# Coconut Oil as a Biofuel in Pacific Islands

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*There are great opportunities to utilise coconut oil as a fuel in the Pacific. Coconut oil can be blended with diesel fuel, and under certain conditions totally replace it. Coconut oil in Pacific islands countries is increasingly used in both transport and electricity generation through its lower local cost. Other benefits include the support to local agro-industries and a decrease in emissions.*

## Biofuels in the Pacific

The use of biofuels is nearly as old as the diesel engine itself, as Mr. Diesel designed his original engine running on peanut oil. During periods in history when regular diesel supply was hampered seriously such as during World War II, throughout the world vegetable alternatives from different sources and in different forms have been used.

The specific circumstances of small Pacific Islands call for local solutions. Since most Pacific island countries import their fuels at very high transport costs, it makes economic sense to find local fuel supplies. Even though the Pacific islands on a world-scale do not contribute much to the emission of greenhouse gasses, their case for mitigation assistance under the Kyoto Protocol becomes much stronger if they simultaneously look for environmentally beneficial alternatives to fossil fuels.

The traditional production of copra (flesh from a coconut) and its oil, an industry inherited from colonial times, has been suffering from low world market prices and high transport costs. In a number of countries, the copra industry is nearly extinct, especially through the high inputs of labour required, with low return. By switching to mechanised production of local fuel substitutes instead of focusing on highly competitive exports, economic niches can be found on the islands themselves.

There are a number of ways in which vegetable oils such as coconut oil can be used in compression engines (See Coconut Oil Fuel Technology). Another promising technology includes straight gasification of whole coconuts, however this requires further technological development.

## Coconut Oil Fuel Technology

***Use of Coconut Oil in Standard Engines***

Figure 1 gives an overview of the options to use coconut oil in Compression (Diesel) engines. Coconut oil can be blended with diesel, straight in an adapted engine or turned into biodiesel. Because of higher specific density and slightly lower energy content, specific fuel consumption using coconut oil is generally 8% higher.

Many studies involving the use of vegetable oils such as coconut oil were conducted in the early 1980s. Short term

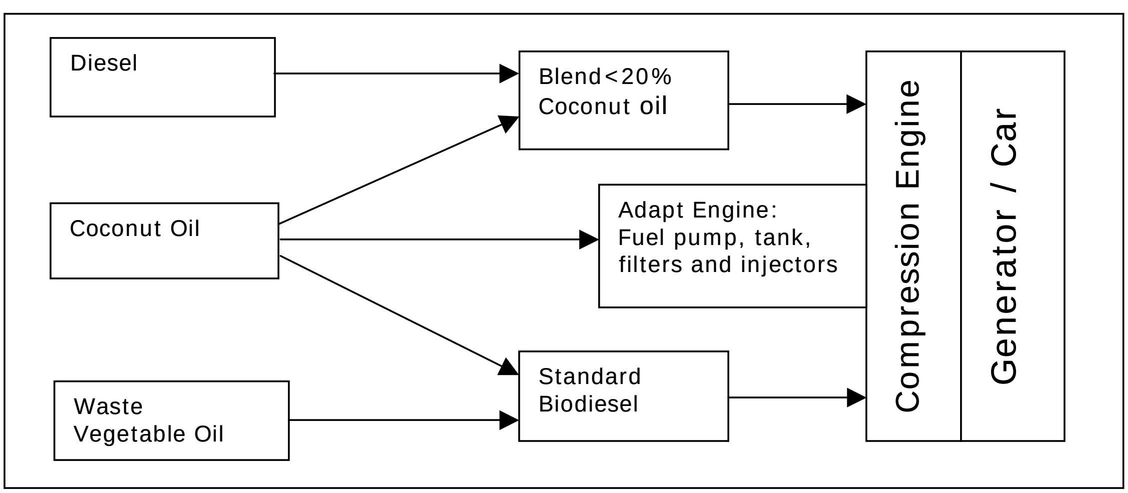


**Figure 1**: Overview of Biofuel Choices for Compression Engine

engine testing indicates that vegetable oils can readily be used as a fuel or in a range of blends with diesel. Long-term engine research however shows that engine durability is questionable when fuel blends contain more than 20% vegetable oil [1,2,5,11]. Especially deposits on the pistons, valves, combustion chambers and injectors can cause severe loss of output power, engine lubricant deterioration or even catastrophic failure to engines [6].

Using pure coconut oil in standard engines is very attractive through its low cost, however it requires special technical supervision and may shorten engine life.

