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Feasibility Study of Bitumen Asphalt (Asbuton) Plant in Mass-Production Scale

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Abstract

Purpose – This study aims to assess the operational and financial feasibility of mass-producing Asbuton (Buton natural asphalt) as a sustainable alternative material for road construction in Indonesia.

Methodology – This study adopts a feasibility study framework integrating operational and financial analyses. The operational assessment covers plant location selection, plant capacity determination, facility layout planning, and production process evaluation. Financial feasibility is analyzed through projected cash flow estimation based on capital and operational expenditures, employing investment appraisal indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP). A sensitivity analysis is further conducted to evaluate the impact of price variations on project viability.

Findings – The results indicate that the proposed Asbuton production plant is both operationally and financially feasible. The financial indicators demonstrate satisfactory investment performance, while sensitivity analysis shows that the project remains viable under reasonable fluctuations in key economic variables. Technological advancement and efficient operational planning play a critical role in improving cost efficiency and competitiveness.

Originality – This study offers a comprehensive feasibility assessment by integrating operational design, financial evaluation, and sensitivity analysis for large-scale Asbuton production. It contributes empirical evidence to the limited literature on natural asphalt commercialization in emerging economies, particularly Indonesia.

Introduction

Development of Indonesia, with its large population and high economic growth, requires robust infrastructure to support land transportation. The development of national and regional infrastructure is crucial for spurring economic growth, reducing unemployment, alleviating poverty, and improving people's welfare (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2012). The government is committed to enhancing infrastructure development, recognizing its significance in supporting economic activities and business growth. Roads, as a critical part of infrastructure, facilitate the distribution of goods and services, contributing

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significantly to economic and social development (Herez, 2019). Asphalt, essential for road construction, is increasingly in demand as Indonesia continues to build toll roads, airports, ports, and other infrastructure projects (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2011).

From 1996 to 2021, the length of national roads in Indonesia increased, with national non-toll roads spanning 47,017.27 km (Keputusan Menteri Pekerjaan Umum dan Perumahan Rakyat No. 248/KPTS/M/2015). The National Medium-Term Development Plan (RPJMN) drives the rising demand for asphalt, focusing on preserving 15,616 km of road assets from 2022 to 2024. The Indonesian Buton Asphalt Developers Association (ASPABI) projects asphalt demand from 2022 to 2024 to be 862,000 tons per year, with a total national requirement of around 1.2 million tons annually (Miswanto et al., 2023). However, Indonesia's domestic production, mainly by Pertamina, meets only a fraction of this demand, necessitating imports to fill the gap.

The high demand for asphalt impacts Indonesia's international trade, with significant imports required to meet domestic needs. This reliance on imports, amounting to approximately IDR 50 trillion annually, exposes the country to supply instability and price fluctuations (Anggraeni, 2021). Despite having 662 million tons of domestic asphalt deposits, mainly in Buton Island, Indonesia struggles to fully utilize these resources (Pasra et al., 2022). Natural Buton asphalt, a mixture of bitumen and rocks, offers superior engineering properties and potential benefits for road construction (Sumiati et al., 2019).

Efforts to reduce asphalt imports have led to regulatory measures and increased focus on utilizing domestic resources. The Ministry of Public Works and Public Housing issued regulations to promote the use of Buton asphalt for road construction (PerMen PU No. 35 Year 2006). Supported by research initiatives from institutions like Sepuluh Nopember Institute of Technology (ITS), these efforts aim to develop sustainable bitumen processing technologies and optimize the use of Buton asphalt in infrastructure projects.

The need of designing asbuton’s plant and financial feasibility are needed. Effective facility planning, encompassing the design and arrangement of people, machines, and activities, is essential for operational efficiency and cost reduction (Garcia-Diaz & Smith, 2008). This research aims to design an operational and financial projection for bitumen asphalt (asbuton) production, evaluate the feasibility of an asphalt bitumen plant, and develop a facility layout that supports sustainable technology and business operations.

