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Techno-Economic Analysis of Utilization of Tofu Production Liquid Waste into Liquid Organic Fertilizer Using Experimental Methods

Rini Gustiari[1]
[1]Universitas Pancasila, Jakarta, Indonesia
rinigustia_r@gmail.com

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ABSTRACT
The Tofu Industry is a company that produces liquid waste that has the potential to pollute the environment and is one of the industries that makes organic waste. The presence of organic elements in tofu liquid waste causes researchers to use tofu liquid waste into liquid organic fertilizer that has added value. This liquid organic fertilizer can be an alternative at a low price compared to other liquid organic fertilizers on the market. This liquid organic fertilizer is manufactured mainly from tofu liquid waste with coconut water, brown sugar solution, and EM4 solution. The method of making liquid organic fertilizer is a random design complete with three treatments. Each sample composition is 1 liter of liquid waste, 2 liters of liquid waste, and 3 liters of liquid waste. The laboratory test results show that in liquid organic fertilizer, N, P, and K show that treatment A has the best results with N values of 0.42%, P 0.13%, and K 0.29%. The results of the techno-economic analysis are that the cost of goods produced is obtained at IDR. 5,178.75 / liter, the break-even point of 95.58 liters, and it takes 42 days to break even. The payback period only takes 0.9 years. For further research, the process of making liquid organic fertilizer should produce samples on a large scale to minimize the calculation of techno-economic analysis in the direct labor wage section.

Keywords: Cost of production, Break Even Point, Payback Period, Techno-Economy, Value Added

INTRODUCTION

Tofu is one of the food industries that produces protein sources with essential ingredients from soybeans, which are very popular with the people of Indonesia (Shahabuddin, 2020). The industry is proliferating in line with the increase in population. On the other hand, this industry produces liquid waste that has the potential to pollute the environment and is one of the industries that produce organic waste (Abdin, 2019).

This research was conducted in the tofu manufacturing industry, and the company has not implemented appropriate measures in handling tofu liquid waste. In a day, the company produces 300 liters of liquid waste, and the waste generated from the treatment process is directly discharged into ponds and trenches in the back area of the company. This waste disposal, if continuously carried out, can cause a very foul odor, kill ecosystems, pollute groundwater, and, of course, affect community health because it could be a source of disease that can be dangerous (Pohan et al., 2023).

Handling unused tofu liquid waste by discharging it into ditches and ponds, the BOD level of waste from this disposal is still very high, which, of course, can affect the life of the aquatic ecosystem, foul odor, and cleanliness of the surrounding groundwater. In connection with that, tofu industry liquid waste can be reprocessed or recycled into organic fertilizer because tofu liquid waste contains organic compounds that can be used to fertilize plants. These compounds are protein by 40-60%, carbohydrates by 25-50%, 8-12% fat, and calcium, iron, phosphorus, and vitamins.

The use of tofu waste for organic fertilizer is made in liquid form to make it easier for plants to absorb nutrients than solid fertilizer. The sale of circulating fertilizers is a reference for the potential market for selling liquid fertilizers from tofu waste. The price of fertilizer in the market is shown in Table 1(Sari & Dini, 2023).

Table 1 Fertilizer Prices in the Market

Fertilizer Name	Types of fertilizers	Characteristic	Price (IDR)
NPK Pearl	Inorganic	Granules	25.000/kg

STU Organic	Organic	Powder	5.000/kg
Kocor Oranik Fertilizer	Organic	Powder	40.000/kg
Tough Decomposer	Organic	Liquid	86.000/liter
POC Nasa	Organic	Liquid	70.000/liter
Organic Compost Planting Media	Organic	Powder	35.000/kg

