested are:

- Net Present Value (NPV)
  Net Present Value is an investment criterion that is widely used in measuring whether a project is feasible or not.

- Internal Rate of Return (IRR)
  The Internal Rate of Return is a discount rate that results in a net present value equal to 0 (zero). Thus, if the IRR calculation results are greater than the Social Opportunity Cost of Capital (SOCC) it is said that the project is feasible, if it is the same as SOCC, it means that the project is home and under SOCC, the project is not feasible.

- Pay Back Period (PBP)
  Pay Back Period is a certain period of time that shows the occurrence of receipts (cash flows ) cumulatively equal to the amount of investment in the form of present value.

- Break Even Point (BEP)
  Break Even Point is the principal return point where total revenue equals with total cost. Formula used for calculate the BEP shows time return total cost , as the following [14][15][16]:

\[
\begin{align*}
TR = TC \\
(P)(N_{BEP}) = (TFC)+(VC)(N_{BEP}) \\
N_{BEP} = \frac{TFC}{P-VC}
\end{align*}
\]

Where:
- \(N_{BEP}\) = Number of output points for return point
- \(TFC\) = Total fixed cost
- \(P\) = Sale cost per product unit
- \(VC\) = Variable cost per product unit

There are several conclusions in the Break Even Point:
1. If TR> TC then get profit
2. If TR = TC then a break even point happens
3. If the TR <TC then the company of loss experiences
- Profitability Index (PI)
  Profitability Index is the activity ratio of the total present value of net income with the present value of investment outcome over the investment life. PI (Profitability Index) shows how much we earn or lose on the investment [17].

2. Methodology
The purpose of the study is to measure the level of hydrogen feasibility and hydrogen availability production process from Oil Palm Empty Bunches. The data were collected from many research of build renewable energy industry and information of cost empty bunches. The data are the investment capital, fixed costs and variable costs. First, the data is investment of capital data where it consist of investment used in manufacture product from the machinery and equipment. Second data is fixed costs to run the company each years, the example are operating labour, maintenance, etc. The last is variable costs where it consist of material for production. The data is used for feasibility economic analysis with financial aspect.

On the financial aspect the feasibility of the factors test is the NPV (Net Present Value), IRR (Internal Rate of Return), BEP (Break Even Point), PBP (Payback Period), and Profitability Index (PI) are tested. The calculation starts from describe the investment capital data component, fixed costs and variable costs. Then the hydrogen cost is calculated to obtain a BEP value and as a basis for calculating the value of the tested factor.

3. Result and Discussion

3.1. Investment of Capital Data
Investment capital is investment used in manufacture product from the machinery and equipment. Fixed capital investment per 1000 kg capacity equal to $4,031/Rp55,986,000/kg/day. By the number of working days obtained Rp17,467,632.000 / kg / year. The total capital cost plant is as fixed capital investment as + working capital working capital where 10% of the fixed capital cost and the total plant capital costs Rp 1,746,763,200 + Rp17,467,632.000 = Rp19,214,395.200.

3.2. Fixed Cost Component
The fixed cost component is the costs included each year to run the company [18]. These components consist of:

| Name            | Price/Unit (Rp) | Category                                      |
|-----------------|-----------------|-----------------------------------------------|
| Operating labor | 65,977,776,00   | - 2 employee-hours per 1000 kg of product * work hour  |
|                 |                 | - Workers = 16 people                         |
|                 |                 | - District / City Minimum Wage Data = Rp. 2,749,074.00 |
| Maintenance     | 29,112,720,00   | - 2% FCI                                      |
| Insurance       | 14,556,360,00   | - 1% FCI                                      |
| Supervision     | 4,398,518,40    | - 10% labor                                   |
| Laboratory      | 4,398,518,40    | - 10% labor                                   |
| Plant Overhead  | 21,992,592,00   | - 50% labor                                   |
| Depreciation    | 145,563,600,00  | - 10% FCI                                     |
| Finances        | 160,119,960,00  | - 10% TCI                                     |
| **Total**       | 446,120,044,80  | Per Month                                     |
|                 | 5,353,440,537,60| Per Year                                      |
3.3. Cost Component Changed

Variable cost of Components for produce hydrogen are:

Table 2. Variabel Cost.

| Raw Materials and Others | Price (Rp) | Unit | Amount | Total | Information                        |
|--------------------------|------------|------|--------|-------|------------------------------------|
| EFB                      | 10, 00 Kg  | 2212 | Rp1,106,050 | EFB Requirements 2212 1 per day |
| Water                    | 26, 00 Litre |      | 442420 |       | Water needs for 5 kg of TKKS = 100 litres |
| Electricity              | 1,467.28 kWh| 68132.68 | Rp99,969,719 | Electricity needed for 1 kg EFB = 3.08 kWh |
| Plant Supplies           | -          | -   | 10%    | Rp2,911,272 | 10% Maintenance                   |

| Total                    |           |       | Rp3,002,738,978 | Per month |
|                         |           |       | Rp36,032,867,742 | Per year |

3.4. Break Even Point

As a measurement undertaken for determine Break Even Point namely:

- Determination of Sell Cost Product
  
  If the profit desirement of company is by 10% as the following:
  
  Profit = TR - TC
  
  10% . TC = TR - TC
  
  (TFC + TVC) (10 % + 1) = TR
  
  P = Rp. 145,913
  
  P ≈ Rp 146,000

  Obtained sell cost product is Rp 146,000.00

- Determination of BEP Point
  
  Variable cost of one kilogram hydrogen calculated
  
  TC = TR
  
  TFC + VC (N BEP) = (P) (N BEP)
  