Literature Review

Asbuton

Asphalt is a dark brown to black, cement-like material primarily composed of bitumens, derived from petroleum refining or naturally occurring. It can be classified into three types: artificial asphalt, natural asphalt, and polymer asphalt (Simanjuntak & Saragi, 2013; Permana & Aschuri, 2009; Al-Amri, 2019; Adebiyi & Akhigbe, 2015). Natural asphalt forms through geological processes and includes types like natural lake asphalt and natural rock asphalt, found in places like Buton Island and Lake Trinidad (Al-Amri, 2019; Riadi, 2019). Artificial asphalt is produced from petroleum refining, and polymer modified asphalt includes polymers for improved pavement properties (Prastanto et al., 2015). Bitumen asphalt, or asbuton, is a natural mixture of bitumen and rocks, with bitumen content varying in Buton asphalt from B10 to B40 (Lasbutag). Asbuton processing involves extracting bitumen from limestone and upgrading it through refining techniques like hydrocracking and hydrotreating (Yuniarti, 2015). The asphalt production process includes selecting and heating aggregates, mixing them with bitumen, and ensuring uniform dispersion to create a cohesive mixture. The hot asphalt mixture is then transported to construction sites for compaction (Novin Trades, 2023).

Feasibility Study

This study contains 2 (two) feasibility studies. Technical feasibility evaluates the operational capabilities of an organization to determine if they meet the proposed project requirements and identifies any technical constraints early in the feasibility study, allowing for alternative solutions if needed (Blecke, 1966). Operational feasibility analyzes potential methods to run the project or business, predicting possible outcomes and solutions (Basuki, 2020). Economic feasibility assesses all cost aspects of a project to understand how financial conditions impact decision-making, aiming to determine if the project will be profitable or not (Bridgwater, 1995).

Operations Feasibility

Operational planning involves creating a production schedule detailing the type, quantities, and sequence of products (capacity planning), and the order of production tasks (work schedule and capacity utilization) (Greasley, 2013). It also establishes machine operation times, accounts for delays and changeover times, and outlines production process phases (Sule, 2007). In this research, emphasis is on facility layout planning for the asbuton plant. Facility layout planning determines the products to be produced, production levels, necessary equipment, equipment placement, and product pathways within the facility (Askin, 1986). Proper layout design aims to reduce injuries, environmental harm, property damage, and business disruptions from toxic releases, fires, and explosions (CCPS, 2018).

Financial Feasibility

Financial management involves utilizing financial projections to influence an organization's financial health, allowing for project planning, forecasting future financial outcomes related to capital and resources, and maximizing investment returns (St Kliment Ohridski et al., 2017). It defines how organizations achieve strategic objectives, identifying raw materials, production, and efficient market methods, impacting resource utilization and profitability. Net Present Value (NPV) is the difference between the present value of net cash flow and the investment's present value, suitable for evaluating projects involving cash flows over time (Khan, 1993; Pujawan, 2004). The payback period, the years needed to recoup investment through cash flows, straightforwardly determines when cash outflows are recovered, with shorter periods indicating favorable outcomes (Brigham & Houston, 2019; Brooks, 2018). The Internal Rate of Return (IRR) is the discount rate where NPV equals zero, estimating the project's rate of return (Brigham & Houston, 2019).

Sensitivity Analysis

Sensitivity analysis (SA) is a scientific method used to explore how a system's outputs are influenced by its inputs, examining the interactions and effects of various factors such as processes, hypotheses, parameters, and scales (Razavi et al., 2021). This involves systematically changing one parameter at a time to assess its impact on investment feasibility, with key parameters including investment costs, cash flows, residual values, interest rates, and tax rates, all significantly influencing decision-making (Pujawan, 2004). SA is valuable in engineering economics to test scenarios and evaluate financial models, determining which input values most affect financial evaluation criteria and parameters.

Research Methods

Preliminary Data Collection

The preliminary preparation stage is crucial for a study's success, beginning with formulating and identifying issues, followed by gathering structural, numerical, and other pertinent data through quantitative methods and literature studies. Quantitative data collection starts with secondary data to draft a cost budget for the pilot-scale bitumen research project, identifying plant location, and necessary technology or machinery. Literature studies provide fundamental understanding from credible sources, covering theories on asbuton, asphalt plant design variables, and feasibility studies. Key data for this study include financial budgeting for the asbuton research project, identifying labor, materials, machinery, and equipment costs, divided into fixed and variable costs. Identifying asbuton specifications involves understanding the materials for industrial-scale production, gathered through qualitative methods like researcher interviews. Identifying technology and machines follows, ensuring they meet manufacturing process rules. The bitumen asphalt production plant scheme estimates machine capacity, calculates plant size, and determines production methods. Business risks, including market, financial, operational, legal, and management risks, are identified through qualitative interviews. Lastly, other data impacting plant design, like bitumen prices, exchange rates, and inflation, though not directly related, significantly influence decision-making.

