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Techno-Economic Analysis of Lanthanum Oxide Nanoparticles Production using Combustion Solution and Hydrothermal Supercritical Water Condition

Asep Bayu Dani Nandiyanto [a*], Irine Sofianty [a], Rofi Fadilah Madani [a], Adani Ghina Puspita Sari [a], Fitri Febriyanti [a], Risti Ragadhita [a], Rina Maryanti [a], Eddy Soeryanto Soegoto [b]
[a] Departemen Pendidikan Kimia, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229 Bandung, Indonesia
[b] Program Studi Manajemen, Universitas Komputer Indonesia, Jl. Dipati Ukur No. 112-116 Bandung, Indonesia
* Corresponding author: nandiyanto@upi.edu

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ABSTRACT

Lanthanum oxide (La_2O_3) nanoparticles are widely applied in various fields and have the potential to be made on a fabrication scope. Consequently, feasibility studies for generating industries for La_2O_3 production are required, particularly in developing countries. This research aimed to evaluate the prospect of producing La_2O_3 nanoparticles. This study was carried out to determine whether large-scale La_2O_3 production using solution combustion (SC) and hydrothermal supercritical water conditions (HSWC) is profitable or vice versa. The analysis method was evaluated based on economic parameters such as gross profit margin, payback period, and cumulative net present value while also considering technical aspects by designing commercial tools. In addition, an economic evaluation also was made based on estimates of ideal conditions, such as tax increases, changes in raw materials, sales, workers' salaries, and utility costs. The analysis results show that the best method with great advantages is the HSWC method. From an engineering perspective, this method produces 4.08 tons of La_2O_3 in 20 years. This study is expected to provide information on the production of La_2O_3 nanoparticles by comparing the solution combustion method and hydrothermal supercritical water conditions on an industrial scale.

1. Introduction

Rare earth oxides and their mixed oxides, such as lanthanum, have drawn much interest in industry and innovation as a result of their somewhat minimal expense and great physical and chemical execution in their applications [1, 2]. Lanthanum(III) oxide (La_2O_3) is known as lanthania. Lanthania has odorless, white, rare earth metal oxides in the solid phase, and is insoluble in water but soluble in dilute acid. In addition, lanthania

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has the highest optical band gap (4.3 eV) among rare earth oxides, the lowest lattice energy, and the highest dielectric constant [3, 4]. According to its unique physical and chemical properties, La_2O_3 has been used in various applications, including H_2 storage, superconductors, optoelectronic devices, laser crystals, LEDs, biosensors, high-refractive-index optical fibers, and catalyst materials [5-8]. Because of these intriguing properties, lanthania has many potential applications.

Because of the high-quality applications of La_2O_3 nanoparticles in many fields, it was successfully fabricated using various chemical and physical methods. Several studies have reported on the synthesis of La_2O_3 by various methods, including combustion, co-precipitation, hydrothermal, sol-gel, reflux, sonochemical, solvothermal, spray pyrolysis, and thermal decomposition methods [9-17]. The method election for the production of lanthanum nanoparticles is based on advantages. However, some of the methods mentioned for sure have disadvantages such as being time-consuming, expensive, not environmentally friendly and requiring high energy. Therefore, solution combustion and hydrothermal methods were chosen because the synthesis is relatively simple and inexpensive [9, 18].

Understanding the production of nanoparticles requires an understanding of the techno-economy. This techno-economic analysis seeks to comprehend current market conditions thus, the product marketing strategy can run smoothly and profitably. Several examples of economic evaluations of nanoparticle products are further described. Economic evaluation on the production of NiO nanoparticles synthesized by the co-precipitation method has been successfully carried out. The NiO nanoparticle project is very promising when viewed from the value of the payback period (PBP), which shows that profit gains can be achieved in a relatively short period of 4 years. An economic analysis of the worst conditions (such as changes in raw material and labor prices) has also been carried out, which shows that changes in raw material prices which rose to 115% indicate less than ideal conditions because PBP was achieved in a relatively long period, namely 10 years. Then, the number of workers affects the project conditions, where the addition of the number of workers to 18 workers makes the project conditions not ideal because PBP is obtained in a relatively long period of about 7 years [19]. Another project successfully evaluated from an economic perspective was the production of silica nanoparticles from agricultural waste (i.e., rice husk, rice straw, bagasse, and corn cob) by extraction method. The results of the economic analysis show that the ideal condition (as depicted by the 20-year cumulative net present value (CNPV) curve) is very promising, as evidenced by PBP values that are relatively short (in only 2 years) to return all capital costs. The final CNPV values of various wastes are sorted sequentially from highest to lowest profits for rice husk, rice straw, bagasse, and corn cob. This project can still survive and operate until the price of raw materials reaches 200% of the estimated price, and the projects must be completed with sales of at least 50%. The project will fail if the product prices are less than half of the ideal sales price [20].

Furthermore, the project's economic analysis of silica and carbon particles from rice straw synthesized by the extraction method has also been successfully evaluated. The results show that converting rice straw waste into silica and activated carbon particles is promising. Other analyzes such as changes in raw materials, sales, labor, and utilities, show a positive correlation between sales and gross profit margin (GPM). In contrast, raw materials have an opposite relationship. More sales directly impact the project's success (profitability). In contrast, raw material issues impact the project's sustainability. The project's minimum capacity must be greater than 60%. In short, using less than 60% of the available capacity will result in an unprofitable project [21]. However, despite many

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reports on economic evaluation, the research regarding the production of lanthanum oxide nanoparticles is still limited.