**Use of Coconut Oil in Adapted Engines**

***Fuel Heater***

As coconut oil has up to 30 times higher viscosity than regular diesel at the same temperature, most engine modifications include a fuel heater. As heat is exchanged between the engine coolant and the fuel, the oil viscosity approximates that of diesel [7]. As coconut oil solidifies below temperatures of 25$^0$C, often an electrical heater is incorporated in the fuel tank.

***Start / Stop on Diesel***

Most adaptations incorporate a start and stop on regular diesel. As soon as the engine is operating at rated temperature, the fuel supply switches to coconut oil and just before shutting down, the supply is switched back to diesel. This system ensures that the fuel system has diesel ready for a cold start and avoids coconut oil residues in the fuel system.

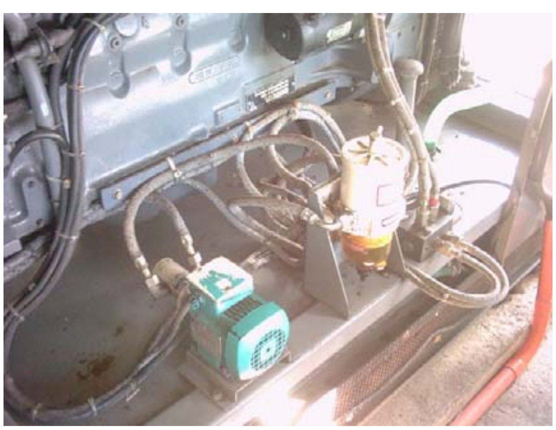

**Figure 2:** Fiji Rural Electricity Generation adaptations: special pump and filter.


**Figure 3**: Coconut Oil Adapted Vehicles in Vanuatu (Tony Deamer)

***Fuel System Adaptations***

It is also possible to adapt the fuel system of a compression engine to start and stop on pure coconut oil. Mostly, these engines feature adapted injectors, dedicated fuel pumps and extra filters. A good example of this is the pilot plant in Ouvéa, New Caledonia, implemented by SPC and CIRAD in the 1990's [3,12]. Further feasibility studies have shown favourable opportunities for both electricity generation and taxis in Vanuatu [9,10].

In Europe and the United States, the use of dual fuel systems, mainly in automotive applications, is slowly developing. Through a combination of high taxation on fuels (Europe), low vegetable oil prices (U.S.) an increasing number of consumers have acquired an alternative fuel system built in their vehicles. Reportedly, the emission reductions achieved through use of these fuels have been mixed [8].

The main advantage of adapted engines is their fuel flexibility and relatively low additional cost. The major disadvantage is the loss of guarantee from the engine manufacturer, even though some engine manufacturers are now supporting the use of coconut oil under certain conditions. A second disadvantage is the requirement for higher loads, as low loads result in heavy deposits on the combustion chamber components, reducing engine life [12].

***The use of Biodiesel***

Biodiesel is a standardised fuel that consists of vegetable oil Methyl Ester. It is a product of vegetable oil that reacts with an alcohol (methanol) and a catalyst (sodium hydroxide). This process generates two products: glycerine, which can be used in soap production, and biodiesel. There are two fully developed standards of biodiesel, ASTM-D 6751 in the U.S. and EN14214 in the E.U. Following these standards upholds the guarantee of the engine manufacturer [4].

Positive impacts on engines include increased lubricity and a reduction of visible particles in the exhaust. Secondly, other (waste) vegetable oil can be included in the feedstock of biodiesel production.

The major disadvantage of biodiesel is its high costs through the use of a chemical facility and the requirement of imported methanol. Current research by the University of the South Pacific will have to point out whether the production of standard biodiesel can be competitive using locally produced ethanol from sugarcane.

## Coconut Oil Economics

The world production of coconuts in copra equivalent has been floating around 10 million tonnes per year. Of this market, between 1 and 2 million tonnes has been traded on the world market. Figure 4 shows the volume of the global copra oil market and the associated price per litre over the last 5 years.

The price fluctuation of coconut oil has been significant, between 0.3 and 0.7 US$/litre. The export market consists mainly of industrial processes that can use other vegetable oils if the world price for coconut oil is high. This can be seen for example 1999 when there was a worldwide shortage of coconut oil. The world market price is therefore also very much linked to the prices and yields of other oils such as palm, corn and canola. Since the Pacific island countries only produce a small percentage of the world export (Papua New Guinea: 2.2%, Solomon Islands: 1% Samoa 0.4%, Fiji 0.3%), any increase or decrease in production in the Pacific will not alter the