Table 1 shows that fertilizer prices in the market are pretty variable. Therefore, this study was conducted to obtain economic opportunities in making liquid organic fertilizer and find out the process of making liquid organic fertilizer that is environmentally friendly (Fasihi, 2019). Environmentally friendly means that liquid organic fertilizer no longer emits a pungent stench because, previously, using fertilizer from livestock manure emitted a somewhat pungent odor (Kannah, 2021). Then, fertilizer manufacturers do not use livestock manure alone but utilize unused liquid waste using experimental design as a research method. This will undoubtedly be more useful and have economic opportunities because it uses waste raw materials that previously had no selling value. In addition to processing tofu liquid waste into liquid organic fertilizer and knowing the test of nutrient content contained in fertilizer redeemed from the waste, this study also carried out techno-economic analysis calculations aimed at determining the cost of goods produced (COGS), Break Event Point (BEP) value and Payback Period (PBP) value in making organic fertilizer (Deng, 2019).

The purpose of this study is to make liquid organic fertilizer using tofu liquid waste, carry out laboratory tests, carry out implementation on plants, analyze the techno-economics of making liquid organic fertilizer using tofu liquid waste by calculating the cost of production (HPP), Break Even Point (BEP) and Payback Period (Filhaq et al., 2023; Permadi & Nisa, 2023).

MATERIALS AND METHODS

Data Collection

The data collected is in the form of the composition of materials and tools to be used to manufacture liquid organic fertilizer. The materials and tools to be used are as follows (Lam, 2019):

Material:	**Tools:**
Tofu Liquid Waste	Scales
Coconut Water	Gallon
EM4 Solution	Jars
Brown Sugar	Collider
Clean Water	Spoon
	Bowl
	Dosage
	Funnel
	Filter

Stages of Making Liquid Organic Fertilizer

The process of making liquid organic fertilizer is carried out through several stages, as shown in Figure 1

