



ECONOMIC FEASIBILITY OF THE SOPAC-CATD BIOFUEL PROJECT, NADAVE, TAILEVU, FIJI ISLANDS

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ABSTRACT

Fossil-based energy imposes huge costs to the domestic economy. These include risk from the volatility of oil prices, trade deficits due to high energy imports; and greenhouse gas emissions contribution to global warming. Rural electrification projects in remote areas of Fiji have been predominantly diesel based. Under the Fiji Rural Electrification Policy, Government will contribute up to 95 per cent of project cost whilst the community/village provides the remaining 5 per cent. Rural electrification also faces a great number of challenges due to transportation difficulties and lack of income-generating opportunities. SOPAC and CTA [The Technical Centre for Agricultural and Rural Cooperation, based in the Netherlands] recently jointly funded a biofuel (coconut oil) project in Fiji. Using local copra supply as biofuel for rural electrification is perceived as a potentially viable and sustainable option. Under this biofuel project, a package of compatible components are provided to a local community, including a mini oil mill, settling tanks, other accessories to blend the coconut oil with diesel and an 18-kVA indirect injection diesel engine. These components were installed and commissioned at the Centre for Appropriate Technology and Development (CATD) in Nadave, Tailevu, Fiji Islands. CATD is a Government training centre that provides training to Fijian nationals from rural and remote island communities in a wide range of disciplines such as carpentry, small engine repair, energy and small/micro business management skills to facilitate community development. The operation of the biofuel project – particularly the performance of the biofuel generator – will be monitored by SOPAC¹ and CATD for the first five years after installation. This paper describes a preliminary economic analysis of the feasibility of the project.

1 Introduction

Biofuel is defined as solid, liquid, or gaseous fuel obtained from relatively recently lifeless or living biological material. Various plants and plant-derived materials are used for biofuel manufacturing, (New World Encyclopedia, 2009)². Biofuel is an area of interest for Pacific Island Countries (PICs) to reduce reliance on expensive imported fuels. Over the past years, there have been ongoing trials of coconut biofuel as a substitute to diesel fuel within the region; however, most trials were undertaken on an ad-hoc basis, with a lack of success due to a variety of issues that include poor management and lack of ownership by stakeholders. Identifying successful biofuel options for replication among rural communities in PICs is a challenge currently faced by many energy offices in the region. The type of biofuel best to use will depend principally on the type of available feedstock and factors such as the quantity of the resource as well as that the energy can be used locally (Wikipedia, 2009). Assuming that oil, gas and coal are being consumed at a constant rate, researchers suggest that we can consume fossil fuels produced from crude oil at the present rate for another 45 years, gas for about 72 years and coal for about 252 years before none of these finite resources are left (Ethridge, 2007). Biofuels, in this case coconut oil, can be re-grown giving it a potential edge over fossil fuels as the latter are in danger of extinction and are non-renewable. The anticipated benefits of using biofuels include boosting rural economies, promoting energy independence and hence security of supply and reducing GHG emissions (Marshall, 2009).

In exploring the opportunities to develop practical applications for the use of coconut oil as biofuel, SOPAC and the Fiji Department of Energy (FDoE) have, since 2005, undertaken a number of feasibility studies in rural communities within Fiji to assess the potential of using coconut oil derived from copra. By changing from the traditional production of dried copra to value adding activities such as biofuel for use in an adapted diesel engine, cooking oil and/or body lotions, coconut oil provides the village community with opportunities to increase and diversify their income base and therefore their economic resilience.

¹ The Energy component of SOPAC was transferred to the Secretariat of the Pacific Community (SPC) as of 1 April 2010 and therefore this monitoring function is now the responsibility of SPC.

² On the other hand, fossil fuels, such as coal and petroleum, are derived from long-dead biological materials that have been transformed by geological processes.

2 Background of the project

The Centre of Appropriate Technology and Development (CATD) provides training relevant to the development of Fiji nationals from rural communities where youth are taught a range of technical skills to contribute to building their economy and long-term sustainability. In 2008, CATD was offered the opportunity to establish a demonstration project on coconut oil processing through a project jointly funded by SOPAC and the ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA) via the project “Generating and Disseminating Knowledge on Community Based Processing of Coconut Oil in the Pacific”. Under the project, SOPAC procured, installed and commissioned a coconut mini oil mill, a biofuel blending unit and a biofuel engine/generator as well as provided staff resources for the coordination and implementation of the project on Viti Levu in Nadave, Tailevu, Fiji Islands.

