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Renewable Energy for Micronesia

Doug Kelly

Where We Are, How We Got Here, and Where We Are Going

The bad news is that Micronesia has an energy problem. The good news is that Micronesia has the opportunity to solve that energy problem while improving quality of life, expanding economic opportunities, and preserving traditional cultural values for Micronesians. One of the keys to Micronesia's future is renewable energy. This means energy from sources that grow back or renew themselves. Micronesia is blessed with sun and wind, rain and mountain, ocean waves and depths; all sources of renewable energy for those with the wit and will to harvest them.

Energy from sources such as gasoline or diesel is not renewable because the petroleum they are made from formed over millions of years (hence 'fossil fuel'). Once the current supply of fossil fuels is gone, it's gone forever. Micronesia has no fossil fuel resources, so every gallon of fossil fuel we burn is imported. Many oil-exporting countries, or the supply routes the refined fuel must travel through, are politically unstable; any upset along the way causes shortages and higher prices here.

Micronesia has become addicted to imported fossil fuels. The supply of this 'drug' is becoming more expensive. Just as an addict will do anything to secure the next 'fix', so Micronesia will be tempted into unwise choices if it remains dependent. The wise choice is to kick the habit now, to immediately begin reducing Micronesian dependency on imported fossil fuels.

Micronesia became dependent on imported fossil fuels during the Trust Territory days. Although other options did exist, the technical

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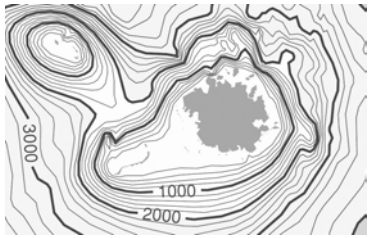
OTEC has a steep drop-off to 1000-meter depths close to shore. The bathymetric and reef charts for Pohnpei show that the southeast corner of the island, Nan Diadi, looks like a promising spot.



Bathymetric Chart of Pohnpei

Besides providing power, OTEC is good for fish. The deep ocean water is loaded with nutrients; when it is discharged, it feeds the local sea life, which grows rapidly. Perhaps we should build an OTEC plant just to improve the fishing.

A Call to Action

Micronesia's energy problem will not go away if we ignore it. We need to think carefully, to make wise choices, and to take action if we are to have a viable energy future. Technical problems can be solved. Resources can be found to cover the costs. The only thing we are lacking is the political will.

Don't assume the government will take care of everything. Communities, families and private organizations can make energy policy, too.

Personal choices make a difference. The next time you need to replace an engine, choose a diesel and fuel it with coconut oil. When you need batteries, buy rechargeables and a (solar) charger. If your land has a stream, install a turbine. When you build a house, build a renewable energy system into that house. Encourage your family to learn how energy systems function. Make energy work 'worthy of respect.'

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advice and technology offered to Micronesians was the same as that used in mainstream America: gasoline engines for cars and boats, and large diesel generators feeding a centralized power grid, all burning imported fossil fuels. Because the costs of capital equipment, fuel, and maintenance were being paid by Uncle Sam, there was no reason to look for other solutions; energy wasn't perceived as a problem. The only issue was how quickly generators could be installed, and how often they could be resupplied with imported fossil fuels. Following the advice of conventional experts seemed to be a good idea at the time, but in hindsight it is clear that Micronesia needed to follow a different path.

Independence and the Compact of Free Association did not materially change the prevalent attitudes toward energy in Micronesia. Compact funds included subsidies for generator fuel, so the new governments did not have to shoulder the full economic burden of imported fossil fuels. For many years, government fuel supplies were regarded as a fringe benefit for those with influence, and for friends and relatives of government workers. As with so many other examples of misappropriation, we do not have exact numbers, but certainly a large portion of official fuel supplies found its way into private tanks. With energy so freely and conveniently available, why should policymakers and elected officials press for any changes?