The purpose of this study was to analyze the techno-economics of the production of lanthanum oxide nanoparticles and to design an industrial-scale production using two comparison methods, namely solution combustion (SC) and hydrothermal supercritical water conditions (HSWC). In this study, we calculated the La_2O_3 production capacity of 4.08 tons/year with several economical evaluation calculations (i.e., gross profit margin (GPM), internal rate return (IRR), PBP, cumulative net present value (CNPV), break-even point (BEP), return on investment (ROI), and profitability index (PI)). In addition, the worst case is used to predict non-ideal conditions by changing the sensitivity of the ideal condition calculations and calculating costs based on internal (i.e., raw materials, sales, utility, labor, employee, fixed cost, variable cost, and production capacity) and external problems (i.e., taxes) encountered during the manufacturing process. These analyses are necessary to obtain information about the process's profitability.

2. Theoretical Synthesis of Lanthanum Oxide

La_2O_3 material is produced by adopting the SC method suggested by Pathan, et al. [10] and the HSWC method suggested by Hojo, et al. [22].

2.1 Theoretical Synthesis of Lanthanum Oxide using Solution Combustion Method

For the synthesis of La_2O_3 nanoparticles using the solution combustion method, the materials needed are lanthanum nitrate (as oxidator) and acetamide (as a fuel) with analytical grades. All raw materials are reacted using distilled water. To synthesize La_2O_3 by the combustion solution method, the two reactants (lanthanum nitrate and acetamide) were mixed in the same container. Then, both mixtures should be stirred until homogeneous. After that, the reactant mixture is put into a muffle furnace at a temperature of 600˚C for 4-5 hours to get solid particles. The schematic of the Al_2O_3 synthesis process using the combustion solution method is illustrated in Fig. 1.

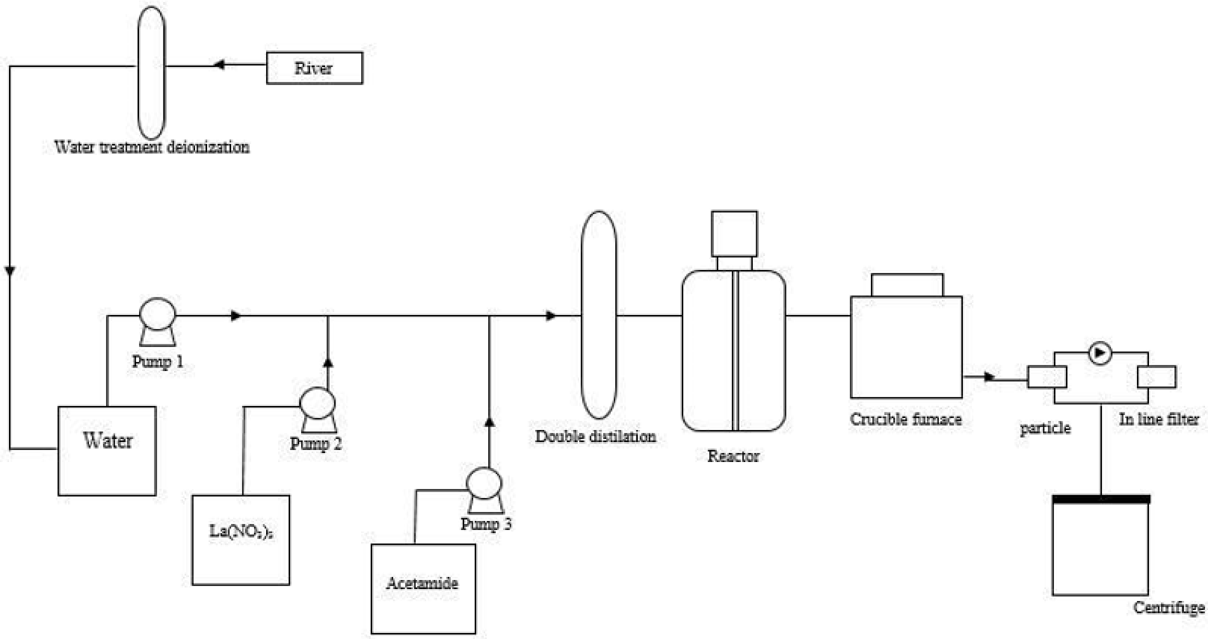

Fig. 1. The schematic of the Al_2O_3 synthesis process using the solution combustion method

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2.2 Theoretical Synthesis of Lanthanum Oxide using Hydrothermal Supercritical Method

The reactants that must be prepared to synthesize La_2O_3 by the supercritical hydrothermal method are lanthanum nitrate solution, deionized water, nitric acid (HNO_3), and sodium hydroxide (NaOH). In the hydrothermal supercritical condition method, 50 ml of a liquid solution of lanthanum nitrate with a certain concentration and pH are mixed in the reactor vessel. Based on the literature, the hydrothermal reaction was completed in the reactor vessel at the temperature and time [22]. Then, the reactor vessel is cooled with cold water to stop the reaction. The product is collected by centrifugation and purged in the reactor with deionized water. Then, the lanthanum oxide nanoparticles are dried in an oven at 60˚C for 24 hours. The schematic of the Al_2O_3 synthesis process using the supercritical hydrothermal method is illustrated in Fig. 2.