CATD had been keen in pursuing a biofuel project in previous years as part of its Appropriate Technologies Programme. The activities covered in the current CTA/SOPAC project include the following activities some of which have contributed to meeting the objectives of the CATD as mentioned above:

- Milling and refining equipment –
 - adaptation of generator;
 - production of biofuel; and
 - production of cooking oil, body lotion and soap.
- Conduct training on processing and marketing oil-derived products.
- Prepare and disseminate information on small-scale processing of coconut oil.
- Implementation of one regional workshop on proposal writing for small-scale coconut oil processing projects.

The demonstration project was designed to ensure that the set up would be self contained, meaning that the 18-kVA engine/generator included in the biofuel demonstration project package would be used to provide power for the coconut oil mill, the biofuel blending unit and, subsequently, the production of other value adding activities such as coconut soap and body lotions. In addition to this, the project would provide backup power to the CATD during FEA and supply blackouts.

Identifying and addressing the technical, economic and management challenges of the project was one of the objectives of setting up the project at CATD. This demonstration project when replicated into rural communities would provide a trialed and proven technology that is appropriate within the context of being user friendly, reliable and sustainable.

3 Supply, installation and commissioning

Calls for the supply of milling equipment were mainly undertaken in two lots – the first lot of the tender, which was funded by CTA covered the supply of 25 kg/hr coconut oil milling equipment, filtration and a biofuel blending unit. The second lot which was funded by SOPAC covered the supply of a generating set with an expected load in the order of 20 kVA. Tender specifications for the milling equipment and generator were sized based on the findings of the prefeasibility studies undertaken in Nacamaki, a rural community on Koro Island within the Fiji group. Schematics of the tender specification on the proposed equipment required are highlighted in Figures 1 and 2.

TECHSO (Pty) Ltd, an Australian company was awarded the tender to supply the milling equipment and biofuel generator. As part of the supply agreement, TECHSO (Pty) Ltd supplied 25 kg/hr coconut oil mill equipment, biofuel blending unit, 3-stage inline filtration system, 18-kVA diesel generator and spare parts to last two years. In addition, TECHSO (Pty) Ltd were also responsible for the installation and commissioning of the equipment; as well as train the local technicians during installation. A follow-up refresher course after 3 months was part of the agreement.

Installation and commissioning of the biofuel project equipment was undertaken in July 2009 at the CATD. As part of their contribution to the project, CATD provided the shed to house the equipment, store the copra and the electrical wiring in the shed. The coconut oil mill during installation was firstly powered from the national grid to test the performance of the equipment. The generator was first operated with diesel for a couple of hours which then supplied power to the coconut oil milling equipment. Initially 150 kg of copra was used during the commissioning, producing 70 litres of filtered coconut oil. Using a blending ratio of 80 per cent coconut oil to 20 per cent diesel, 48 litres of coconut oil was blended with 12 litres of diesel. This produced 60 litres of biofuel which was then used to fuel the 18-kVA generator. The generator was then put on load to supply power to the milling equipment. In producing the biofuel blend, care was taken to ensure that the required International Biofuel Standards relating to quality were met.

3.1 The process

The coconut oil processing system comprises a copra cutter and coconut oil mill, biofuel blending unit and storage tanks, a power generator and the production of value adding products (Figure 1).

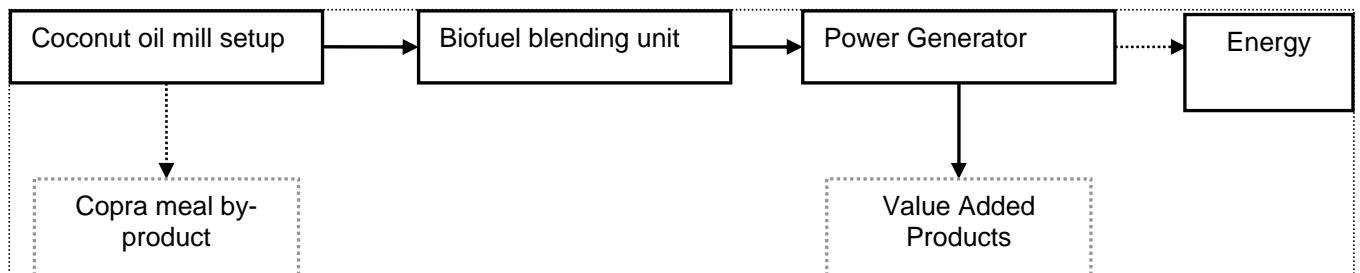


Figure 1. Coconut oil processing system.