Compact II brought a significant change in the actual costs of energy for Micronesians: the subsidy for generator fuel ended. Now the cost of the fuel oil burned in the central generators is a separate budget item that the power companies - state government monopolies - must pay for by charging higher rates. The recent rise in the cost of imported fossil fuels has made the difference even more apparent. In April 2006 the consumer fuel cost of a kilowatt-hour of electricity on Pohnpei was 17.5 cents, up 80% from 9.74 cents in September 2002. There have been similar increases in the consumer price of gasoline, diesel and kerosene. Fuel prices in the outer islands are sometimes double the price on the main islands, when fuel is available at all.

In 2002 (the last year for which the FSM government has released official numbers) the FSM imported nearly $15 million in fuels and lubricants, including gasoline, oil, diesel, kerosene, and aviation fuel. Even if demand remained flat, projecting the costs using the known increase in price would put 2006 imports into the range of $27 million - over a third of Compact funding ($79 million for 2006).

Every resident of Micronesia is feeling the effects of higher energy prices. Outer islanders are being served less frequently by field trip boats due to fuel costs and shortages. Taxi drivers are trying the patience of their passengers, running convoluted routes to maximize the number of passengers carried for every gallon of fuel burned, trying to compensate for the higher prices at the pump, which have nearly doubled in the last 5 years. Local businesses are economizing by turning off lights and air conditioning until customers complain. Homeowners who used to be able to run their household for a week or more on five dollars' worth of Cash Power are now expending that amount in a few days. Traffic at fuel stations backs up for blocks whenever there is a rumor of an impending price increase. Prices for transportation and for imported goods are increasing, and exported goods are bringing less money home because more of the selling price goes to shipping costs. Perhaps most disturbing, Micronesian families are arguing more: Do we have a hot dinner, or watch TV, or machine-wash the laundry because we cannot afford the electricity for all the options we used to have?

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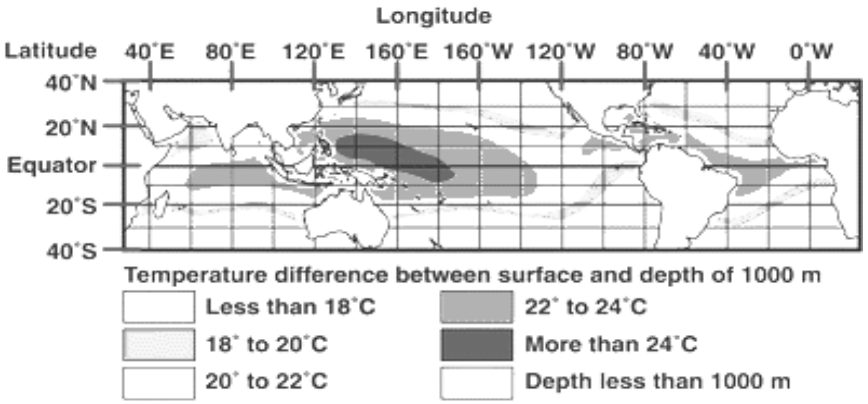
It's going to get worse. Most experts agree that we have already passed "peak oil" and that global oil production is on its way down, never to recover. Increasing demand and diminishing supply will continue to push prices higher. What will life in Micronesia be like five years from now, when gasoline is $10 a gallon on the main islands?

temperature difference in ocean waters between the sun-warmed surface and the cold depths. The larger the difference, the greater the potential energy harvest. OTEC is a technology that has been understood in principle for over a century, but it has been applied to only a few locations.

If you look at the map, you can see why OTEC has been neglected by most of the developed countries: their population centers are too far from the richest OTEC regions. Micronesia, however, is sitting in the middle of the richest possible OTEC region on the planet.



Surface and Deep Ocean Temperature Differences

OTEC technology is simple in principle, requiring only a pipe, a pump, and a pond. The pipe extends from the ocean surface to the cold depths, 1000 meters or more; the pump draws that cold water up the pipe. The pond holds warm surface water. A low-pressure turbine system using ammonia as the working fluid is heated on one side by the surface water, and cooled on the other by the deep water. The turbine spins, turning a generator to produce electricity.

A multi-megawatt OTEC plant could replace some of Micronesia's large diesel generators. A good onshore location for

Maintenance workers can support themselves in a traditional economy through barter, as long as the accumulation of marketable commodities will meet the cost of imported replacement parts. An outer islander who learns to repair and maintain VCO processing equipment, diesel engines, or VCO-burning pressure stoves and lamps should be able to barter services for VCO, which can then be traded to the main islands for replacement parts and other imported goods.