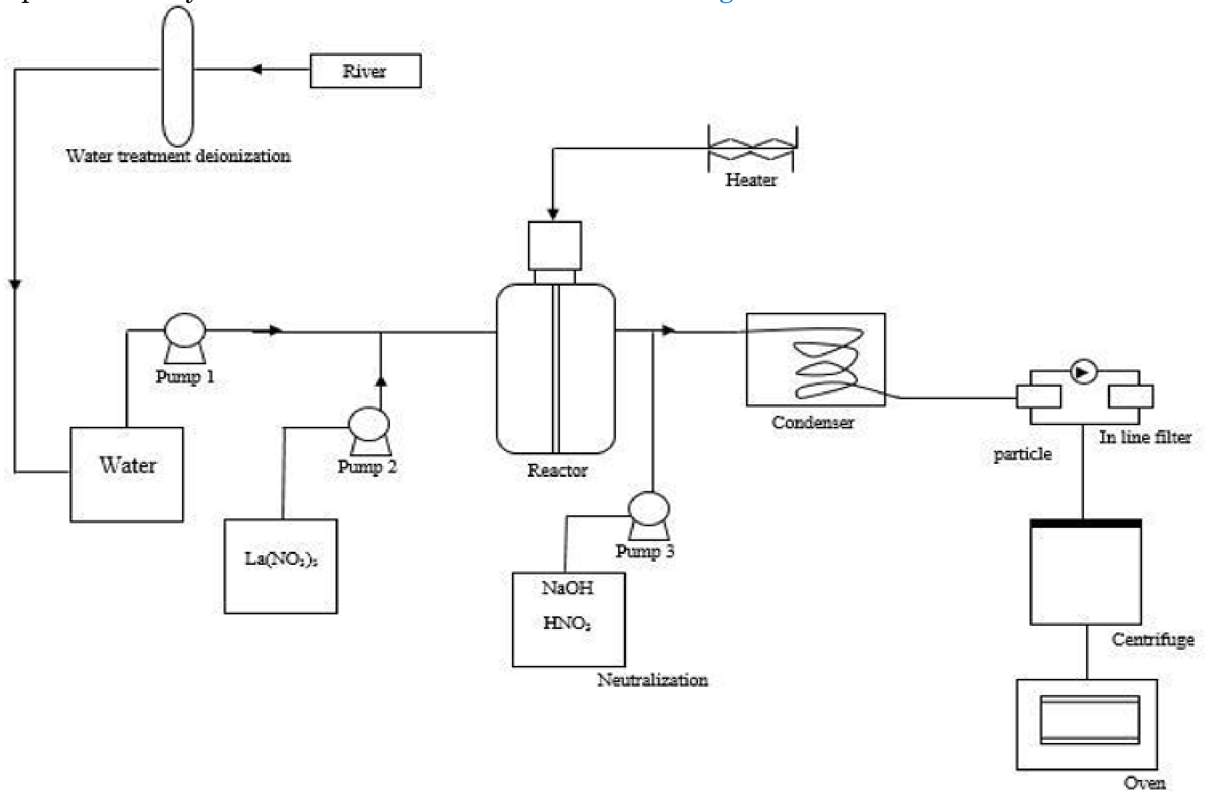

Fig. 2. The schematic of the Al_2O_3 synthesis process using the hydrothermal supercritical water condition method

3. Methods

The current method used data based on the average price of commercially available products on online shopping webs. A simple mathematical analysis was used to compute all of the data. Several economic evaluation parameters were used to confirm this project's economic evaluation, including (i) Cumulative Net Present Value (CNPV) is a cost that forecasts the circumstance of a construction task in the form of a fabrication function in numerous years; (ii) Gross Profit Margin (GPM) is the primary examination to decide the degree of productivity of an undertaking by diminishing the expense of marketing the item with the expense of unrefined components; (iii) Payback Period (PBP) is an estimation performed to anticipate what amount of time it will require for a venture to restore the absolute beginning consumption. PBP is determined when the CNPV is at zero for the primary time; (iv) Breakeven Point (BEP) is the minimum quantity of product that ought

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to be sold at a sure fee to cowl the overall value of production. BEP can be determined by calculating the fee of fixed expenses divided (total selling charge minus general variable prices), and (v) Profitability Index (PI) s an index to recognize the connection between project expenses and effects. PI can be determined by dividing the CNPV by the Total Investment Cost (TIC). The venture can be delegated unfavourably if the PI is less than one. If the PI is more than one, the project is profitable. Then, various conditions were tested to determine feasibility, such as raw material changes, sales capacity, labor conditions, and interest rate. These economic parameters are calculated using a simple tool, namely Microsoft Excel [23].

4. Results and Discussion

4.1 Energy and mass balance analysis

There are a few presumptions used for mass balance analysis, including (i) all the reactants are consumed perfectly, (ii) the reduced mass (as a mass loss) of the material is 10% in each process, and (iii) the conversion rate of La_2O_3 products is 90%, (v) the final product is only La_2O_3, (iv) in one-day handling, the absolute handling cycle is 1 cycle and 5 cycles/week.