Identification Process

The second stage in conducting research is the process of identifying the existing conditions of the plant project. This stage is carried out in order to find out the location of the plant, the size of the plant, how much total investment the plant need, and the long-term scheme of the plant and the desired production capacity. In this stage, further projections can be made regarding future business and technical projections (production quantities that can affect the feasibility test of scale up from the pilot stage to the mass-production stage).

Feasibility Study

The technical feasibility study involves identifying operational parameters, including production processes and facility layout.

The financial feasibility study, in turn, examines financial modeling, initial investment, cash flow calculation, and financial analysis metrics such as net present value (NPV), internal rate of return (IRR), and payback period (PBP). These metrics are used to assess the overall profitability, expected rate of return, and time to recover the initial investment, providing a comprehensive view of the project's financial viability.

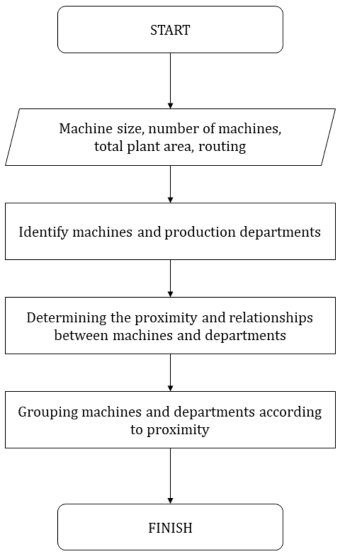

Figure 1. Layout Planning Flowchart

Sensitivity analysis examines how changes in construction, benefit, and operational costs affect the investment parameters. It involves identifying key variables and determining their ranges for best- and worst-case scenarios. The more sensitive a business is, the more unstable it will be to changes in conditions (Anityasari & Wessiani, 2011).

Results and Discussion

Operational Feasibility

The asbuton plant is planned to be built on an area of 5 ha with a size of 50,000 m2 in an industrial area located in East Java. The size of the plant will be 250x200 m. The technical assumptions in making the plant can be seen below.

Table 1. Technical Assumptions

Parameter	Value	Metrics
Production Target	10,000	ton/year
Proposed Land Area	5	hectare
Production Method	*continuous*	
Production Capacity (per hour)	1,947.04	kg/hour
Total Working Hours (per year)	5,136	hours/year
Operator Rate	4,000	IDR
Number of Operator (per shift)	10	
Number of Shift	3	per day
Downtime	30	days

Table 2. Calculation Base

Parameter	Value	Source
Calculation Base	214	Project contract
Evaluation Year	2023	Project contract
Asbuton Price	Rp600/kg	Market
Solar Price	Rp8.000/liter	Market
NaOH Price	Rp6.650/kg	Market
Surfactant Price	Rp32.725/kg	Market
Asphalt Price	Rp5.500/kg	RTC Pertamina

The layout of the plant emphasizes cost-effective material and personnel movement and safe distances for hazardous processes. After drafting the design, the author validated it with academic experts of asphalt plant and factory planning. The ideal factory layout, per the Ministry of Industry's regulations, includes roads, green spaces, transportation networks, telecommunications, electricity, water sources, drainage, waste treatment plants, and fertile land. Supporting facilities for industrial activities and labor include a polyclinic, worship facilities, sports facilities, commercial facilities, and security posts.

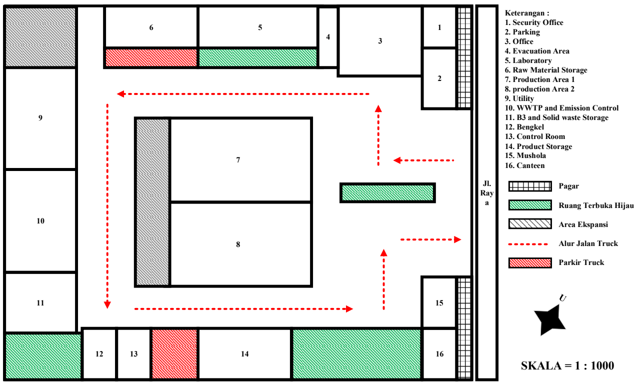

Figure 2. Scale-Up Layout of Asphalt Plant

The layout structure includes process areas, power sources, offices, workshops, warehouses, and waste treatment units (Zhuang, 2016). Key areas in the asbuton plant layout are: the office area, placed away from hazardous processes; the laboratory area, located near raw material storage; the production area, with control rooms close to processing equipment and product storage; utility buildings, placed to minimize piping between process units and located behind the factory; and waste collection and processing, with the wastewater treatment plant near production areas for efficient waste flow and hazardous material storage.