The paragraphs below explain the individual components in the biofuel generation setup at CATD.

Coconut oil mill (Figure 2)

The coconut oil mill consists of a copra cutter to cut dried copra (preferably with a moisture content of less than 6 per cent) into small pieces that are then passed through a cold press which squeezes coconut oil from the copra, producing a by-product of copra meal which can be used as pig fodder or as manure. The expelled coconut oil is then stored in a settling tank for 1-2 days, allowing the big particles in the oil to settle and fall to the bottom of the settling tank.

Ideally after settling, the top layer should not contain any particles greater in size than 100 microns. The oil is then passed through a filter which removes any remaining particles larger than 1 micron in size. The filtered oil is then stored in 200 litre tanks for future use.

The coconut oil mill is designed to produce on average an output of around 15 to 18 litres of coconut oil per hour. Around 12-15 coconuts are required to produce 1 litre of oil. The moisture content of the copra is a determining factor in the output/production rate of the oil mill, such that the higher the moisture content – the lower the coconut oil yield. The expeller used in the coconut oil mill is a cold press expeller, meaning that virgin coconut oil can also be produced by the coconut oil mill if green copra is used.

The filtered coconut oil can be used later for a variety of purposes. For example, oil with a maximum particle size of less than 5 microns can be used for biofuel, while oil with a larger particle size might be used as a basis for value added products such as body oil, body lotion or coconut soap.

Biofuel blending unit (Figure 3)

A biofuel blending unit was included as part of the project to produce and store biofuel. The unit comprises a stirrer fitted into the 200 litre tank where coconut oil and diesel are blended in a ratio of 80 % coconut oil to 20 per cent diesel fuel.³ The blended biofuel is then stored in a biofuel storage tank (200 litre tank). The biofuel as produced has a low freezing point, where pure coconut oil will solidify during the colder months when the temperature is 18 degrees Celsius or less. The 80:20 blend biofuel will remain in liquid state and at a fairly constant viscosity level at this optimal mix ratio.

³ In mixing the 80 % to 20 % (CNO:ADO) biofuel blends, an additive (cetane additive) was also included in a number of cases to facilitate proper mixing and combustion. When introducing coconut oil and diesel biofuel blends for the first time in diesel engines, it is advisable that biofuel blends should contain around 20% coconut oil and slowly increase the coconut oil percentage in the blends over time.

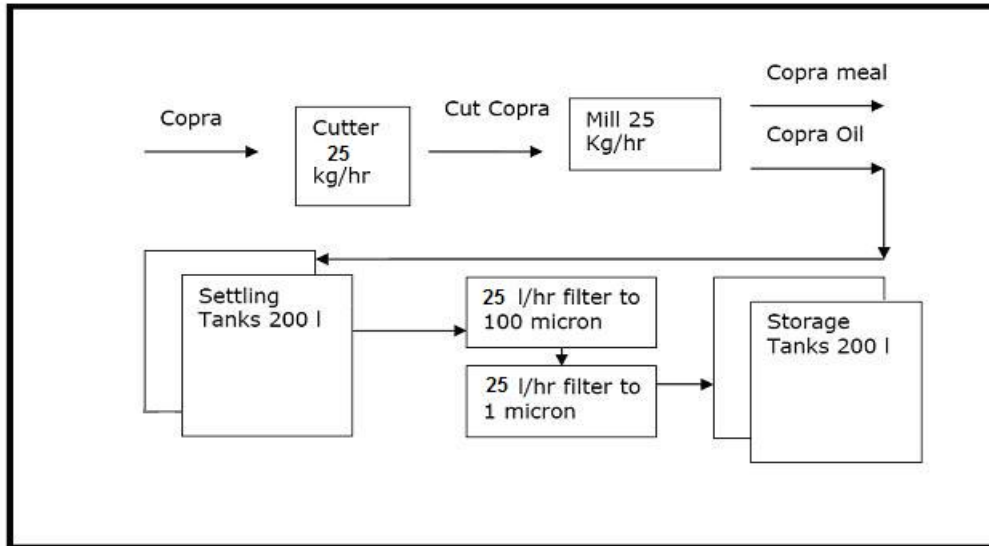


Figure 2. Oil mill with 3-stage inline filtration.

Diesel engine/generator (Figure 3)

The diesel engine/generator comprises an indirect injection engine where the generator is rated at 18 kVA (14.4 kW) under standard (prime) operation. In theory “indirect injection” diesel engines are recommended for use with biofuels as they have the capability to burn practically any heavy fuel oil including straight (100 %) vegetable oil; this is provided the oil has a low level of viscosity which can be achieved by including a heat exchanger in the system or using a biofuel mixture such as that produced in the CATD biofuel blending process.