According to energy and mass equilibrium, at a 100% baseline (ideal condition), it is accepted that all methods produce 17 kg of La_2O_3 in one cycle. Under ideal conditions, the venture could be increased to 240 cycles in one year, yielding 4,080 kg/year or 4.08 tons/year, similar to other researchers [24].

4.2 Economic evaluation

Several assumptions were used to ensure the economic analysis. This assumption is required to analyze and predict several possible outcomes during the project. The assumptions are as follows: (i) all examination was in USD. 1 USD = IDR 15.000; (ii) for the solution combustion method, the prices of commercially available lanthanum nitrate and acetamide were 21.00 USD/kg and 30.00 USD/kg, respectively; (iii) for the hydrothermal supercritical water condition method, the commercially available price of lanthanum nitrate, NaOH, and HNO_3 were 21.00, 0.30, and 1.60 USD/kg, respectively; (iv) the material was estimated based on stoichiometry; (v) one cycle of the operation of produce La_2O_3 nanoparticles in the solution combustion method and the hydrothermal supercritical water condition method took 9 hours; (vi) shipping fees were borne via the client; (vii) a one-year challenge turned into 300 days (and the relaxation days spent dealing and managing the procedure); (viii) the utility unit can be described and converted as an electricity unit, such as kWh [15], to simplify the utility system. The electricity unit is then converted to a cost by multiplying it by the standard minimum electricity cost. Assuming utility costs of 0.096 USD/kWh; (ix) total wages/labor was assumed to be fixed at 120 USD/day for 15 workers, (x) one product containing La_2O_3 was packaged in 50 grams for 0.35 USD per pack; (xi) income tax was 10% per year; (xii) the discounted rate is 15% annually; (xiii) the equipment price for 2 procedures are based on commercially available equipment (See

Table 1) and other fees (for example, start-up, instrumentation, and electrical-related components) were overlooked; (xiv) total investment cost (TIC) was decided primarily based at the Lang Factor [20, 25-27]. The total investment cost for the 2 procedures is shown in Table 2; as well as (xv) the project period is 20 years.

Table 1. Equipment cost and process condition using SC and HSWC procedure. All prices and apparatus information are taken from currently available apparatuses on the online shopping web

No	Equipment	Price (USD)	Electricity (kW)	Temp (°C)	Process time (h)
		SC Procedure			
1	Reactor vessel pressure-resistant SUS316 vessel 500 L	6,000	7.5	-	8
2	Centrifuge	3,400	1.5	-	8
3	Double distillation	609	32	-	12
4	Crucible furnace	8,004	250	600	6
5	Pump	867	1.5	-	8
6	Water Treatment	1,500	20	-	2
7	Tank	50	-	-	-
8	In line filter	120	-	-	-
		HSWC Procedure			
1	Reactor vessel pressure-resistant SUS316 vessel 500 L	6,000	7.5	-	8
2	Centrifuge	3,400	1.5	-	8
3	Electrical heater	1,000	100	-	8
4	Oven	2,000	6.9	-	9
5	Pump	1,632	1.5	-	8
6	Water treatment	1,500	20	-	2
7	Condenser	500	5.5	-	8
8	Tank	50	-	-	-
9	In line filter	120	-	-	-

Table 2. Estimated total investment for 2 production procedures

Component	Factor	SC Procedure	HSWC Procedure
		Price (USD)	Price (USD)
Plant Cost (Equipment)			
Purchased Equipment	1.0	22,993.00	17,169.00
Piping	0.5	11,496.50	8,584.50
Electrical	0.1	2,299.30	1,716.90
Instrumentation	0.2	4,598.60	3,433.80
Utilities	0.5	11,496.50	8,584.50
Foundations	0.1	2,299.30	1,716.90
Insulations	0.06	1,379.58	1,030.14
Painting, fireproofing, safety	0.05	1,149.65	858.45
Yard Improvement	0.08	1,839.44	1,373.52
Environmental	0.2	4,598.60	3,433.80
Building	0.08	1,839.44	1,373.52
Land	0.5	11,496.50	8,584.50
Subtotal 1		77,486.41	57,859.53

Table 2 (continue). Estimated total investment for 2 production procedures

Component	Factor	SC Procedure	HSWC Procedure
		Price (USD)	Price (USD)
Plant Cost (Management Services)			
Constructions, engineering	0.6	13,795.80	10,301.40
Contractors fee	0.3	6,897.90	5,150.70
Contingency	0.2	4,598.60	3,433.80
Subtotal 2		25,292.30	18,855.90
Total Plant Cost (Equipment + Management Service)		02,778.71	76,745.43
Total Plant Cost - Land		13,795.80	10,301.40
Starting-up Fee			
Off-cite facilities	0.2	4,598.60	3,433.80
Plant start-up	0.07	1,609.51	1,201.83
Working Capital	0.2	4,598.60	3,433.80
Subtotal 3		10,806.71	8,069.43
Total Investment Cost (Total Plant Cost + Starting-up Fee		24,602.51	18,370.83
Total Investment Cost - Land		13,106.01	9,786.33

4.2.1 Ideal conditions

Fig. 3 shows the ideal condition of CNPV/TIC (%) against the time (years) of the SC and HSWC methods. The y-axis was CNPV/TIC, and the x-axis was a lifetime (year). The initial time showed a negative CNPV/TIC from the first and second years due to the initial expenditure for the production of La_2O_3. The lowest CNPV/TIC value was in the second year. In the third year, the value increased to 23.2331 for the SC method and 33.4426 for the HSWC method. This point was called the PBP point. Based on Fig. 3, The CNPV/TIC curve continues to increase from the 3rd to the 20th year. The CNPV/TIC value from the 3rd year to the 20th year for the La_2O_3 project using the SC and HSWC methods has a CNPV/TIC value of 169,6209 and 241,5691, respectively.