Table 3. Breakdown of Land and Equipment Area

Building	Dimension (m)		Area (m^2)
	Height	Width	
Security	23	18.4	423.2
Parking	32.5	18.4	598
Office	37.5	45	1687.5
Evacuation area	32.5	10.85	352.625
Laboratory	23	66.5	1529.5
Raw Material Storage	23	50	1150
Production area 1	45	78.5	3532.5
Production area 2	45	78.5	3532.5
Utility	55	38.5	2117.5
WWTP	55	38.5	2117.5
B3	32.5	38.5	1251.25
Workshop	27.5	18.4	506
Control Room	27.5	18.4	506
Product Storage	27.5	50	1375
Prayer's Room	27.5	18.4	506
Canteen	27.5	18.4	506

Financial Feasibility

The financial feasibility assessment involves a thorough analysis incorporating key metrics such as Net Present Value, Payback Period, and Internal Rate of Return.

Tabel 4. Financial Assumptions

Parameter	Value	Source
Corporate Tax Rate	22%	MoF Decree 90/2023
Discount Rate	11%	Financial Statement
Perpetual Growth Rate	5%	Indonesia GDP
Fixed Capital Investment	Rp20.000.000.000	Project contract
Inflation Rate 2025	2.5%	IMF
Inflation Rate 2026	2.51%	IMF
Inflation Rate 2027	2.28%	IMF
Inflation Rate 2028	1.62%	IMF
USD Exchange Rate	Rp15.755	Central Bank of Indonesia

The price of the asphalt in the next year can be estimated using the CAGR formula. First, before determining the revenue that the project will generate, we can benchmark the price of asbuton to the market price of oil asphalt by finding the average annual growth rate to make the price competitive

$$CAGR = \left(\frac{Vfinal}{Vbegin}\right)^{1/t} - 1 \qquad (1)$$

The growth rate of asphalt price is 8.13% per year. The initial asbuton price in 2024 was set at Rp5,500 per kilogram using data from the asbuton feasibility test analysis by Pertamina's Research and Technology Center (RTC). Using this price and an annual growth rate of 8.13%, it was found that the price range for asbuton is between Rp5,500,000 and Rp7,519,895 per ton from 2024 to 2028.

Table 6. Financial Analysis

Year	Project
NPV	Rp12,172,470,493.49
IRR	46.80%
Payback Period	2.2 years

The base case scenario with an asbuton price of 5,500 IDR/kg results in a positive present value of Rp12,172,470,493 in the first year, indicating a positive NPV and capital gain. The project's IRR for 2024-2028 is 46.80%, significantly higher than the 11% discount rate, suggesting profitability and a good return on investment. The payback period (PBP) for the project is 2 years and 2 months, meaning the initial investment is quickly recouped, reducing investment risk and indicating swift cash flow generation. Positive cash flow is achieved by the third year, ensuring the project's ability to cover investment costs and start generating profits. Overall, the data suggests the asphalt plant project is feasible, with a high IRR and short PBP.

Sensitivity Analysis

The number of indicators used in the sensitivity analysis was reduced by -40% to +40% to find out how sensitive the changes in the values of NPV, IRR, and PBP are when some of these indicators change in the market later.

Tabel 7. Sensitivity Analysis of Price and CAPEX Indicators

Sensitivity Scenario	NPV		IRR		PBP	
	Price	CAPEX	Price	CAPEX	Price	CAPEX
40%	36,037,808,187	10,346,669,386	83.58%	37.99%	1.5	2.5
30%	33,118,075,247	9,780,624,178	80.00%	38.29%	1.5	2.5
20%	30,251,354,483	8,957,306,670	76.34%	38.24%	1.5	2.5
10%	27,436,808,404	10,535,190,864	72.62%	42.16%	1.6	2.4
0%	24,682,169,317	15,001,262,381	68.83%	51.44%	1.6	2.1
-10%	19,440,945,661	15,864,912,169	61.06%	56.13%	1.8	2
-20%	16,777,994,309	15,447,029,753	56.89%	58.82%	1.8	1.9
-30%	16,683,955,578	17,084,309,383	56.83%	66.92%	1.8	1.7
-40%	14,118,054,202	18,721,589,013	52.58%	77.26%	1.9	1.5

The data in table 7 is used as a graph according to the respective financial analysis.