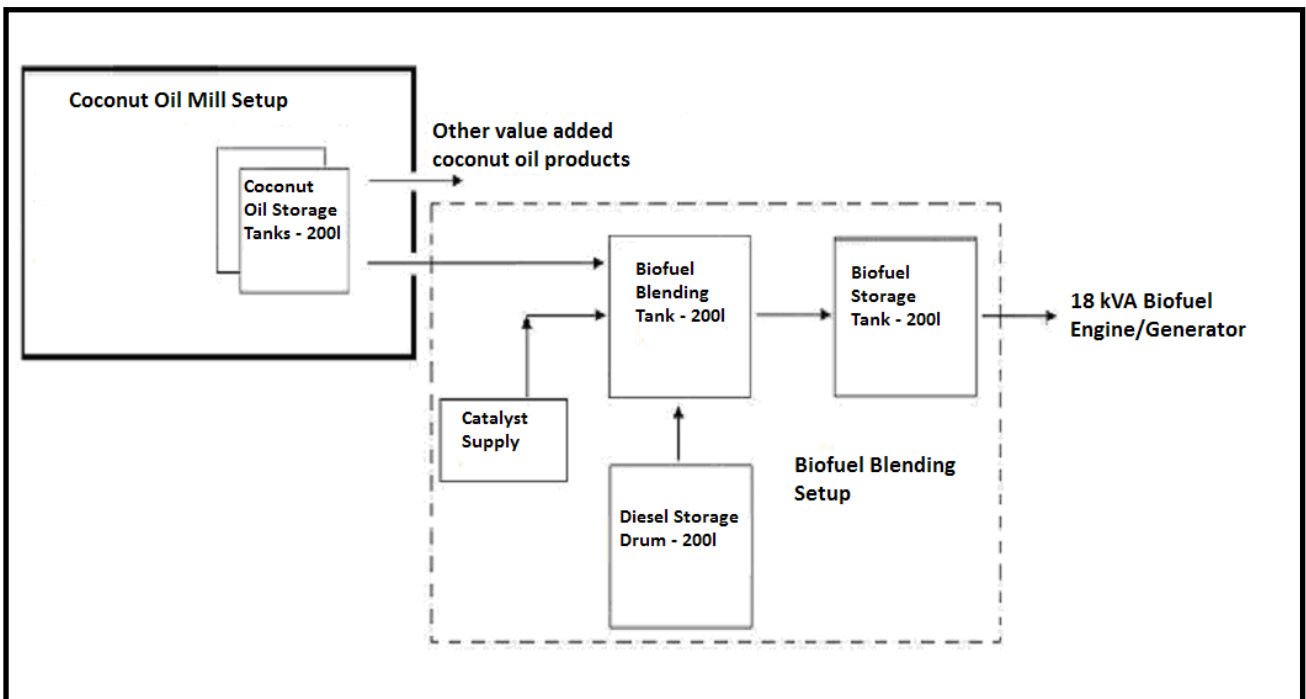


Figure 3. Coconut oil mill and biofuel blending unit.

Value adding activities (Box 1)

Theoretically, refined coconut oil can be processed to produce value added products, such as body lotions and coconut soap, instead of being used solely for biofuel. This option is important where income generation is important to improve the quality of life in the community. Also, if the coconut mill is used at capacity, it is possible that more coconut oil is produced than needed at some point. Value added products such as soaps and lotions could theoretically be marketed locally in the local and peri-urban markets.

The production of value added products requires additional/alternative processing activities and costs, such as:

- Coconut Oil Biofuel – consisting of a blended ratio of 80 % coconut oil and 20 % diesel fuel.
- Coconut Soap – involving coconut oil, mixed with caustic soda (sodium hydroxide), water, essential oils and incenses consisting of native flowers. Soap produced is for washing, bathing and as souvenirs.
- Body Oil – involving a traditional process of oil making where the refined coconut oil is heated with incense consisting of native flowers and adding essential oils.
- Body Lotion – involving a mixture process of blending emulsifying wax (bees wax), coconut oil, water, essential oil and fragrances consisting of native flowers.

Presently value adding activities are not being applied in the CATD Nadave project at this stage, but it is anticipated that these will be targeted in the future. The processing costs and any revenue generated from the production or sale of value adding products would be expected to have an impact on the financial feasibility of the CATD project.

