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DESIGN AND ANALYSIS ON EMISSIONS OF C. I. ENGINE USING PONGAMIA BASED BIO DIESEL

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ABSTRACT

The rising demand for fuels poses a problem for modern scientists. There are decreasing amounts of fossil fuels left to use. As a result, biodiesel has emerged as a promising alternative fuel for the future of the planet. It's a fuel that won't harm the planet. Many scientists have made concerted efforts to develop compression ignition engines that can run on biodiesel generated from plant oils. There is a wide range of raw materials to choose from, such as Pongamia Pinnata, Neem seeds, cashew nuts, waste vegetables, cotton seed, etc. Biodiesel fuel and lubricants are made from non-edible oil seeds and vegetable oils such palm oil, soybean oil, sunflower oil, rapeseed oil, and canola oil. However, Pongamia pinnata shows promise as a raw material source because it can be collected from the wild with relative ease. The Pongamia pinnata tree is a nitrogen-fixing, drought-resistant, semi-deciduous legume. In this paper, we look at the feasibility of producing biodiesel on Vanua Levu's 58,897 hectares of marginal, underutilised land. According to the output forecast, it is possible that the available land area might yield 488 million litres of Pongamia oil and 645 million litres of biodiesel. For all discount rates up to 10%, the benefit-cost ratio is greater than 1, and the net present value of the project is positive, as determined by a cost-benefit analysis.

Key words: Biodiesel, blends of biodiesel, performance analysis,economic feasibility

1. INTRODUCTION

Hydroelectric and nuclear energy constitute the remaining portion of the global energy supply after the depletion of petrochemicals, coal, and natural gas. Over time, fossil fuel reserves will deplete. These energy sources, however, are not renewable and will be used up in the not-too-distant future. To replace diesel, biodiesel appears to be a realistic choice.

A diesel engine is quite similar to a petrol engine except that it operates on diesel instead of petrol. Rudolf Diesel, a German, came up with this new kind of fuel in the early 20th century and gave it his name. Lorries and buses have typically utilised diesel engines due to their improved power and dependability. Although they are more cost-effective than petrol engines, diesel engines are notoriously loud and stinky. Compressing air rather than fuel is what the compression stroke of a diesel engine does. During the ignition stroke, the engine cylinder is filled with highly pressurised air, and fuel is pumped into the cylinder with the aid of an injector, both of which cause the cylinder to develop tremendous heat and spark the ignition of the fuel. In a diesel engine, the spark plug is unnecessary. The petrol will detonate when exposed to the highly hot compressed air. Diesel engines have a far higher "compression ratio" than petrol engines.

The predicted depletion of fossil fuel reserves and the fast rise in energy consumption owing to population growth both play a role in driving up fuel prices significantly in the market. This situation presents a significant problem for developing countries like PICs because they have no domestic fossil fuel supply.

Islands in remote locations can only meet their energy demands for household electricity, inter-island transit vessels, and fishing boats by importing these fuels at massive rates. For such energy needs, diesel engines are a popular choice, and biofuels, especially biodiesel, are receiving a lot of interest as a potential replacement for or addition to pure diesel.

Transesterification is a method used to convert vegetable oils into biodiesel by decreasing the oil's viscosity. Using a catalyst of either sodium hydroxide (NaOH) or potassium hydroxide (KOH), triglycerides (long chain fatty acids) isolated from refined vegetable oils are reacted with an alcohol such as methanol or ethanol to produce biodiesel. Biodiesel is the end result of heating the ester. Glycerol is a crucial component in the production of several drugs. It has been discovered that diesel engines can potentially run efficiently on biodiesel fuel, with reduced emissions of greenhouse gases, and without requiring any major changes to the engine components[2].

Understanding the economics of biodiesel production is now just as critical as knowing about the technical aspects of making the fuel. If the benefits of manufacturing biodiesel outweigh the expenditures, the initiative to create biodiesel will be viable. To ensure the project's long-term viability, economic analysis must be conducted to confirm important parameters like levelized cost of biodiesel (LCOB), cost of biodiesel (COB), net present value (NPV), discount rates, internal rate of return (IRR), simple payback period (SPP), and benefit to cost ratio (BCR).

The sum accounted for all costs associated with building the factory, including labour, materials, decorticators, oil press machines, extraction/refining equipment and installation, skilled labor/expertise, depreciation, operations and maintenance (including electricity), production input (phosphoric acid and water), and analysis. A cost analysis of a comparable facility in Samoa was used to determine the price of oil refining equipment, operations, and maintenance [3].