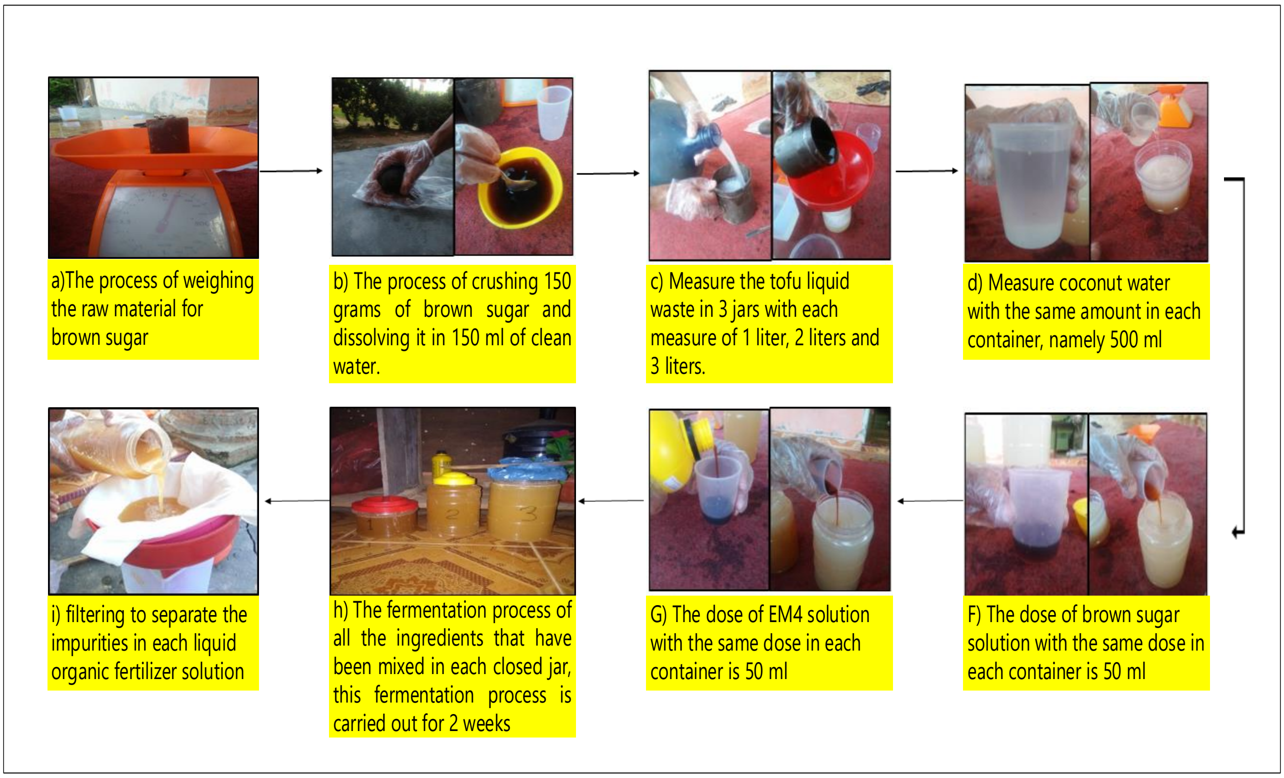

Figure 1 Stages of the process of making liquid fertilizer from tofu waste

Fertilizer-Making Process Based on Complete Random Design

Making liquid organic fertilizer using Complete Random Design by making three experimental treatments using tofu liquid waste material as the main ingredient in making liquid organic fertilizer. The three treatments are as follows (Jamshidi, 2019)(S. Kumar, 2019):

1. Organic fertilizer A with ingredients 1 liter of Tofu Liquid Waste, 500 ml of Coconut Water, 50 ml of brown sugar liquid, 50 ml of EM4 Solution, and 50 ml of clean water.
2. Organic fertilizer B with ingredients 2 liters of Tofu Liquid Waste, 500 ml Coconut Water, 50 ml brown sugar liquid, 50 ml EM4 Solution, 50 ml clean water.
3. Organic fertilizer C with ingredients 3 liters of Tofu Liquid Waste, 500 ml Coconut Water, 50 ml brown sugar liquid, 50 ml EM4 Solution, Clean Water 50 ml.

Techno-Economic Analysis

The techno-economic analysis is done by calculating the value or price of production, the payback time or break-even point, and the payback period of making liquid organic fertilizer from Tofu Liquid Waste (Niermann, 2019).

1. Calculation of Cost of Goods Produced

Production costs aim to find out how much cost is needed for the manufacture of organic fertilizer. The costs in this analysis include all activities (inputs), including funds used to produce a product (Output) within a specific time. The inputs include direct material, labor, and variable overhead costs (Elkadeem, 2019).

2. Break-Even Point Calculation

A break-even point or break-even point is a condition experienced by a company that does not get an income after the company incurs the costs used to meet production activities. In other words, the total revenue equals the total cost (Das, 2019).

3. Payback period calculation

The payback period helps determine how long it takes to recoup investment expenses using cash flow (Ilse, 2019).

RESULTS

Laboratory Tests

Laboratory tests are carried out to determine the value elements of N (Nitrogen), P (Phosphorus), and K (Potassium) contained in liquid organic fertilizer made from tofu liquid waste. There were three samples tested, namely sample A, sample B, and sample C.

Table 2 Composition of making liquid organic fertilizer from tofu liquid waste

Sample	Composition of each POC sample			
	Liquid Waste	Coconut Water	EM4 Solution	Solution. Brown Sugar
Sample A	1 liter	500 ml	50 ml	50 ml
Sample B	2 liter	500 ml	50 ml	50 ml
Sample C	3 liter	500 ml	50 ml	50 ml

Table 3 Test Results of Nitrogen (N), Fospor (P), and Potassium (K)

Sample	N (%)/standard	P (%)/standard	K (%)/standard
Sample A	0.42/0.4	0.13/0.1	0.29/0.2
Sample B	0.40/0.4	0.13/0.1	0.21/0.2
Sample C	0.39/0.4	0.12/0.1	0.21/0.2