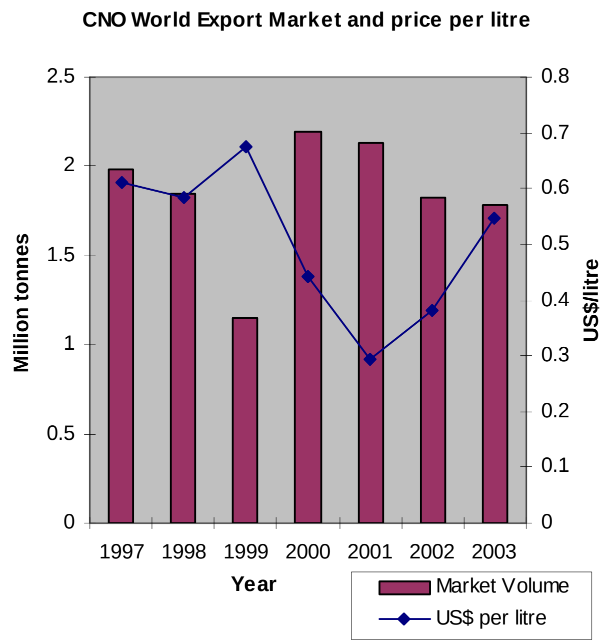


**Figure 4:** Copra Oil World Export Market and Price *(Source: Philippines Coconut Authority)*

world price. The price composition for traditional production of copra oil in Fiji is given in table 1. The value of the coconuts and the labour to create copra (includes cutting the coconut flesh out of the shell and drying it) are almost equal. On top of that the mill obtains 11 US cents per litre in return for producing and filtering the oil. Finally 11 US cents are required to get the oil to the world market, in this example, the port of Rotterdam.

One of the reasons why the copra oil industry in many Pacific island countries is suffering is because they have a relatively small size and little opportunities for economies of scale. Because of the low return for the harsh work involved with the cutting and drying of copra, many rural farmers are diverting to other cash crops, leaving coconuts unharvested in plantations. Regional potential production estimates amount up to a total of 100 million litres of coconut oil.

There are many opportunities to mechanise the process of copra production, but this will only materialise when investors perceive the risks of the investments required to be minimal. Switching to higher value product-market combination such as Coconut Oil Fuel might assist in this transition. The electric utility of Western Samoa (EPC) is currently carrying out a feasibility study of a mechanised Coconut Oil Fuel production plant on the island of Savai'i.

**Table 1**: Fiji Coconut Oil Price Composition

| | Price in Oil Equivalent [US$/l] | Share of Local Oil Price [%] |
|---|---|---|
| Coconuts on field | 0.22 | *39* |
| Return for labour to Cut/Dry Copra | 0.25 | *42* |
| Dry Copra at Mill | 0.47 | *81* |
| Return for Milling / Filtering | 0.11 | *19* |
| **Coconut Oil Price at Mill (Fiji)** | **0.48** | ***100*** |
| Storage, Transport, Financing | 0.11 | *19* |
| World Coconut Oil Price (Rotterdam) | 0.59 | *123* |

What becomes apparent when looking at the figures in Table 1 is that the local price of coconut oil is significantly lower than the world price, through the cost of storage, transport and financing. Since one litre of diesel must be replaced by 1.08 litre of coconut oil (see box "Coconut Oil Fuel Technology"), the opportunity cost for local coconut oil versus diesel is therefore US$ 0.52 per litre.

Figure 6 shows the retail prices and landed cost of diesel fuel in the region, the difference being taxes, excise and distribution costs. The line in the graph depicts the opportunity cost of a litre of coconut oil of being exported. The price difference is even larger for remote islands and villages inside the Pacific islands countries, where additional local transport costs have to be taken into account.

**Figure 5:** Traditional Copra Production in Samoa

Given the volatility of both the prices for coconut oil and diesel, flexible fuel systems running on both fuels, have preference. Even running generators on low blends (10-20%) of coconut oil without investing in engine adaptation can have great financial benefits.