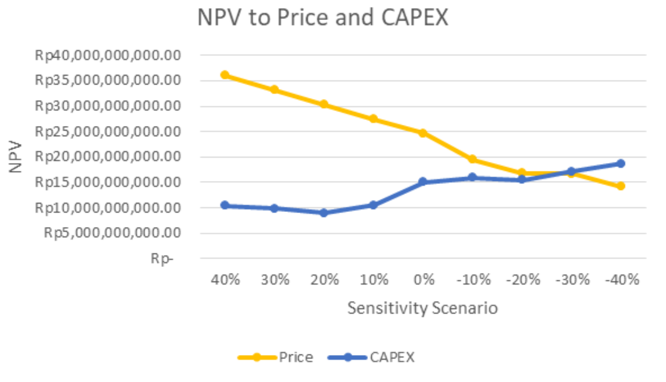

Figure 3. Sensitivity Analysis of NPV to the Price and CAPEX

The analysis of NPV suggests that there is a positive correlation between increases in price, leading to higher NPV. Similarly, when price decreases, resulting in lower NPV. The pattern of change of the two indicators is directly proportional, where the lower the price, the lower the NPV. Nevertheless, there's a difference in CAPEX, where the smaller the CAPEX, the higher the NPV. However, it can be seen that changes in the CAPEX variable do not have much effect on NPV, judging from the slope of the graph, which is not as steep as changes in product prices. The Net Present Value (NPV) is most responsive to variations in unit sales and unit prices compared to changes in cost per unit, tax rates, and salvage values (Durham et al., 2015). From the results of the sensitivity analysis of NPV, it is concluded that the factors that have the most influence on changes in the NPV value is price indicators.

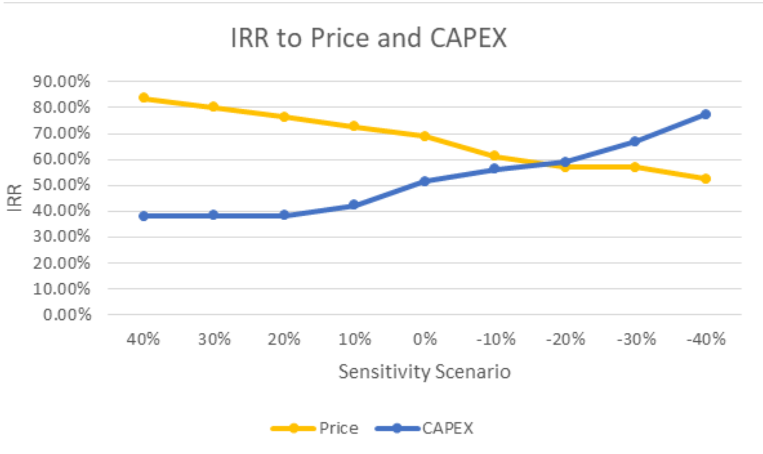

Figure 4. Sensitivity Analysis of IRR to the Price and CAPEX

The sensitivity analysis of the project's internal rate of return (IRR) reveals that it is highly sensitive to changes in product pricing and capital expenditure (CAPEX). As the price increases, the IRR also increases, reaching its highest value at a 40% price increase (IRR = 83.58%). Conversely, a decrease in price results in a decrease in IRR, with the lowest value observed at a 40% price decrease (IRR = 52.58%). Similarly, a decrease in CAPEX results in an increase in IRR, while an increase in CAPEX results in a decrease in IRR. The results highlight the critical role of effective cost management and pricing strategies in enhancing project profitability.

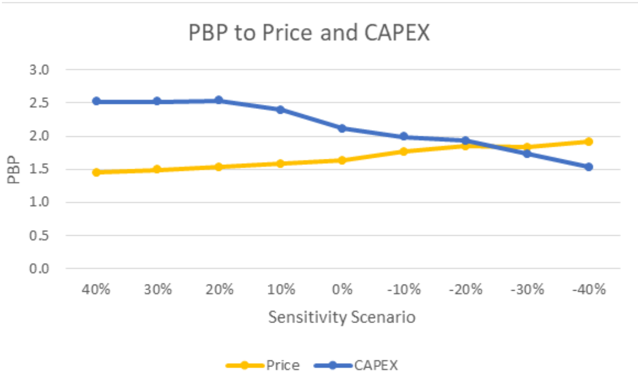

Figure 5. Sensitivity Analysis of PBP to the Price and CAPEX

The sensitivity analysis of the asphalt plant's payback period (PBP) reveals that price increases shorten the PBP, while capital expenditure increases lengthen it. A 40% price increase results in a PBP of 1.5 years, while a 40% decrease results in a PBP of 1 year and 9 months. Conversely, a 40% increase in capital expenditure results in a PBP of 2.5 years, while a 40% decrease results in a PBP of 1.5 years. The results indicate that price changes have a greater impact on the PBP than changes in capital expenditure, underscoring the importance of considering price fluctuations in investment decisions.