Nitrogen content in sample A was 0.42%, Sample B was 0.40, and Sample C was 0.39, meeting the minimum standard for the quality of liquid organic fertilizer, which was an average of 0.4%. Phosphorus content in samples A, B, and C met the minimum standards for the quality of liquid organic fertilizer, namely sample A of 0.13%, sample B of 0.13%, and sample C of 0.12% with a minimum standard of 0.1%. Potassium content in samples A, B, and C met the minimum standard for the quality of liquid organic fertilizer, namely 0.2%, and the K content in sample A was 0.29%. Sample B was 0.21%, and sample C was 0.21%.

Fixed cost

In this study, fixed costs include all costs of depreciation or depreciation of the tools used to make liquid organic fertilizer, and detailed costs can be seen in Table 4.

Table 4 Fixed Cost

No	Tools and materials	Amount	Price	Residual Value	Period Wear (Year)	Depreciation
1	Scales	1	IDR. 120,000	0	4	IDR. 30,000
2	Gallon	1	IDR. 30,000	0	4	IDR. 7,500
3	Jar	5	IDR. 18,000	0	4	IDR. 4,500
4	Pounder	1	IDR. 5,000	0	4	IDR. 1,250
5	Spoon	1	IDR. 1,000	0	4	IDR. 250
6	Mug	1	IDR. 2,000	0	4	IDR. 500
7	Dose	2	IDR.12,000	0	4	IDR. 3,000
8	Funnel	1	IDR. 5,000	0	4	IDR. 1,250
9	filter	1	IDR. 5,000	0	4	IDR. 1,250
Total			IDR. 198,000	Total		IDR. 49,500

Raw Material Costs

Raw material costs are costs incurred in the process of making liquid organic fertilizer. It is assumed that the price of tofu and coconut water liquid waste is because these materials are wasted or no longer used. The details of the costs can be seen in Table 5.

Table 5 Cost of Raw Materials

No	Raw material	Amount	Price
1	Tofu Liquid Waste	1 liter	IDR. 100
2	Coconut water	500 ml	IDR. 50
3	Brown sugar	50 gram	IDR. 800
4	EM4 solution	50 ml	IDR. 1,250
Total			IDR. 2,200

The cost of making raw materials for each manufacturer costs IDR. 2,200 and produces 1.6 liters of liquid organic fertilizer.

Direct Labor Costs

Direct labor costs are used to pay workers who make liquid organic fertilizer. Namely, there is a worker with a salary of IDR. 114,000 per day. Making it requires a short time, only 20 minutes from the weighing process, the dosing process, the mixing process, and until it is ready to be stored for the fermentation process. Wages per Liter = "IDR 11,4000" /"38.4 Liters" = IDR 2,968.75 / Liter

COGS Calculation of Liquid Organic Fertilizer

Cost of Goods Produced Per Liter of Liquid Organic Fertilizer.

The price per Liter of liquid organic fertilizer can be calculated by the total variable cost and divided by the amount of product obtained. The details of costs before calculating the cost of goods produced are in Table 6.

Table 6 Recapitulation of the Cost of Making Liquid Organic Fertilizer

No	Types of Fees	Cost per day	Annual cost
1	Variable costs		
	Cost of raw materials	IDR 84,480	IDR 27,793,920
	Direct labor costs	IDR 114,000	IDR 37,506,000
	Variable overhead	IDR 384	IDR 126,336
	Total variable costs	IDR 198,864	IDR 65,426,256
2	Fixed Costs		
	Depreciation	IDR 136	IDR 49,500
	Total	IDR 199,000	IDR 65,475,756