Cash flow affects the net present value (NPV), ultimately impacting the CNPV value and providing economic risk [28]. In detail, the cash flow value is explained as follows. Cash flow value for lanthanum production with SC procedure in years 0, 1, 2, and 3 are 0.00; -16,738.90; -12,462.21; and 655.30 USD, respectively. Cash flow value for the 4th to the 20th year was stable, with a relatively high value of 254,633.88 USD. Meanwhile, the cash flow value for lanthanum production using the HSWC procedure in years 0, 1, and 2 are 0.00; -12,499.03; and -9,305.60, respectively. The cash flow value for the 3rd year to the 20th year was stable with a relatively high value of 961,608.28 USD. In the lanthanum production project using the HSWC procedure, the cash flow value is positive when entering the 3rd year. Meanwhile, when using the SC procedure, the positive cash flow value is relatively longer than the HSWC procedure when entering the 4th year. The negative cash flow values for both projects indicate that the project is still in the construction and development stage. If analyzed from the cash flow value, the cash flow value of lanthanum production with the HSWC procedure is greater than the SC procedure, indicating that lanthanum production with the HSWC procedure is more profitable. Details of the economic evaluation parameter values are shown in Table 3. It shows the positive economic value for all economic parameters.

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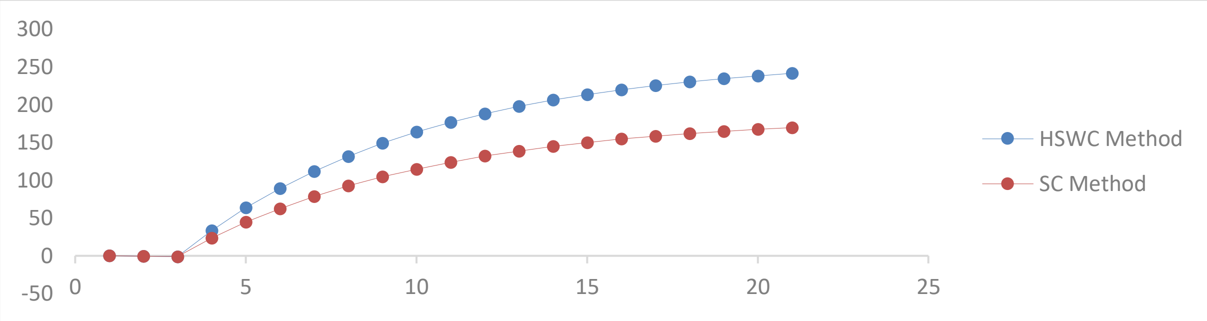

Fig. 3. Ideal conditions for lanthanum oxide production using (a) HSWC and (b) SC for CNPV/TIC (%) at the time (years)

Table 3. Economic parameters of lanthanum oxide project

Economic evaluation parameter	SC	HSWC
	Value	
GPM (USD per year)	1,232,474	1,258,766
PBP (years)	4.31	6.07
BEP (packs)	11,311	8,446
Break Even Capacity (%)	35	25
IRR (%)	653,54	794,22
Final CNPV/TIC (%)	16962	24156
ROI per year (%)	22970	32324
Total ROI	4093,13	5818.40
PI profit-to-sales (%)	65,03	69,02
PI profit-to-TIC (%)	4093.13	5818.40

The GPM evaluation determines the profitability of the project. Each project method showed decent, respectable profits, but the HSWC method had an extra advantage compared to SC. The difference in profit between the two methods was significant. The product sales profits from the SC and HSWC methods were more than 1,200,000 USD per year (see Table 3). PBP analysis showed the project obtained a PBP after working for about 4 years. The HSWC method gets a faster payback than SC, which was nearly 1 year slower (see Table 3). BEP analysis estimates the minimum number of products that should be offered to be sold to cowl overall manufacturing charges. This analysis showed that the total production of La_2O_3 nanoparticles by SC and HSWC methods must be sold yearly at a minimum of 11,311 and 8,446 packs/year, respectively. Then, BEC promotes at least 35 and 25% of SC and HSWC products, respectively, which should be accessible in the market to cover the overall fee of manufacturing (see Table 3). IRR analysis under ideal conditions shows the value of 653.54 (SC) and 794.22% (HSWC) for 20 years which is only 4-6% per year (see Table 3). Because this value measures an indicator of the efficiency level of an investment, this analysis calculation gives a high level. The final CNPV/TIC analysis showed positive results.