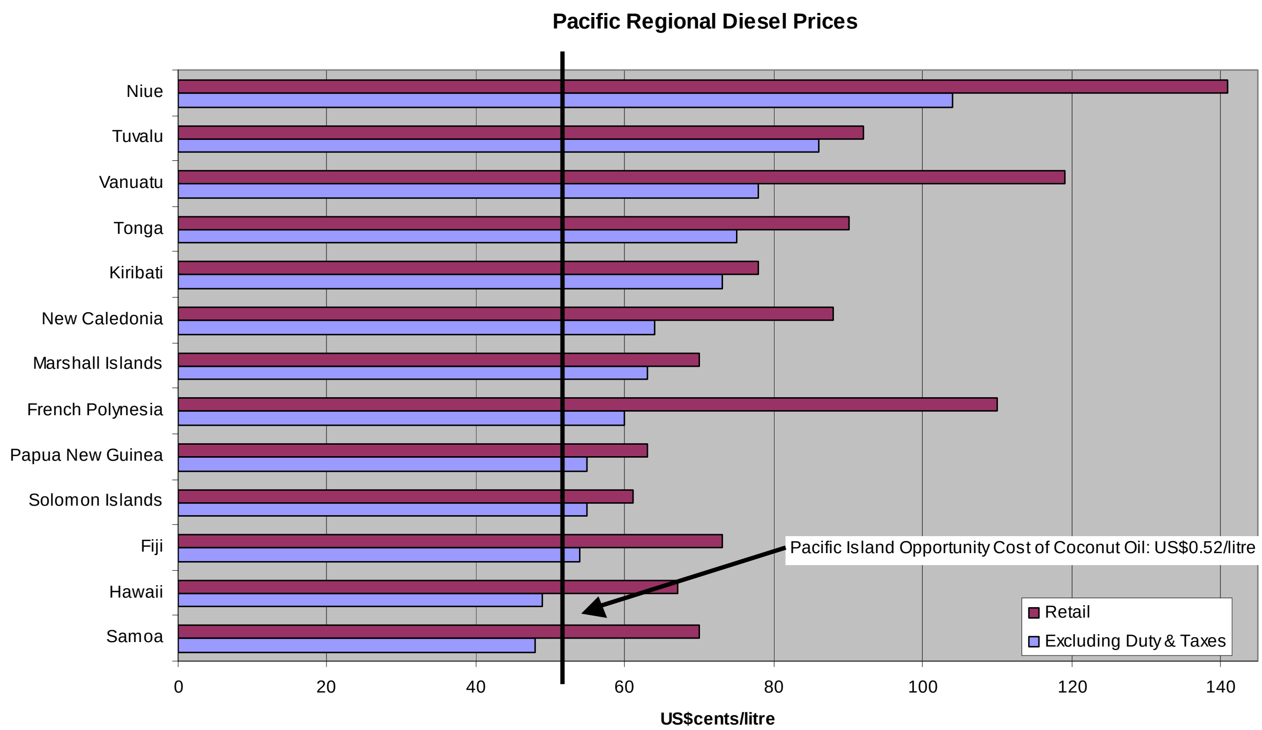


**Figure 6:** Pacific Regional Diesel Prices *(Source: Pacific Islands Forum Secretariat Fuel Price Monitor Nov-Dec 2004)*

The further rationalisation and mechanisation of the coconut oil supply chain will increase the security of supply, however this requires significant investment in the coconut oil sector. After restructuring and replanting of coconut plantations, most Pacific islands have the potential to provide one third to half of their current diesel imports.

## Environmental Benefits

The widespread use of Coconut Oil to replace diesel has a range of potential environmental benefits. First, there is the decrease of emissions of poisonous gases and particulate matter as compared to diesel, through the higher oxygen content of coconut oil. These benefits however do not materialise so well using straight vegetable oil in standard engines [8]. Secondly, the use of coconut oil can be considered $CO_2$ neutral. The $CO_2$ stored in the coconuts, husks and shells are used in the process of oil production (husk and shells for drying the copra) and burning of the oil. This $CO_2$ is again sequestrated during the growing of new trees and nuts.

## Socio-Economic Benefits

Creating a local industry that substitutes fuel imports, benefits fragile Pacific island countries substantially through improvements in balance of payments [13] and job creation. Simultaneously, coconut farmers are given access to a new, potentially booming market once the difference with the benchmark of the diesel price further increases.

## Conclusion

***Even though there is quite some evidence of the environmental benefits using vegetable oils as a fuel, it is the local cost of fuel that is the real driver behind these developments in the Pacific island economies. Electric Utilities generally suffer from great dependence on imported diesel for power generation and are seeking new ways to hedge these risks. Motorists have successfully blended coconut oil with diesel to decrease costs per km. For coconut oil fuel to be a sustainable alternative to diesel fuel in the Pacific, restructuring of the coconut industry and replanting of coconut plantations is required. Widespread utilisation of alternative fuels will require active involvement of engine manufacturers and local mechanics.***

## Acknowledgement

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## Links for further information

http://www.journeytoforever.org/biofuel_library.html
http://www.sopac.org/tiki/tiki-index.php?page=Energy+Projects+COPRA

## Biography Jan Cloin

*Joined SOPAC – Community Lifelines Programme – in December 2003 as a U.N. Associate Expert. He started his career with PV Solar Home Systems research in Southern Africa for the Netherlands Energy Research Foundation (ECN). After that, he worked briefly for the UNDP Energy & Atmosphere Programme in New York. Before joining SOPAC, he was active in the green electricity sector in The Netherlands. Currently, he is working on the use of Biofuels, Wind Energy Education and Renewable Energy Training.*