COGS per Liter = Total variable costs /"POC result

= IDR 198,864 /38.4

= IDR 5,78.75 /liter

Selling price = Total Cost.+ Desired profit/Total Production

= IDR 198,864 + (10% x IDR 198,864) /38.4 liters

= IDR 5,696.6 /liter

Break Even Point (BEP) Calculation

The Break Even Point is the Point of income equal to total costs incurred where the company has not achieved profits and has not suffered losses. The following is the calculation of BEP liquid organic fertilizer from tofu liquid waste:

$$\text{BEP (unit)} = \frac{\text{Fixed cost}}{\text{Selling price per unit-variable per unit}}$$

$$= \frac{\text{IDR 49,500}}{\text{IDR 5,696.6 - IDR 5,178.75}} = 95.58 \text{ liters}$$

$$\text{BEP (IDR)} = \frac{\text{Fixed cost}}{\text{1-Variable cost/sales}}$$

$$= \frac{\text{IDR 49.500}}{\text{1-(IDR 65,426,256/IDR 71,968,566)}} = \text{IDR 544,523,8}$$

$$\text{BEP (time)} = \frac{\text{BEP unit}}{\text{Production volume}}$$

$$= \frac{\text{95,58 liter}}{\text{38,4 liter}} = 2.5 \approx 3 \text{ days}$$

The break-even point of 95.58 liters takes three days to break even by producing 3.8 liters of predetermined liquid organic fertilizer daily.

Payback Period Calculation

The payback period calculates the years it takes to return the initial investment or capital from cash inflow gains. The initial investment is Rp.198,000 to buy organic fertilizer manufacturing equipment and Rp. 198,864 for material costs and wages, then cash inflow is obtained from the production of as much as 38.4 liters at a selling price of Rp.5,696.6 per Liter for one year

Initial investment = IDR.198,000 + IDR. 198,864
= IDR 396,864

Cash in = 38.4 x IDR.5.696.6 x 329 days = IDR. 71,968.566

$$\text{Payback Period} = \frac{\text{Initial investment}}{\text{Cash In}} \times 1$$

$$= \frac{\text{Rp.396,864}}{\text{Rp.71,968,566}} \times 1$$

= 0.0055 years = 1.8 ≈ 2 days

DISCUSSION

Material Analysis to Make Liquid Organic Fertilizer

The main ingredients in the manufacture of POC are Tofu liquid waste, which contains organic compounds that can be used to fertilize plants. These compounds are protein by 40-60%, carbohydrates by 25-50%, fat around 8-12%, and the rest in the form of calcium, iron, phosphorus, and vitamins (Abdin, 2019). The next ingredient is Coconut Water. Chemical compounds contained in coconut water consist of macroelements and microelements (Krishan, 2019). The macro elements in coconut water are hydrated charcoal (carbohydrates) and nitrogen (in the form of amino acid proteins). Coconut water's carbohydrate consists of sucrose, glucose, fructose, inositol, and sorbitol. At the same time, the microelements in the composition of coconut water are potassium (potassium), calcium, ferum, sodium, sulfur, phosphorus, magnesium, sodium, chlorine, and cup rum (Alirahmi, 2021). Brown sugar is Made from coconut sap, which contains sucrose around 13-17%, protein 0.02-0.03%. Water is 75-90%, and everything else is organic, such as carbohydrates, amino acids, dyes, fats, and mineral salts. Coconut sap contains small amounts of mineral salts and vitamins, including ascorbic acid, amounting to 16-30 mg / 10 ml of coconut sap. EM4 contains 90% of Lactobacillus sp. (lactic acid-producing bacteria) phosphate solvents, photosynthetic bacteria, Streptomyces sp, cellulose-decomposing fungi and yeast. EM4 is an addition to optimizing the use of food substances because bacteria contained in EM4 can digest cellulose, starch, sugar, protein, and fat (Banu, 2020). The content contained in each ingredient is undoubtedly very supportive in making liquid organic fertilizer (Akhtari, 2020).