Box 1: Value adding products

If value adding production is to occur in the future, soaps, lotions and body oils could be produced. The following is an indication of the types of products that could be targeted:

- Scented bathing soap from the coconut oil sold at \$3.00 each. These include around 4 varieties of scents.
- 100 ml bottles of virgin coconut oil sold at \$6.00 each.
- 100 ml bottles of body lotion sold at \$5.00 each. The body lotions come in around 4 types of scents.

From experience, around 4 bars of soap can be produced from 1 litre of coconut oil. However, production solely for sale purposes has not yet begun as the above figures are based on the initial production for demonstration. It should be noted that the packaging costs would be minimal as most if not all of the packaging materials are recycled products such as using plastic bottles, coconut leaves, natural fasteners, empty containers obtained at minimal or free of costs. Therefore, initially only marketing costs would be required to enable the products to gain market share. Likewise, the selling prices of the soap, oil and body lotions are based on similar products in the market (Pure Fiji for example). These other product prices are higher than those ascertained for the above value added products since they have an established market. Being conservative, it is anticipated that these products will gain its market share quite quickly since there are not many such products in the market. A second round of analysis on this would be helpful after the product is in the market so that the actual selling price and costing can be ascertained. Additionally, it is expected that net benefits would be achieved from the production of these value adding products since costs are being minimized during the production and selling of the products.

Load demand for the biofuel demonstration project

The total demand for all the equipment used for the coconut oil mill and crusher, the biofuel blending unit including the pumps, heater and inline filtration system is around 7.1 kW. At present the 18-kVA (14.4 kW) biofuel engine in the project is running at less than 50 % load meeting only the biofuel production needs. The inclusion of other value adding activities (coconut soap, lotion and body oil making) and other equipment and appliances will see the biofuel engine operating at the recommended 75 % load or more which is optimal for better efficiency and performance. For backup power to CATD, the 18-kVA biofuel engine/generator will provide power to the important areas in CATD (refrigeration in the kitchen premises, the water pumps and around the main office premises).

Production capacity and operation of the biofuel demonstration project

The actual production rate from the coconut mill was 10 to 15 litres of coconut oil per hour, capable of producing around 460 litres of coconut oil from 1 tonne of copra or 2.17 kg to produce 1 litre of coconut oil. Oil produced is filtered to 1 micron particle size and is stored in a 200 litre drum.

To begin initial production and operation, 51 litres of diesel fuel is needed to generate power (from the 18-kVA generator for 13 hours at 75 % load) to meet the coconut oil mill and biofuel blending unit load of 7.1 kW. The oil mill produced 128 litres of filtered coconut oil in 13 hours, fractionally under the lower specified production rate of 10 litres per hour. When the 128 litres of coconut oil is blended with 32 litres of diesel, 160 litres of coconut biofuel will be produced. This amount of coconut biofuel (80:20 blend) is capable of running the 18-kVA generator for 41 hours when operated at the recommended 75 % load. According to supplier specification, the fuel consumption is 3.9 litres/hour. The biofuel system as operating can provide fuel for the biofuel engine and production of value adding products.

4 Economic assessment methodology

A benefit cost analysis (BCA) was used to assess the economic feasibility of the entire project. Assessment was based on a scenario where the project was installed in a village rather than at the CATD. The project was then considered using a standard “with” and “without” analysis. In the ‘without biofuel project’ scenario, the village would need to use a diesel generator for energy supply. No diversification of income generation would occur. By comparison, the ‘with biofuel project’ scenario, coconuts would be converted to fuel locally and pig fodder and manure/fertilizer are produced as ‘free’ by-products. Additionally, various value adding by-products could potentially be produced for sale (although presently these are not).

The benefits and costs achieved under the ‘without biofuel project’ and ‘with biofuel project’ scenarios were calculated over a twenty-year period from 2009 to 2029. Possible costs that would incur over the life of the biofuel generator relative to the diesel generator include:

- **Initial capital costs:** Includes initial and up-front costs associated with a project including the costs of any project feasibility studies, system design costs and equipment purchase, transportation and installation. In other words, all costs incurred up to the point where the project starts running are considered capital costs.
- **Operation and maintenance costs:** Includes any costs associated with maintaining and operating the project such as administrative costs, transport costs and other costs associated with operating the project.
- **Fuel costs:** Include the market value of the annual costs of any fuel used (diesel or biofuel) (Woodruff, 2007).