Yields appear high for a project running for 20 years. The project gets extra profit from the invested funds. Furthermore, the final CNPV/TIC shows that the HSWC scheme is more promising than the SC (see Table 3 and Fig. 3). ROI examination shows positive consequences of about 20,000–30,000% (see Table 3). PI analysis shows the best way to recognize the relationship between project costs and effects. This PI analysis includes profit-to-sales and profit-to-TIC. PI shows some positive results where products through

HSWC have the best results in having a large impact on sales and project investment costs. These results indicate a fairly good project prospect. According to the discussion of the analysis of several economic parameters, the product of La_2O_3 nanoparticles through HSWC was found to have more prospective economic parameters than SC. However, economic parameters show that SC was superior to HSWC, such as PBP. The results of the economic evaluation showed that the project was very prospective. The new idea in this research is expected to provide information and understanding concerning the feasibility of producing La_2O_3 nanoparticles on an industrial scale.

4.2.2 Effect of external conditions

External factors influence the achievement of a project. One of the external factors that influence a project's manageability is the project's economic condition, which can be favorable or unfavourable [29, 30]. This connects to monetary expenses or one-of-a-kind responsibilities pressured on projects by the country's aid to fund distinct public makes use of. Figs. 4(a and b) show the CNPV curve with several tax variations. Figs. 4(a and b) confirm that tax changes impacted the worth of CNPV/TIC beginning from the subsequent two years. In the initial years (0–2), identical indicates ideal conditions. Figs. 4(a and b) show the initial conditions until the second year the CNPV/TIC results are negative for both methods. Positive results are obtained in the third to twentieth year. When the tax value varies from 10, 25, 50, 75, and 100%, the PBP obtained for the production of La_2O_3 by the SC method is 5.78, 14.44, 28.88, 43.32, and 57, respectively. Meanwhile, for the HSWC method, the PBP values for tax variations of 10, 25, 50, 75, and 100% are 6.14, 15.36, 30.72, 46.08, and 61.44%, respectively. Fig. 4(b) on the HSWC method shows a higher increase in tax variation compared to the SC method in Fig. 4(a). Variations in tax affect the CNPV/TIC rate. In contrast, the increase in the price of tax variations affects the decrease in the CNPV/TIC rate, which indicates a decrease in project profitability.

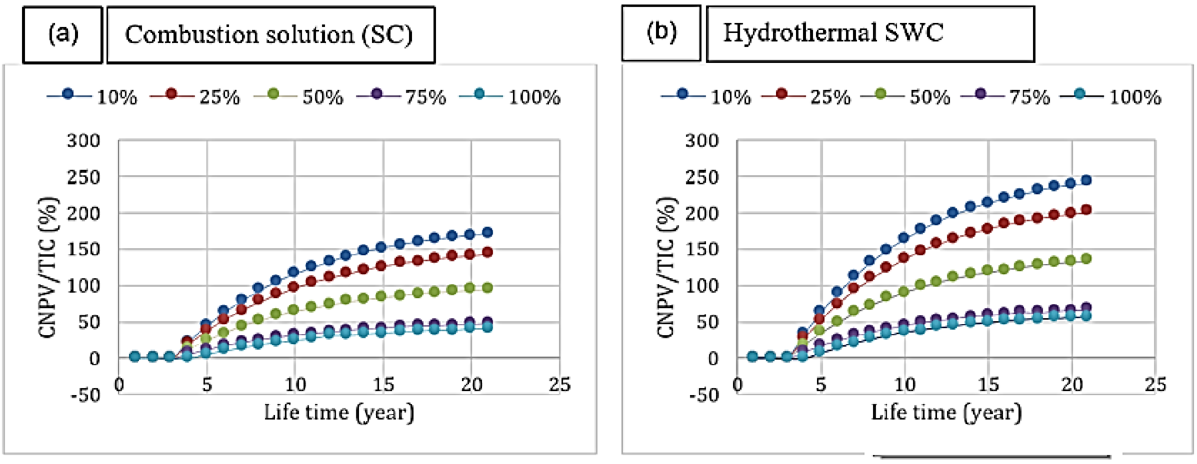

Fig. 4. CNPV curve against tax variation in a lifetime (year)

4.2.3 Changes to sales

Fig. 5 shows the CNPV chart of the variation in sales for the last 20 years. The analysis was carried out for variations in the decrease of 10 and 20% from the ideal condition (100%), with a sales value of 90 and 80%, respectively. Then, the analysis is also carried out for variations in the increase of 10 and 20% from the ideal condition (100%) with a sales value of 110 and 120%, respectively. The decrease in the selling price of the product affected the GPM price, which could result in decreased profits for the project. The higher the selling value, the higher the benefit. Based on the PBP analysis in Fig. 5, the refund if there are variations in sales of 120, 110, 100, 90, and 80% occurs in the third year

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because the project is still under construction in the first and second years. The analysis results, Fig. 5 show that the payback value began to be positive in the third year. For variations of 80, 90, 100, and 120%, in the SC method, the payback values were 16.05, 19.51, 22.97, 26.44, and 29.91, respectively. Meanwhile, the HSWC method's payback values are 24.16, 28.89, 33.44, 38.08, and 42.72, respectively. Thus, the minimum sales to get BEP is 80%. If sales are less than 80%, then the project is a failure. According to Nandatamadini, et al. [24], sales are profitable assuming they increase by more than 100 percent. Fig. 5 shows a positive CNPV/TIC value, thus this project is feasible.