N, P and K Nutrient Test Analysis

Liquid organic fertilizer from tofu liquid waste passes nutrient tests, namely the Nitrogen (N) test, the Phosphor (P) test, and the Potassium (K) test (Tian, 2021). Three treatments of liquid organic fertilizer from tofu liquid waste are by distinguishing the composition of tofu liquid waste used, sample A 1 liter of tofu liquid waste, sample B 2 liters of tofu liquid waste, and sample C 3 liters of tofu liquid waste. So, it was obtained that sample A, with a composition of 1 liter of tofu liquid waste, has the highest nutrients. It can be seen in the table where the NPK in sample A shows a reasonably high percentage according to laboratory results and by the N, P, and K test standards (Saqib, 2019). This shows the potential of Tofu Liquid Waste, which can be used as organic fertilizer that meets nutrients where the organic fertilizer nutrient standard is 0.4% Nitrogen. Phosfor 0.1% and Potassium 0.2%.

Table 7 Recapitulation of N, P, and K Test Results

Elements	Test Standards	Sample		
		A	B	C
Nitrogn (N)	0.4 %	0.42 %	0.40 %	0.39 %
Phosphor (P)	0.1 %	0.13 %	0.13 %	0.12 %
Potassium (K)	0.2 %	0.29 %	0.21 %	0.21 %

Table 4 shows two samples that reached the N, P, and K Test standards, while the C in nitrogen nutrients did not. Table 7 also shows that sample A has the highest test results compared to samples B and C. This proves that the more composition of coconut water, brown sugar solution, and EM4 mixed in the manufacture of liquid organic fertilizer, the better it is for the fermentation process and can produce high liquid organic fertilizer macronutrients (Sahoo, 2019).

Techno-Economic Analysis

Organic fertilizers that meet the basic fertilizer nutrients should have economic feasibility considerations where every agricultural sector needs fertilizer to support agricultural products (Elmaadawy, 2020). For this reason, there is a need for an alternative or breakthrough homemade organic fertilizer previously obtained by buying fertilizer products on the market (Niermann, 2019)(Solarte-Toro, 2019). Making this organic fertilizer uses materials that are easy to find, and the price of the ingredients is very economical (Kargbo, 2021). The products made are then calculated COGS of liquid organic fertilizer obtained by 38.4 liters/day of production, and the tofu capacity reaches 12.634 liters per year with a total capital without fixed costs of Rp. 65,426,256 and obtained an HPP of Rp. 5,178.75 / liter, the profit taken is 10%, and a selling price of Rp. 5,696.6 / liter is obtained because organic fertilizer from tofu liquid waste is still new. Therefore, the nominal price must be cheap, and It has good nutrients. Consumers can still consider a price of Rp.5,696.6 / liter to buy because the nutrient content has been tested with N, P, and K content sufficient to meet the standards of liquid organic fertilizer (Zhang, 2020).

The product's break-even point is as much as 95.58 liters or equal to Rp. 544,523.8 is obtained by making organic fertilizer according to the predetermined composition. It takes three days to make organic fertilizer break even, so the profits obtained after the break-even point are pretty profitable(A. Kumar, 2020). The market share is quite large, especially for vegetable farmers, farmer groups, or households that need low prices and appropriate results for organic fertilizer (Li, 2020).

The payback period or investment capital payback period is relatively fast and does not arrive within one year, which requires two days. This is because the incoming cash is greater than the initial investment. The initial investment tends to be small because it uses simple equipment, and the materials are cheap and straightforward. Therefore, the profit obtained is enough to return the investment capital quickly (Javed, 2019).

CONCLUSION

Making liquid organic fertilizer with the main ingredient of tofu liquid waste only takes a very short time, which is 20 minutes for liquid organic fertilizer with a production yield of 1.6 liters. The results of implementing liquid organic fertilizer from tofu liquid waste on spinach and tomato plants obtained by Fertilizer A samples are the best results from the experiments. The results of techno-economic analysis by calculating COGS that the acquisition of the selling price of liquid organic fertilizer from tofu liquid waste is for IDR. 5,696.6 / liter by taking a profit of 10%, BEP or break-even point is obtained in the amount of 95.58 liters or several sales of IDR. 544,523.8, so it takes three days to make organic fertilizer to achieve and pay back BEP. The period embraced for two days is very fast, not up to 1 year of Payback. The period of investment incurred.