As the choice of assumptions varies under certain scenarios, a sensitivity analysis was undertaken to check the impact of changing these key assumptions. Sensitivity analysis involved adjusting various assumptions used within the analysis to determine the effect on key economic indicators of a range of likely future scenarios. The sensitivity analysis was necessary since assumptions made about the project in some cases had degrees of uncertainty in regard to values for future parameters, such as fossil fuel/oil prices. For the purpose of the analysis, a partial sensitivity analysis, in which only one assumption is adjusted at a time, with all other assumptions held constant, was used.

The stream of benefits and costs over time were discounted to estimate the present value of the project, using a discount rate of 10 percent. Non-monetary or secondary benefits were not assessed in this analysis since the project was in its early stages and data was not available. It should be noted that the analysis is still preliminary as the value adding activities generated from the project as mentioned earlier have not yet been fully assessed and are not included in the analysis. Although these activities have commenced, the products are yet to be launched in the market thus the unavailability of sales revenue data.

4.1 Assumptions

The following assumptions were made:

- Biofuel Generator:
 - The economic lifetime of the biofuel generator was estimated at 20 years.
 - The initial generator setup and installation cost was \$FJ 97 300. For the purpose of this analysis, only the cost of the generator is taken into consideration for consistency purposes. Therefore, the biofuel generator cost of \$FJ 26 000 was considered in the analysis. The analysis is thus based on the assumption that coconut oil will be purchased to run the biofuel generator.

- The maintenance cost is estimated at 3 % of the capital cost and it is expected to increase at the rate of 1 % every year. This increase can be attributed to the other equipment involved in the process of producing coconut oil for use in the generator.
- The generator operates for 10 hours per day.
- Biofuel cost is estimated on a per unit basis with a price of \$2.13/litre.
- The generator has an operating capacity of 18 kVA (14.4 kW).
- Diesel Generator:
 - The economic lifetime of the diesel generator was estimated at 20 years.
 - The initial generator setup and installation cost was estimated to be \$FJ 17 500.
 - The generator operates for 10 hours per day.
 - Fuel cost was estimated on a per unit basis with a price of \$1.73/litre.
 - The maintenance cost was estimated at 1.5 % of capital cost and is expected to increase at 1 % per annum.
 - The generator has an operating capacity of 18 kVa (14.4 kW).

Note that the analysis is in Fiji dollars.

5 Economic analysis

A summary of the key issues in the “with” and “without” scenarios are presented in Table 1, together with key values used.

Table 1: Summary of scenarios and values.

Without Analysis (Diesel Generator)		With Analysis (Biofuel Generator)	
Inputs	Costs	Inputs	Costs
<ul style="list-style-type: none"> ▪ 14 235 litres of diesel to run a generator for 10 hours per day for 365 days. 	<ul style="list-style-type: none"> ▪ \$1.73 per litre of diesel 	<ul style="list-style-type: none"> ▪ 4015 litres diesel per day for 365 days to make biofuel. ▪ 34 tonnes of copra per annum ▪ 15 litres of additive per annum ▪ Labour/salaries required to access copra, produce oil and value-added products. ▪ Inputs⁴ required to make soap, body lotion, virgin coconut oil and massage oils. These include the other ingredients apart from coconut oil to make the products and labeling, marketing and distribution. 	<ul style="list-style-type: none"> ▪ \$1.73 per litre of diesel ▪ \$622 per tonne of copra ▪ \$0.07 (additive) per litre of biofuel ▪ \$2 per hour paid for labourers ▪ Costs of inputs to make body lotion ▪ Costs of inputs to sell products
Outputs	Benefits	Outputs	Benefits
<ul style="list-style-type: none"> ▪ Electricity generation 	<ul style="list-style-type: none"> ▪ Improved lighting system ▪ No major modifications required to the main switch to start up the generator. 	<ul style="list-style-type: none"> ▪ 16 060 litres of coconut oil solely for biofuel generation ▪ Value added products ▪ Pig meal ▪ Manure 	<ul style="list-style-type: none"> ▪ Sales revenue ▪ Employment to locals

Source: SOPAC and Soqosoqo Vakamarama (2009)

Preliminary analysis indicates that assuming continual coconut processing to enable generator operation of 10 hours per day, the project would generate a social net loss over 20 years of over F\$ 40 000 (Table 2). In other words, the value of social benefits of the project would not be expected to cover its costs. The benefit cost ratio at this point is 0.88, indicating that for every \$1 invested in the project, only \$0.88 would be recouped over the life of the project.

Table 2: Cost Benefit Analysis Indicators; capital cost included.