The total price tag for making biodiesel includes everything from the initial investment in machinery to its installation, commissioning, construction, service facilities, engineering supervision, legal fees, contractors, operation and maintenance, insurance, wages, plant overhead, contingency, depreciation, and raw materials (methanol and sodium hydroxide).The costing for a biodiesel manufacturing plant on Crete Island with an annual output of 10,000,000 kg was used to estimate all of these expenditures [4]. Expenses on things like land purchase and operating capital were also incurred.

The oil refining and biodiesel manufacturing plant's lifespan was used to determine a 20-year lifespan for the biodiesel production projects [5,6]. A cost-benefit analysis was performed using NPC and NPB to identify an ideal COB at which a positive net present NPV could be achieved at discount rates as high as 10%. We also computed and double-checked the project's simple payback period (SPP), internal rate of return (IRR), and benefit cost ratio (BCR) to guarantee its long-term viability.

2. LITERATURE REVIEW

Biodiesel is the most potential alternative fuel for CI engines since it can be produced and distributed at relatively low cost and is widely available. Biodiesel for use in a compression ignition engine has been studied for its optimal raw materials, production process, and emissions. Nadaf looked on using pongamia biodiesel in a CI engine by analysing its efficiency and pollution levels [7]. Pongamia biodiesel was used as a diesel fuel substitute in these tests at concentrations of 5, 10, and 15%. When comparing BSFC and BTE, it was discovered that the 10% blend was the most effective.

Direct injection compression ignition (DICI) engines have been studied for their potential to run on pongamia biodiesel (PBD), and the methods involved in producing it have been outlined in [8]. PBD has a lower BTE than diesel throughout a wide range of BMEPs because of its higher viscosity and lower calorific value. PBD engines emit more brake specific nitrogen monoxide (BSNO) because of the higher oxygen content and peak in-cylinder gas temperature. A performance and emission evaluation additive was performed by Navada on Mad. longifolia methyl ester. Dimethyl carbonate was added to mixtures of diesel and biodiesel made from Mad. longifolia at concentrations of 5, 10, and 15% [9]. When compared to diesel, the BTE of pure Mad. longifolia biodiesel is significantly lower. The use of additives results in a somewhat higher concentration of biodiesel and BTE from Mad. longifolia.

Experiments on PME blends' combustion, emissions, and performance are detailed in [10]. When compared to diesel, PME's maximum CO and HC emissions are 8.2% and 8.9% lower, respectively. Additionally, it has been shown that NOx emissions have decreased significantly. PME's BSFC went up 4.2% while the BTE was down 2.4%. It was discovered that PME has a shorter ID time than diesel, and that this period gets even shorter if more biodiesel is added.

Diesel engines that run on methyl ester Mangifera indica oil (MEMSO) were tested for efficiency and emissions [11]. The composite emissions of BTE, smoke, and HC were all lower than those of diesel. Despite having a lower calorific value than diesel, MEMSO blends have a better BSFC. Using biodiesel instead of diesel, however, increases NOx emissions.

A DI diesel engine operating on Mad. longifolia oil ethyl ester (MOEE) was studied for its efficiency and emissions [12]. Despite having a lower BTE than diesel, the lower calorific value of MOEE was found to increase its specific fuel consumption (SFC). It was also found that under all load situations, MOEE has fewer emissions of smoke, NOx, CO, and HC than diesel.

Mahua Mad. longifolia methyl ester/diesel blends were tested for performance and emissions [13] in multicylinder turbocharged diesel engines. The BTE drops and the BSFC rises as biodiesel's fraction in the fuel mix increases. Blends of Mad. longifolia methyl and biodiesel, which contain oxygen, create fewer greenhouse gases (HC) and carbon monoxide (CO) than diesel, which does not contain oxygen. Adding more biodiesel to the fuel mix increases NOx emissions due to the fuel's greater EGT and higher oxygen content.

In [14]. evaluated the efficiency and emissions of LHR engines powered by biodiesel. Their research shows that using LHR coating in conjunction with either biodiesel or diesel yields significantly superior BTE results.

Using biodiesel in low-speed diesel engines has been proposed due to the fuel's ability to boost both power and torque at those speeds. Pineda-Camacho investigated how Ann. muricata methyl ester (AME) affected the efficiency and pollution output of a diesel engine. When compared to the other fuels used in the experiment, B20 was shown to have the lowest BSFC. The LHR engine has a slightly greater BTE for B20 mix than the uncoated diesel engine. Coated engines increase combustion chamber temperatures, resulting in higher NOx emissions than uncoated engines for all test fuels [15,16].