REFERENCES

Abdin, Z. (2019). Hybrid energy systems for off-grid power supply and hydrogen production based on renewable energy: A techno-economic analysis. *Energy Conversion and Management*, *196*, 1068–1079.

https://doi.org/10.1016/j.enconman.2019.06.068
Akhtari, M. R. (2020). Techno-economic assessment and optimization of a hybrid renewable earth - air heat exchanger coupled with electric boiler, hydrogen, wind and PV configurations. *Renewable Energy*, *148*, 839–851. https://doi.org/10.1016/j.renene.2019.10.169
Alirahmi, S. M. (2021). A comprehensive techno-economic analysis and multi-criteria optimization of a compressed air energy storage (CAES) hybridized with solar and desalination units. *Energy Conversion and Management*, *236*. https://doi.org/10.1016/j.enconman.2021.114053
Banu, J. R. (2020). Microalgae based biorefinery promoting circular bioeconomy-techno economic and life-cycle analysis. In *Bioresource Technology* (Vol. 302). https://doi.org/10.1016/j.biortech.2020.122822
Das, M. (2019). Techno-economic optimization of an off-grid hybrid renewable energy system using metaheuristic optimization approaches – Case of a radio transmitter station in India. *Energy Conversion and Management*, *185*, 339–352. https://doi.org/10.1016/j.enconman.2019.01.107
Deng, R. (2019). A techno-economic review of silicon photovoltaic module recycling. In *Renewable and Sustainable Energy Reviews* (Vol. 109, pp. 532–550). https://doi.org/10.1016/j.rser.2019.04.020
Elkadeem, M. R. (2019). Feasibility analysis and techno-economic design of grid-isolated hybrid renewable energy system for electrification of agriculture and irrigation area: A case study in Dongola, Sudan. *Energy Conversion and Management*, *196*, 1453–1478. https://doi.org/10.1016/j.enconman.2019.06.085
Elmaadawy, K. (2020). Optimal sizing and techno-enviro-economic feasibility assessment of large-scale reverse osmosis desalination powered with hybrid renewable energy sources. *Energy Conversion and Management*, *224*. https://doi.org/10.1016/j.enconman.2020.113377
Fasihi, M. (2019). Techno-economic assessment of CO <inf>2</inf> direct air capture plants. *Journal of Cleaner Production*, *224*, 957–980. https://doi.org/10.1016/j.jclepro.2019.03.086
Filhaq, G., Aprianto, S., & Alfianto, H. (2023). Design of Smart Locker Door Using Quality Function Deployment Based on ATMega 2560 Microcontroller. *Jurnal Riset Ilmu Teknik*, *1*(1), 25–35.
Ilse, K. (2019). Techno-Economic Assessment of Soiling Losses and Mitigation Strategies for Solar Power Generation. In *Joule* (Vol. 3, Issue 10, pp. 2303–2321). https://doi.org/10.1016/j.joule.2019.08.019
Jamshidi, M. (2019). Techno-economic analysis and size optimization of an off-grid hybrid photovoltaic, fuel cell and diesel generator system. *Sustainable Cities and Society*, *44*, 310–320. https://doi.org/10.1016/j.scs.2018.10.021
Javed, M. S. (2019). Techno-economic assessment of a stand-alone hybrid solar-wind-battery system for a remote island using genetic algorithm. *Energy*, *176*, 704–717. https://doi.org/10.1016/j.energy.2019.03.131
Kannah, R. Y. (2021). Techno-economic assessment of various hydrogen production methods – A review. In *Bioresource Technology* (Vol. 319). https://doi.org/10.1016/j.biortech.2020.124175
Kargbo, H. (2021). "Drop-in" fuel production from biomass: Critical review on techno-economic feasibility and sustainability. In *Renewable and Sustainable Energy Reviews* (Vol. 135). https://doi.org/10.1016/j.rser.2020.110168
Krishan, O. (2019). Techno-economic analysis of a hybrid renewable energy system for an energy poor rural community. *Journal of Energy Storage*, *23*, 305–319. https://doi.org/10.1016/j.est.2019.04.002
Kumar, A. (2020). Hydochar and biochar: Production, physicochemical properties and techno-economic analysis. In *Bioresource Technology* (Vol. 310). https://doi.org/10.1016/j.biortech.2020.123442
Kumar, S. (2019). Optimal DG placement by multi-objective opposition based chaotic differential evolution for techno-economic analysis. *Applied Soft Computing Journal*, *78*, 70–83. https://doi.org/10.1016/j.asoc.2019.02.013
Lam, S. S. (2019). Microwave vacuum pyrolysis of waste plastic and used cooking oil for simultaneous waste reduction and sustainable energy conversion: Recovery of cleaner liquid fuel and techno-economic analysis. *Renewable and Sustainable Energy Reviews*, *115*. https://doi.org/10.1016/j.rser.2019.109359
Li, J. (2020). Optimal design and techno-economic analysis of a solar-wind-biomass off-grid hybrid power system for remote rural electrification: A case study of west China. *Energy*, *208*. https://doi.org/10.1016/j.energy.2020.118387
Niermann, M. (2019). Liquid organic hydrogen carriers (LOHCs)-techno-economic analysis of LOHCs in a defined process chain. *Energy and Environmental Science*, *12*(1), 290–307. https://doi.org/10.1039/c8ee02700e