Indicator	Value (\$)
Net Present Benefit	295 000
Net Present Cost	336 000
Net Present Value	(41 000)
Discounted Benefit-Cost Ratio	0.878

⁴ Since the project is just in its early stages, the actual quantity of value added products that can be produced in a year is not yet known and the costs involved in making the products and marketing them is also known. Thus this analysis is still in a preliminary form and after a year or two of operations is successfully completed and then another analysis incorporating each of these real costs would provide a much better picture of the biofuel system.

Key in the loss in the performance of the project is the costs of establishing the project, notably the expense of infrastructure (Table 2). In fact, the project was funded by CTA and SOPAC so the actual costs to the community are only its variable costs. If initial capital costs are excluded from the analysis and the feasibility of operations alone assessed, losses become much smaller, although the net value of the system over 20 years can be expected to remain negative (Table 3). In this case, the benefit cost ratio increases to 0.95, indicating that, for every one dollar invested in the project, \$0.95 would be recouped over the lifetime of the project.

Table 3: Gross Margin Analysis (economic returns with capital cost excluded).

Indicator	Value (\$)
Net Present Benefit	295 000
Net Present Cost	310 000
Net Present Value	(15 000)
Discounted Benefit-Cost Ratio	0.952

5.1 Sensitivity analysis

The biofuel project increases in economic feasibility if diesel costs increase over time. With capital costs excluded from the analysis, the project can be expected to achieve positive net benefits, provided diesel price increases by more than 4 percent per year (Table 4). According to the US Energy Department's Energy Information Administration (EIA) forecast, high crude oil prices are expected for the next 20 years.⁵ In addition to this, improving global economic prospects will increase the demand for crude oil leading to price increases. The net present value increases as the expected rate of diesel price increases; if the diesel price increases by 2 percent, 4 percent and 5 percent, the net present value attained is \$500, \$49 000 and \$72 000 respectively. This indicates that over time, the biofuel system has an advantage over the diesel system even if the biofuel generator is not funded; considering just the variable costs.

Table 4: Gross Margin Analysis with diesel prices rising.

Diesel Price Increase	Net Present Benefit (\$)	Net Present Cost (\$)	Net Present Value (\$)
2%	327 000	406 000	(79 000)
4%	725 000	415 000	310 000
5%	835 000	420 000	415 000

Economic analysis thus indicates that the biofuel project requires donor support and continued increases in the price of diesel to be socially feasible; however, given that a main input for the diesel engine is diesel itself, the volatility in diesel prices which is quite prevalent now could encourage the use of biofuel generators. By comparison, if the mill component is also included in the analysis and the total costs of the project would have to be covered by the village, then the net present value would be negative. High start up costs is an obstacle to the project despite low operational costs; however, it is possible that environmental benefits from the project – particularly in the form of reduced carbon emissions – might help render the project to break even from a social perspective.

⁵ <http://www.highbeam.com/doc/1P2-16647301.html>

In a village scenario where copra is freely available, producing a litre of biofuel would cost \$0.71⁶. Additionally, the analysis shows that for every \$1 invested in the project \$1.43 will be returned after the first year of use and is presumed to continue for the life time of the project (Table 5). This outcome is possible even if the villagers are supposed to pay for the biofuel generator as well as the oil mill which gives a total capital cost of \$97 300.

Table 5: Cost Benefit Analysis Indicators; village scenario where copra is free

Indicator	Value (\$)
Net Present Benefit	295 000
Net Present Cost	206 000
Net Present Value	89 000
Discounted Benefit-Cost Ratio	1.432

While these estimates discussed so far are conservative and presented using a 10 per cent discount rate; there may be arguments for lower discount rates, especially for development projects. If a lower discount rate is applied in the analysis, the absolute value of the expected net present value of the activity will be higher (Table 6).

Table 6: Gross Margin Analysis (at various discount rates).

Discount Rate	Net Present Benefit (\$)	Net Present Cost (\$)	Net Present Value (\$)
3%	484 000	520 000	(36 000)
7%	357 000	379 000	(22 000)
10%	295 500	310 000	(15 000)

Additionally, at this point, no value added coconut oil products are being produced for sale (soap, lotions etc.). In the future, if the community diverts coconut oil to these products and successfully markets them, it is possible that the commercial and social viability of the project may increase.

⁶ This includes labour, additive, diesel and generator operation costs.