Business Risks

To prepare the business for future surging risks, identification of business risks is critical to identify and analyze the risks in the business feasibility study to take appropriate mitigation measures. The risks identified include market risks, financial risks, operational risks, legal and regulatory risks during plant operations, and management risks. Data collected was conducted through industry analysis.

In the financial risk category, the main risks identified include market price fluctuations and changes in capital. Market price fluctuations arise from changes in asphalt prices and increasing competition, leading to decreased income if market prices continue to decline. Changes in capital involve variations in the capital provided by the company at the project's inception, which can result in low capital and reduced company performance in producing asbuton due to weak market demand.

Strategic risks include commercial risk and business line risk. Commercial risk occurs when asphalt sales do not align with projections due to customers switching to competitors, resulting in a decline in market share. Business line risk involves inadequate product synergy and limited product innovation, leading to decreased customer trust in the company's offerings.

Operational risks focus on employee turnover and AMP technical problems. High employee turnover rates, especially among plant engineers, are caused by inadequate compensation and benefits, resulting in a loss of competent workers and reduced factory performance. Production disruptions are caused by technical issues at the Asphalt Mixing Plant (AMP) due to poor maintenance, leading to non-achievement of asphalt production targets and disrupted sales.

The Risk Register outlines specific mitigation strategies for each identified risk, along with their positive and negative impacts. For financial risks, market price fluctuations can be mitigated by implementing careful cost analysis and setting competitive prices to maintain market share and revenue, although this might trigger price wars. Changes in capital can be managed by optimizing expenditure and seeking alternative funding sources to extend the cash runway and maintain business operations, which may require compromises in business financing.

In strategic risks, commercial risk can be mitigated by monitoring sales movements and providing renewal offers to retain and attract customers, potentially affecting profit margins. Business line risk can be addressed through regular market research and developing new formulas to increase customer satisfaction and loyalty, which requires significant investment in time, resources, or money.

For operational risks, employee turnover can be mitigated by offering fair incentives and bonuses, along with competitive compensation and benefits, to enhance employee satisfaction and productivity. However, inadequate compensation might lead to lower productivity and product quality. Production disruptions can be prevented by scheduling regular machine maintenance and establishing standard operating procedures (SOP) to avoid machine damage and ensure worker safety, despite the potential for production stops during serious equipment failures.

Conclusion

Starting from the feasibility of technical or operational aspects, the Company must ensure the long-term availability of raw bitumen material, which is the main ingredient in making asbuton. The capability of the machine used has been calculated, resulting in an asbuton production capacity of 10,000 tons per year. The 5 hectares of land provided is sufficient to produce 10,000 tons of bitumen with various considerations of economics, utilities, distance between machines, storage, and process areas. The land area of the asphalt plant is already sufficient based on the government's policy for industrial estates. The placement of rooms and buildings is also in accordance with applicable regulations. From an operational perspective, facilities and machinery are not a problem; this plant project is feasible in terms of technical aspects. Analysis from the financial side, based on the calculation of costs and revenues, shows that the initial investment of Rp20,000,000,000 yields a positive NPV (Net Present Value) of Rp12,172,470,493.49, indicating the project plan is feasible to run because NPV > 0. The IRR (Internal Rate of Return) value of 46.80% and a discount rate of 11% further confirm the project's feasibility, as IRR > Discount Rate, with the Payback Period estimated at 2 years and 2 months. The financial structure of the project is calculated with the main revenue coming from asbuton sales, assuming 100% of the production capacity is sold at an asphalt price of Rp5,500, with a price increase of 8.13% per year based on CAGR calculation, demonstrating the project's financial viability. Sensitivity analysis results show that variables like the price of asphalt plant products significantly impact financial indicators. A decrease in price can negatively affect the NPV, IRR, and payback period of the project, whereas a higher price can positively impact these indicators. Changes in capital expenditure (CAPEX) also affect the project's financial feasibility. Higher CAPEX lowers NPV and IRR and lengthens the payback period, impacting economic viability, while lower CAPEX increases NPV and IRR and shortens the payback period. To generate a profitable investment, the price must be raised, and CAPEX lowered. The most sensitive variable affecting changes in NPV, IRR, and Payback Period is the price.