Permadi, I. N., & Nisa, D. B. (2023). A Model Experiment Design Using the Taguchi Method: A Case Study Of Making Concrete Roof. *Jurnal Riset Ilmu Teknik*, *1*(1), 36–44.

Pohan, F., Saputra, I., & Tua, R. (2023). Scheduling Preventive Maintenance to Determine Maintenance Actions on Screw Press Machine. *Jurnal Riset Ilmu Teknik*, *1*(1), 1–12.

Sahoo, K. (2019). Techno-economic analysis of producing solid biofuels and biochar from forest residues using portable systems. *Applied Energy*, *235*, 578–590. https://doi.org/10.1016/j.apenergy.2018.10.076

Saqib, N. U. (2019). Valorisation of food waste via hydrothermal carbonisation and techno-economic feasibility assessment. In *Science of the Total Environment* (Vol. 690, pp. 261–276). https://doi.org/10.1016/j.scitotenv.2019.06.484

Sari, T. M., & Dini, W. (2023). Risk Assessment and Mitigation Strategy in The Halal Broiler Supply Chain. *Jurnal Riset Ilmu Teknik*, *1*(1), 13–24.

Shahabuddin, M. (2020). Advances in the thermo-chemical production of hydrogen from biomass and residual wastes: Summary of recent techno-economic analyses. In *Bioresource Technology* (Vol. 299). https://doi.org/10.1016/j.biortech.2019.122557

Solarte-Toro, J. C. (2019). Acid pretreatment of lignocellulosic biomass for energy vectors production: A review focused on operational conditions and techno-economic assessment for bioethanol production. *Renewable and Sustainable Energy Reviews*, *107*, 587–601. https://doi.org/10.1016/j.rser.2019.02.024

Tian, M. W. (2021). A techno-economic investigation of 2D and 3D configurations of fins and their effects on heat sink efficiency of MHD hybrid nanofluid with slip and non-slip flow. *International Journal of Mechanical Sciences*, *189*. https://doi.org/10.1016/j.ijmecsci.2020.105975

Zhang, H. (2020). Techno-economic comparison of green ammonia production processes. *Applied Energy*, *259*. https://doi.org/10.1016/j.apenergy.2019.114135