6 Challenges and lessons learned

While potential benefits from the project exist, the project is currently challenged from several direct consequences. Firstly, getting low quality copra (which has high moisture content) would negatively affect the production of coconut oil. High moisture content can even affect the power output of the engine. Moreover, there is no fixed supplier of copra for the biofuel project. Currently, there exists no agreement between a copra supplier and CATD; this can affect oil production in future. In addition to this, some electrical modifications were required at the milling shed before the generator could be operated.

Table 7 lists challenges encountered from the biofuel demonstration project and some of the associated solutions undertaken.

Table 7: Challenges in the CATD biofuel demonstration project.

Situation	Problem that will arise	Associated solution
High moisture content in copra (greater than 6%).	<ul style="list-style-type: none"> ▪ Production rate of coconut oil drops. ▪ Moisture content in biofuel. This has a high chance of affecting the power output of engine. 	<ul style="list-style-type: none"> ▪ Ensure moisture content in copra is decreased by re-drying copra.
Large particles in settling tank entering the coconut oil filter.	<ul style="list-style-type: none"> ▪ Coconut oil filter clogs and shuts down. ▪ Frequent shut downs and washing of filters occur delaying oil production time. 	<ul style="list-style-type: none"> ▪ Ensure one or two days are allocated for settling to allow the large particles in the coconut oil to settle to the bottom. ▪ Avoid sudden movement of the settling tank or stirring of the settled coconut oil during decanting for filtering. ▪ Frequent cleaning of the settling tank.
Coconut oil in settling tank has high viscosity (or solidifies) in the colder months.	<ul style="list-style-type: none"> ▪ Coconut oil filter clogs and shuts down. 	<ul style="list-style-type: none"> ▪ Use heater installed in the settling tank to heat coconut oil. (Care must be taken not to over heat coconut oil, which may result in a fire hazard)
Large particle sizes in biofuel	<ul style="list-style-type: none"> ▪ The large particles will quickly clog the generator fuel filters. Clogged fuel filters result in reducing the flow of fuel to the combustion chamber in the biofuel engine resulting in a breakdown or 'choking'. 	<ul style="list-style-type: none"> ▪ Ensure that the coconut oil filter is frequently cleaned. ▪ Biofuel blending tanks are covered at all times. ▪ Avoid any dust/particles entering exposed/open areas in storage and blending tanks.

Some broader lessons learnt from the project include the following:

- The appropriate technical specifications and design of equipment during procurement.
- Integrated approach feasibility study taking into account the social, economical, environmental risks and sustainability issues.

- Maintaining a continuous supply of copra to CATD since the supply of this is imperative for the successful execution of the project.
- Training of operators to ensure that equipment is operated at optimum level.
- Marketing of oil-derived products from the project be given priority.

More widely, it is not clear at this point the extent to which the commercial production of oils and lotions is financially viable. There is already an established set of suppliers in the beauty industry in Fiji (for instance *Pure Fiji* and *Mokosoï*) and competition would be strong against the established brands. There would need to be a financial assessment of the feasibility; for example, in marketing the value-added products.

7 Concluding remarks

The technical installation of the SOPAC–CATD biofuel project has been successfully completed and commissioned and is now operating. Training on the production of biofuel has been completed with additional training on the production of other value added products to be undertaken towards the end of October 2009.

Preliminary economic analysis of the project found it to be a potentially viable option for replication in other similar locations and in other PICs only if diesel price increases at more than 4 % per year; however, the environmental benefits achieved through the project have not been valued and may also increase social feasibility. In order for the replication to be successful in other locations in the future, the biofuel project needs to be established in an environment where there is an adequate supply of locally-produced copra, there is a willingness to cut the copra, appropriate training in the production of biofuel and other value-added products. There also needs to be an appropriate regular monitoring and servicing programme established. In consideration of these parameters the CATD project has been monitored by SOPAC and CATD for its effectiveness for the first three months of operation where this led to identifying some of the current challenges. In addition continual monitoring will be undertaken by CATD for the next five years to identify the exact performance, challenges, including identifying appropriate adjustments to the biofuel project (especially the performance of the biofuel generator during this period). The observations from the monitoring will be used to ensure that similar projects can be replicated among other rural communities in the Pacific Island Countries to an equal or better standard. In addition, the biofuel installation will serve as a demonstration project that will become an additional valuable training module for CATD. This will further provide opportunity for collaboration with the Fiji Department of Energy to use CATD's facilities for the training of rural technicians under the Department's Rural Electrification Programme. To further test the performance of the project, it is indeed necessary to carry out further BCA that will include the value-adding activities that are currently being carried out from the project, which might help achieve better rate of return.

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