3.MATERIALS AND METHODS

Using Google Earth Pro and data collected from the Department of Land Use, some promising locations for a Pongamia plantation were located. Additional sources were consulted for data on land use. The average seed weight per tree ranged from 9 kilogrammes to 90 kilogrammes, yielding 49.5 seeds per tree when applied to the Pongamia. In addition, a Pongamia plantation density of 500 trees per hectare was evaluated.

The percentage of oil that can be extracted from pongamia seeds using oil expelling equipment was used to estimate oil yields. Phosphoric acid concentrations between 0.05% and 1% would be used for degumming crude oil during the oil refining process. It was believed that 1 tonne of refined oil equals 1.073 tonnes of crude oil.

Using the most popular stoichiometry description of the transesterification reaction, the amount of biodiesel that may be produced from Pongamia oil and methanol was determined (Fig. 1). Catalyst requirements have been approximated at 1.5% of oil volume.

$$\text{1000 kg of oil} + \text{110 kg of methanol} \xrightarrow{\text{NaOH (1.5\% of oil (w/w))}} \text{1000 kg of biodiesel} + \text{110 kg of glycerol}$$

Figure. 1Using NaOH as a catalyst, biodiesel is produced by transesterifying oil and methanol.

Farming, oil extraction/refining, and biodiesel manufacturing are the three stages of Pongamia biodiesel production that were analysed for their relative costs. Expected costs are listed at 2020 levels. Clearing land, building roads, tending seedlings, transplanting, controlling weeds, harvesting, transporting, labour, and vehicles were the primary outlays during the farming phase. Profits from growing Pongamia would be shared with the farmers at a rate of $210.15 per tonne of Pongamia seeds.

The total is the sum of a number of different variables, including the cost of construction, decorticators, oil press machines, oil extraction and refining equipment and installation, labour and expertise, depreciation, operating and maintenance (including the cost of electricity), production input (phosphoric acid and water), and analysis.Costing for an oil refining factory in Samoa was used to determine the price of machinery, labour, and upkeep.

The final cost estimate for the production of biodiesel took into account a number of different aspects, including equipment, transportation, installation, construction, service facilities, engineering oversight, legal fees, contractors, operations and maintenance, insurance, wages, plant overhead, contingency, depreciation, and production input (methanol and NaOH). The budgeting for a biodiesel manufacturing unit on Crete Island with an annual output of 10,000,000 kg was used to estimate all of these expenditures. Expenses on things like land purchase and operating capital were also incurred.

We estimated a 20-year lifespan for the biodiesel production projects, which is in line with the expected lifespan of the combined oil refinery and biodiesel production facility. A cost-benefit analysis was performed using NPC and NPB to obtain an ideal COB at which a positive net present NPV could be attained up to 10% discount rates. This was done in order to determine an optimal COB at which a positive net present NPV could be attained. Calculating and verifying the project's simple payback period (SPP), internal rate of return (IRR), and benefit cost ratio (BCR) was done so that we could increase the likelihood that the project will be effective over the long term.

3.1 Performance evaluation of engine

The testing of the engine's performance was carried out with a Test Rig configuration similar to the one shown in figure 2, which was designed for a single-cylinder, four-stroke diesel engine.

Figure 2Installation of a dynamometer for testing single-cylinder, four-stroke diesel engines.

Loading mechanism, fuel input measuring mechanism, air intake measuring mechanism, cooling water heat removal mechanism for engine jacket, cooling water heat removal mechanism for exhaust gas and control panel are the main parts of the test rig. The following table 1 gives the details about the test engine:

Table 1: details about the test engine

Engine Type	:	Make Kirloskar AK65
Diameter of Piston	:	0.08m
Stroke Length of Piston	:	0.11m
No. of Cylinder	:	1
No. of Stroke	:	4
Type of cooling	:	Water cooled
Rated Power	:	4.8kW at 1500 RPM
Engine Capacity	:	553cc
Compression ratio	:	17.5
Variable CR range	:	12 to 18
Fuel used	:	Diesel
BHP	:	6.5

4. RESULTS AND DISCUSSION

The SPP was calculated by utilising the x-intercept of the cash-flow discounting curves. The discounted cash flow curve is depicted in Fig. 3 with a 10% discount rate, an SPP of around 18 years, and a COB of $1.57.