Recommendations

The research suggests that for the asphalt industry to be successfully competitive in setting up an asbuton plant, it should conduct more in-depth market price research to determine a price competitive with oil asphalt. Since asbuton is still quite new in Indonesia, this presents a great opportunity for the company to set a competitive price. Given the conventional nature of the product line, most revenue comes from asbuton sales. With the demand for asbuton being sensitive, it is recommended that companies consider other income streams, such as selling shares or adding derivative products while considering environmental aspects like reducing waste from asbuton production. For future research, it is suggested that a follow-up study assesses the feasibility of the proposed scenario from the government's standpoint, as the government will be the primary market provider for asbuton. Based on the study results, it is hoped that project feasibility tests will always include business risk factors in the analysis for more accurate calculations. Business risk analysis can help understand potential changes in the company's operational and financial structure with the sensitivity scenarios discussed. Additionally, considering novel unorthodox financing alternatives in the future may bring better benefits, so it is recommended to reevaluate the financing market and strategies repertoire periodically.

References

A. Garcia-Diaz and J. M. Smith, *Facilities Planning and Design*, 1st ed. New York: Perason, 2008.

A. Greasley, *Operations Management*, 3rd ed. Wiley, 2013.

A. Miswanto, I. Suherman, T. Suseno, and W. Pravianto, “Study of supply-demand of Indonesia buton asphalt,” *Indonesian Mining Journal*, vol. 26, no. 1, pp. 49–59, 2023, doi: 10.30556/imj.Vol26.No1.2023.1364.

A. V. Bridgwater, “The technical and economic feasibility of biomass gasification for power generation,” *Fuel*, vol. 74, no. 5, pp. 631–653, May 1995, doi: 10.1016/0016-2361(95)00001-L.

C. A. Durham, A. Bouma, and L. Meunier-Goddik, “A decision-making tool to determine economic feasibility and break-even prices for artisan cheese operations,” *J Dairy Sci*, vol. 98, no. 12, pp. 8319–8332, Dec. 2015, doi: 10.3168/jds.2014-9252.

C. CCPS, *Guidelines for Siting and Layout of Facilities*. Wiley, 2018. doi: 10.1002/9781119474821.

C. J. Blecke, *Financial Analysis for Decision Making*, 1st ed. Pentrice-Hall, 1966.

D. R. Sule, *Production Planning and Industrial Scheduling: Examples, Case Studies and Applications*, 2nd ed. CRC Press, 2007.

E. F. Brigham and J. F. Houston, *Fundamentals Of Financial Management*, 15th ed. Boston: Cengage Learning, 2019.

E. Zhuang, "Process location and layout decisions," *Northwestern University Chemical Process Design Open Textbook*. Northwestern University, Evanston, 2016.

F. Al-Amri, "STUDI PERBANDINGAN PENGGUNAAN ASPAL MINYAK DENGAN ASPAL BUTON LAWELE PADA CAMPURAN ASPAL CONCRETE BASE COURSE (AC-BC) MENGGUNAKAN METODE MARSHALL TEST," *RADIAL – juRnal perADaban saIns, rekayAsa dan teknoLogi Sekolah Tinggi Teknik (STITEK) Bina Taruna Gorontalo*, vol. 4, no. 2, pp. 181–190, Sep. 2019.

F. M. Adebiyi and G. E. Akhigbe, "Characterization of paraffinic hydrocarbon fraction of Nigerian bitumen using multivariate analytical techniques," *Journal of Unconventional Oil and Gas Resources*, vol. 12, pp. 34–44, Dec. 2015, doi: 10.1016/j.juogr.2015.09.003.

H. Prastanto, A. Cifriadi, and A. Ramadhan, "KARAKTERISTIK DAN HASIL UJI MARSHALL ASPAL TERMODIFIKASI DENGAN KARET ALAM TERDEPOLIMERISASI SEBAGAI ADITIF," *Jurnal Penelitian Karet*, pp. 75–82, Jun. 2015, doi: 10.22302/ppk.jpk.v33i1.173.

I. N. Pujawan, *Ekonomi Teknik*. Surabaya: Penerbit Guna Widya, 2004.

Kementerian Pekerjaan Umum dan Perumahan Rakyat, "Pemerintah Harus Tingkatkan Produksi Dan Pemanfaatan Asbuton," 2011.