  Rp. 5,353,440,538 + Rp. 11 5 490 (N BEP) = Rp. 145,913 (N BEP)
  
  N BEP = 175.965 kg / year

  From these results it can be said that the return point of the company is if the production volume has reached 208,720 kg of hydrogen per year. BEP chart from production hydrogen can be seen in Figure 1.
3.5. Net Present Value (NPV)
Calculation of Net Present Value (NPV) with steps as the following:

- Profit Before Tax
  Income Hit Tax for mandatory Corporate tax in the country and form business fixed. High tax determined from dirty profit.
  Profit Before Tax = Acceptance - Total Cost
  Reception = Rp. 45,524,939,107
  Cost Production = TFC + TVC
  = Rp. 5,353,440,538 + Rp. 36,032,867,742
  = Rp. 41,386,308,279
  Profit Before Tax = Rp. 4,138,630,828

- Net Cash Flow
  Net cash flow is in cash flow every time year. High net cash flow is bruto profit minus tax of income. Net cash flow is in cash flow every time in year. High net cash flow is reception minus the total cost and tax income.
  Net cash flow = Profit before tax - Income Tax
  Net cash flow = Rp. 4,138,630,828 - 30% x Rp. 4,138,630,828
  Net cash flow = Rp. 2,897,041,580

\[
NPV = \sum_{i=1}^{n} NB_i (1 + i)^{-n} \tag{2}
\]

Where:

- \(NB\) = Net Benefit = Benefit - Cost
- \(B\) = Discount Benefits
- \(C\) = Discount Cost
- \(i\) = Discount Factor
- \(n\) = Year (time)

Then NPV = Rp37,684,532,764
3.6. Internal Rate Of Return (IRR)

IRR is value discount rate $i$ of NPV from project equal with zero. The formula used is as the following:

$$
\sum_{k=0}^{N} R_k (P/A, 1\%, k) = \sum_{k=0}^{N} E_k (P/F, 1\%, k)
$$

Then do calculation use formula as the following:

$$
Rp.2,897,041,580 (P/A, i\% ,20) - Rp19,214,395,200 = 0
$$

From the table obtained:

- $i = 13\% \Rightarrow (P/A, i\% ,20) = 7.0247$
- $i = 14\% \Rightarrow (P/A, i\% ,20) = 6.6231$

$$
IRR = 13\% + 0.98 = 13.98\%
$$

From the results calculation IRR obtained, businesses the product hydrogen said worth it because IRR obtained is 13.98% higher than level tribe interest applied by Bank Indonesia last one year (4.75%).

3.7. Payback Period

Payback period is period time required for return of capital investment. Selection happen on projects that the shortest return period. Calculation of Cash Balance is as the following:

Cash Balance year $n = \text{Flow cash n year} + \text{Balance cash of year (n-1)}$

In the year 0: - Rp19,214,395,200

In the year 1: Rp 2,897,041,580 + - Rp19,214,395,200 = -Rp16,317,353,620

$$
PBP = T_{p-1} + \frac{\sum_{i=1}^{n} I_i - \sum_{i=1}^{n} B_{icp-1}}{B_{p}} (B_{p} - B_{icp-1})
$$

where:

- PP = Payback Period
- $T_{p-1}$ = Year before there is PP
- $I_i$ = Number of investments discounted
- $B_{icp-1}$ = Number of benefits discounted before Payback Period
- $B_{p}$ = Number of benefits on Payback Period

Then,

$$
PP = 6 + \frac{\text{Rp1.064.895.857}}{\text{Rp1.064.895.857} + \text{Rp1.832.145.723}} (6-5)
$$

PP = 6,367 = in 6 year. month of $(0,3675 \times 12 = 4,4109 \approx 5)$

It can be seen that production hydrogen experiences Payback Period of capital investment approximately in the 6 year 5 months.

3.8. Profitability Index (PI)

The PI method produces an PI profit index where if PI > 1 then the investment is declared feasible and if PI < 1 then it is declared not feasible. Calculation of PI from hydrogen production is as follows. Profitability Index (PI) is total cash inflows divided by investment value,
The Profitability Index (PI) is calculated as follows:

\[
\text{Profitability Index (PI)} = \frac{\text{Rp103,302,805.249}}{\text{Rp19,214,395.200}} = 5.376
\]

The PI value = 5.376 > 1 then the business investment is declared feasible.

4. Conclusion

From financial calculations, financial feasibility can be concluded. It can be concluded that the production of hydrogen from empty palm oil bunches is feasible. Then the sensitivity analysis is done by changing several factors affects the financial. The factors are changed the cost of raw materials (increase of 10% to 50%). Based on sensitivity analysis, the increase in the cost of raw materials causes an increase in the seven factors calculated. This is because every range of cost increase is taken by 10% profit.

Based on the feasibility of using EFB in other products, the feasibility of the hydrogen plant is low. For example the processing of EFB becomes fertilizer, based on the IRR (Internal Rate of Return) research which is produced at 14.48% with a Payback Period produced at 2.36 years. [19]. This is because there is no knowledge of alternative fuel for the community and consumers specifically for hydrogen. But over time hydrogen needed by Indonesia based on project demand and energy supply for the next 2012-2035 period.

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