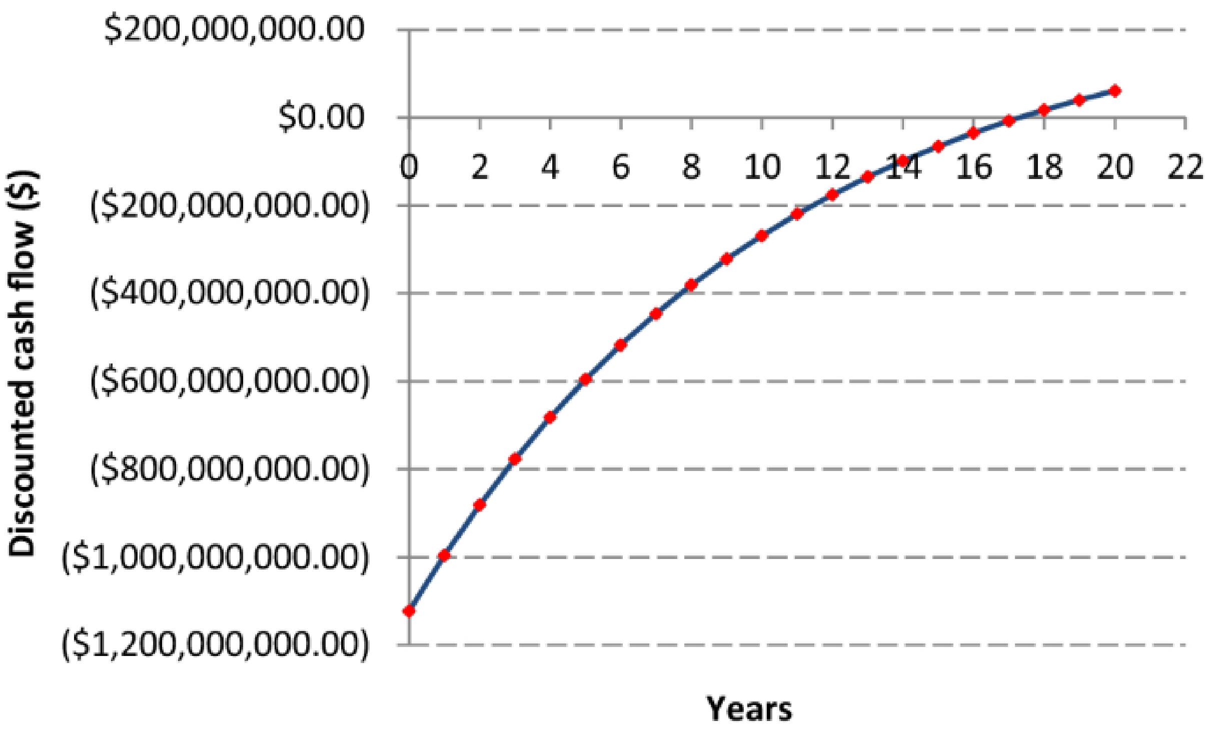

Figure. 3Analysis of SPP using a discounted cash flow curve at COB of $1.57

At a constant cost of production ($1.57/l), we calculated the NPV, IRR, and SPP of producing biodiesel, and the results are shown in Table 1. Even though the net present value (NPV) decreases with an increase in the discount rate from 10% to 20%, the internal rate of return (IRR) remains unchanged at 10.79%. The SPP and the biodiesel production project have similar time frames (nine to eighteen years). The NPV, IRR, and SPP evaluations at various discount rates all conclude that the project is economically viable at a COB of $1.57/l.

Table 2Changes in NPV, IRR, and SPP as a Function of Discount Rate

Discount rate (%)	NPV ($)	IRR ($)	SPP (years)
1	1,386,095,700.43	10.79	9
2	1,150,572,33.16	10.79	9
3	945,656,733.2	10.79	10
4	766,712,166.83	10.79	10
5	609,876,940.42	10.79	11
6	471,924,93.24	10.79	12
7	350,152,801.02	10.79	13
8	242,288,670.95	10.79	14
9	146,477,462.19	10.79	16
10	60,920,196.79	10.79	18
11	− 15,575,770.91	10.79	–