Kementerian Pekerjaan Umum dan Perumahan Rakyat, "Pembangunan Infrastruktur Dorong Pertumbuhan Ekonomi," *Kementerian PUPR*, 2012. Accessed: Sep. 25, 2023. [Online]. Available: https://pu.go.id/berita/pembangunan-infrastruktur-dorong-pertumbuhan-ekonomi

M. Anityasari and N. A. Wessiani, *Analisa Kelayakan Usaha: Dilengkapi Kajian Manajemen Resiko*, 1st ed. Surabaya: Guna Widys, 2011.

M. H. Herez, "Development of a New High Performance Cold Mix Asphalt," *Doctoral Thesis*, 2019, doi: https://doi.org/10.24377/LJMU.t.00010590.

M. Pasra, M. W. Tjaronge, M. A. Caronge, A. R. Djamaluddin, F. E. P. Lapian, and M. Tumpu, "Influence of Tensile Load on Bonding Strength of Asphalt Concrete Containing Modified Buton Asphalt and Polyethylene Terephthalate Waste: A Case Study of Indonesian Roads," *International Journal of Engineering*, vol. 35, no. 9, pp. 1779–1786, 2022, doi: 10.5829/IJE.2022.35.09C.14.

M. Riadi, "Fungsi, Sifat, Jenis dan Analisis Pengujian Aspal." Accessed: Sep. 26, 2023. [Online]. Available: https://www.kajianpustaka.com/2019/03/fungsi-sifat-jenis-dan-analisis.html

M. Y. Khan, *Theory & Problems in Financial Management*. Boston: McGraw-Hill Higher Education, 1993.

Novin Trades, "Bitumen and Asphalt production process."

R. Anggraeni, "Kepala BKPM Kaget Impor Aspal RI Capai Rp50 Triliun : Okezone Economy," *economy.okezone.com*, Mar. 01, 2021.

R. Brooks, *Financial Management: Core Concepts*, 4th ed. Pearson, 2018.

R. G. Askin, "A formulation of the integrated facility layout, product selection and process planning problem," *J Manuf Syst*, vol. 5, no. 4, pp. 267–269, Jan. 1986, doi: 10.1016/0278-6125(86)90057-9.

R. Permana and I. Aschuri, "STUDI SIFAT-SIFAT REOLOGI ASPAL YANG DIMODIFIKASI LIMBAH TAS PLASTIK," in *Simposium XII FSTPT, Universitas Kristen Petra Surabaya, 16-17 Oktober 2009*, 2009.

R. Yuniarti, "KARAKTERISTIK CAMPURAN ASBUTON DENGAN PENAMBAHAN KEROSENE," *Spektrum Sipil*, vol. 2, no. 2, pp. 105–113, 2015, Accessed: Oct. 06, 2023. [Online]. Available: https://spektrum.unram.ac.id/index.php/Spektrum/article/view/26

S. Simanjuntak and Y. Saragi, "Analisa Perbandingan Kualitas Aspal Beton Dengan Filler Bentonite," Lembaga Penelitian Universitas HKBP Nommensen, Medan, 2013.

S. S. A. Basuki, "Evaluasi Penetapan Kebijakan Tarif Angkut Dan Penyesuaiannya Pada Skema Kerja Sama Build-Operate-Transfer Proses Pengangkutan Bahan Tambang Jenis Y Dari

Lokasi Tambang Menuju Smelter Dengan Menggunakan Lokomotif (Studi Kasus: PT. X)," Other Thesis, Institut Teknologi Sepuluh Nopember, Surabaya, 2020.

S. Razavi *et al.*, "The Future of Sensitivity Analysis: An essential discipline for systems modeling and policy support," *Environmental Modelling & Software*, vol. 137, p. 104954, Mar. 2021, doi: 10.1016/j.envsoft.2020.104954.

S. Sumiati, M. Mahmuda, and P. Puryanto, "KEUNGGULAN ASBUTON PRACAMPURAN DAN ASPAL SHELL PADA CAMPURAN ASPAL BETON (AC-BC)," *Jurnal Poli-Teknologi*, vol. 18, no. 1, Feb. 2019, doi: 10.32722/pt.v18i1.1289.

U. St Kliment Ohridski, K. Bojkovska, and N. Jankulovski, "FINANCIAL MANAGEMENT AND FINANCIAL PLANNING IN THE ORGANIZATIONS Vesna Grozdanovska (Corresponding author)," Online, 2017. [Online]. Available: www.vps.ns.ac.rs/Materijal/mat1558