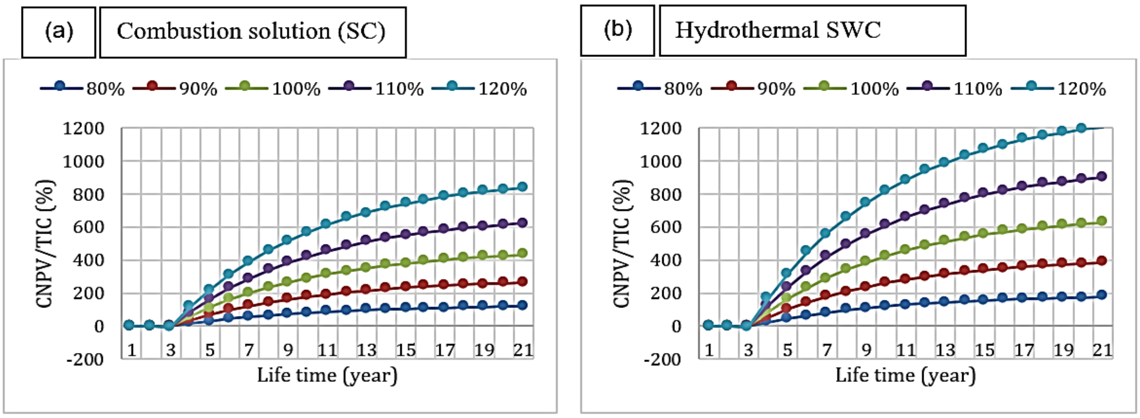

Fig. 5. CNPV curve of sales variation in a lifetime (year).

4.2.4 Changes in variable costs (raw materials, utilities, labor)

Internal factors in the achievement of the undertaking were affected by the state of raw materials, labor, and utilities [29, 30]. Fig. 6 shows the CNPV curve on the variation of raw materials. First, the analysis was carried out for variations of raw material in the decrease of 10 and 20% from the ideal condition (100%), with a sales value of 90 and 80%, respectively. Then, the analysis is also carried out for variations in the increase of 10 and 20% from the ideal condition (100%) with a sales value of 110 and 120%, respectively. Based on Fig. 6, shows an increase in CNPV/TIC from the 3rd to the 20th year. The greater the increase in raw material costs, the lower the increase in CNPV/TIC rates. In the third year, for the SC method, the highest payback point is in the 80% variation with a value of 24.99, and the lowest payback at the 120% variation with a value of 21.95 (see Fig. 6 (a)). Meanwhile, in the HSWC method, the value remains constant for each variation and there is no significant change (see Fig. 6 (a)). The greater the value of the raw material variation, the less the project will benefit from the best conditions.

The value of CNPV in utility variations is shown in Fig. 7. The test is done by varying the utility cost from the ideal cost (100%). The variation of utility costs is done from 80-120%. In the SC method, the payback values for CNPV/TIC with utility variations of 80, 90, 100, 110, and 120% are 23.72, 23.60, 23.48, 23.35, and 23.23, respectively. Meanwhile, in the HSWC method, the payback values for CNPV/TIC are 33.27, 33.18, 33.10, 33.02, and 32.93, respectively. The highest value in the 20th year was in the 80% variation with a value of 173.08 for the SC method and a value of 240.36 for the HSWC method. The lowest value in the 20th year was in the 120% variation with a value of 169.62 for the SC method and a value of 237.97 for the HSWC method (see Fig. 7).

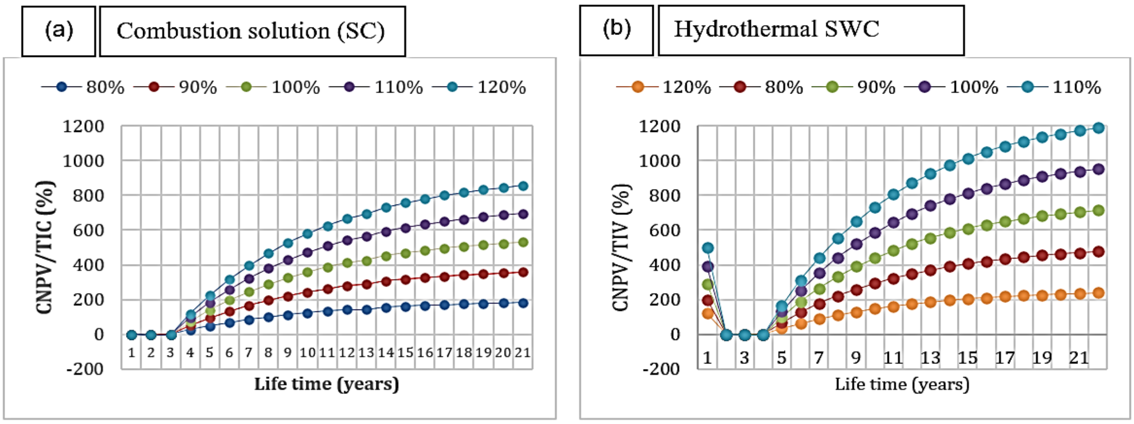

Fig. 6. CNPV curve against variation of raw material on lifetime (year)