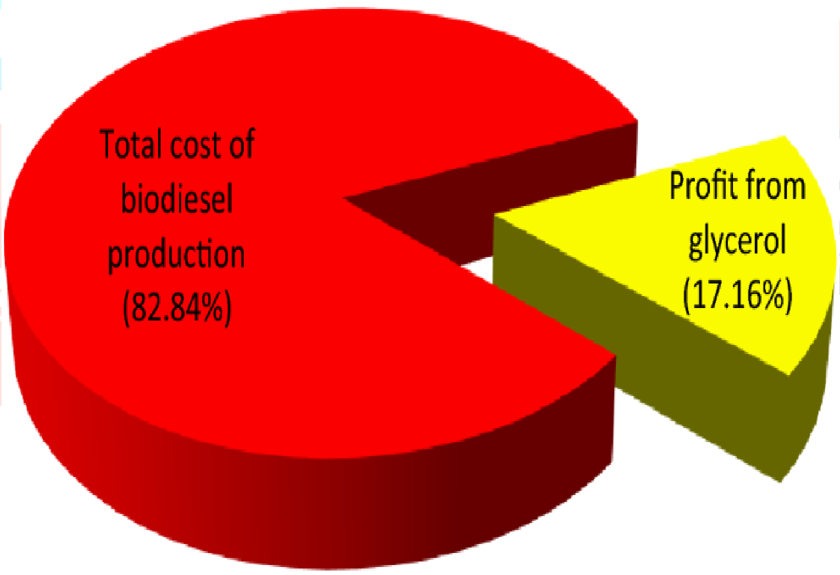

Figure 4: Pongamia biodiesel manufacturing generates a return on investment from glycerol.

Profit from glycerol sales, which is a byproduct of biodiesel production, will further lower the NPC. Figure 4 shows that the NPC is decreased by 17.16% due to return shares from glycerol sales, which also boosts the NPV and decreases the SPP.

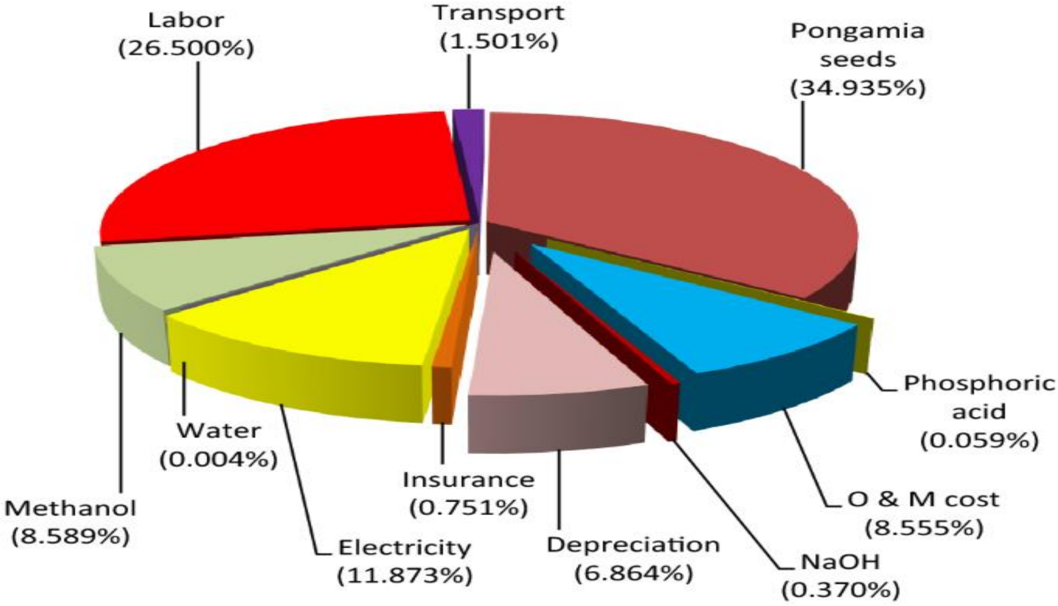

Figure 5: Biodiesel production from all Pongamia-accessible land: an analysis of NPC.

NPC analysis was performed to illustrate the primary cost of biodiesel production (see Fig. 5). About 34.9% of NPC goes towards covering the costs associated with buying Pongamia seeds (the farmers' profit). The price of labour is likewise relatively expensive, accounting for 26.5% of NPC.

CONCLUSION

Pongamia biodiesel can be produced profitably from Pongamia oil on the 58,897 acres of unused periphery land on the island of Vanua Levu. Our current land area is capable of yielding 488,834,780.40 l of crude oil by cultivating pongamia. About 645,602,367.80 litres of biodiesel will result from this method of oil fuel production. Using a discount rate of 10%, the cost-benefit analysis predicts a positive net present value (NPV) and a business critical ratio (BCR) of 1. If the discount rate stays at 5% and the net present cost increases by at least 5%, the sensitivity analysis indicates that the project will still be economical. The research assumes that all accessible land will be used to produce ethanol from pandanus berries. But the output volume can be reduced to a more manageable level at a smaller outlay of resources. If Pongamia biodiesel were produced on a big enough scale, it might replace or be blended with ordinary diesel to supply the energy demands of residences, ships, and fishing boats in the outer and more isolated islands of the PICs.

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