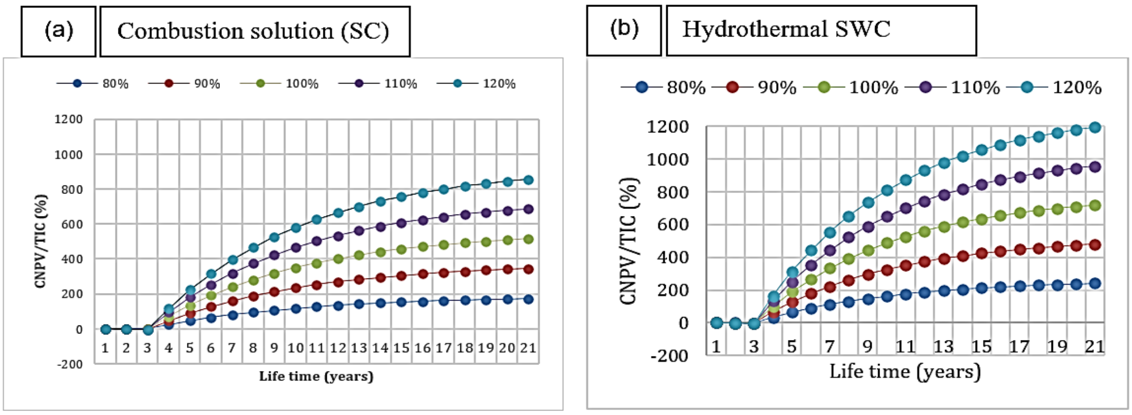

Fig. 7. CNPV curve to utility variation in lifetime (year)

The implementation of CNPV in labor variations is shown in Fig. 8. The inspection is carried out with the ideal salary for workers, which is increased and decreased from the ideal salary (100%). Workers' salaries are varied from 80-120%. The payback values received at CNPV/TIC with employee salary variations of 80, 90, 100, 110, and 120% are 23.49, 23.36, 23.23, 23.10, and 22.97 for the SC method (Fig. 8(a)). Meanwhile, in the HSWC method (Fig. 8(b)), the salaries of employees for variations in salaries of 80, 90, 100, 110, and 120% are 33.51, 33.30, 33.44, 33.27, and 33.10, respectively. Based on these variations, the project can operate well and make a profit.

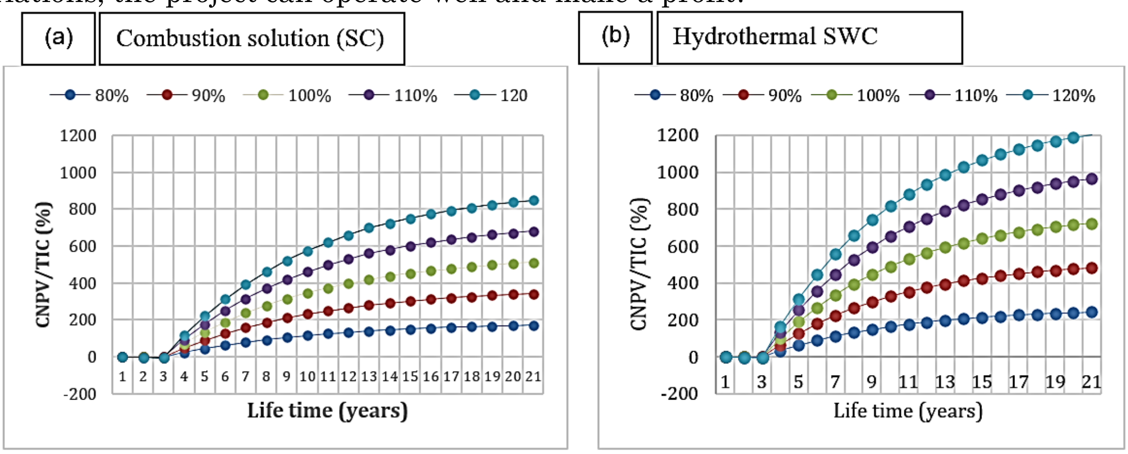

Fig. 8. CNPV curve of sales variation in a lifetime (year).

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5. Conclusion

The consequences of the analysis show that the La_2O_3 nanoparticle project can be produced on a large scale by two types of methods, namely solution combustion and hydrothermal supercritical water condition. The economic analysis of GPM, PBP, BEP, CNPV, PI, IRR, and ROI showed positive results, exhibiting that the project could be profitable. The analysis showed that the best method with a large profit was the hydrothermal supercritical water condition method. Based on the economic evaluation parameters, the higher profit was 31% for the hydrothermal supercritical water condition method and 10% for the solution combustion method. The supercritical water condition hydrothermal method has advantages, such as low raw material costs. PBP examination showed the project could get a return on investment after about 4-6 years of work. From the aftereffects of the financial assessment examination, it was inferred that this project was possible and productive to run. Both methods were profitable only in the specific economic condition. Several sensitivity parameters were also analyzed, showing some limiting conditions for profit. In short, the lanthanum production project is a project that appeals to industrial investors. This work demonstrated the importance of projects in assisting industrial practitioners to develop. This work demonstrated the importance of projects in assisting industrial practitioners to develop.

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