Microhydropower

Some of the high islands of Micronesia have another renewable energy resource in their rainfall. Pohnpei in particular is one of the rainiest places on Earth. As noted earlier, the Corps of Engineers surveyed Pohnpei for hydropower potential, but overlooked most of the available opportunities.

A microhydropower installation does not require a huge concrete dam. The very smallest are simply a propeller and generator trailed in a stream. A larger size diverts some of the water into a flume or pipe, runs it through a turbine or waterwheel then returns it to the stream. Microhydropower provides a renewable, pollution-free source of mechanical or electrical power that will last for many years for an initial investment no more than what you'd pay for a fossil-fueled generator of the same power.

Perhaps most importantly for many Micronesians, it is possible to build a microhydropower plant with local materials using traditional skills and techniques. If you have a stream on your land, wood you can harvest, and the services of a competent woodworker, you can produce your own mechanical power. Attach a recycled car alternator to the turbine, and you can generate your own electricity.

Ocean Thermal Energy Conversion

There is at least one renewable energy system suitable for Micronesia that requires centralized resources to develop. Ocean Thermal Energy Conversion (OTEC) harvests power from the

Micronesia is on a slippery slope to lower quality of life and reduced economic opportunities, but there is still time to reverse these trends. We need wisdom and foresight. We need to have a social conscience: What is best for the people of Micronesia? We need open-mindedness, to be willing to consider new ideas. We need generosity, to be willing to give up profits and graft from fossil fuel imports. Greed, sloth and stubborn ignorance will condemn us to a downward spiral.

What the Experts Don't Say

One should probably not take advice from an 'expert' who repeatedly confuses Indonesia with Micronesia. The challenges and opportunities of these small islands are unique, and call for solutions that have been overlooked, devalued or discarded by conventional experts.

Conventional energy experts tend to favor large, centralized projects. When the US Army Corps of Engineers surveyed Pohnpei for hydropower potential, they found three sites where they could build huge concrete dams - then concluded that it wasn't worth the bother. They failed to identify the hundreds of sites that can each be tapped to provide microhydropower for a few homes or a village, without constructing a dam and for a comparatively tiny investment.

Trying to connect every load, and every generator, to a conventional utility grid is not a wise choice for Micronesia. Distributed power generation is probably a better choice, for technological, financial and social reasons.

A large, centralized system must be designed to power the heaviest possible load attached to it. This means wasted capacity (and wasted money), because not all the electricity generated 'just in case' will actually be used. Smaller systems can be built just large enough for a specific purpose. If you need to power a short-wave radio transmitter that the radio's manual tells you draws 250 watts, you know you won't need to buy a 5,000-watt generator.

The smallest distributed power systems are the safest, easiest and cheapest to build, maintain and repair, and they cause the least disruption when out of service.

Small distributed renewable energy systems are more cost-effective than large centralized generators when the population to be served is scattered over a wide area. Micronesia's few towns on the main islands may be served successfully by large utility-owned generators, but that model does not make financial sense for small villages in the most rural areas or on the outer islands.

Micronesians do not necessarily need or want wall voltage in large amounts, 24 hours a day, 365 days a year. If we break the energy problem down into individual energy needs, far more solutions become feasible. Mechanical power is needed for washing machines and power tools; controllable heat is needed for cooking; electrical power is needed for electronics, computers and communications equipment; and both adults and children need light to read by if Micronesia is to meet its literacy and education goals.

Distributed systems take advantage of the fact that it is often better to directly connect a renewable energy system to the device it is intended to power. For example, a manufacturer of ceiling fans recently found that the most cost-effective design was a solar panel directly connected to a direct current (DC) fan motor. When the sun is shining and the day is hot, the fan turns faster. There is no need for expensive and complicated controllers, batteries or long wiring runs, and the entire system has only one moving part.

Distributed power generation gives Micronesians more choice in preserving traditional cultural values. If the model of large centralized generators is followed, the people have no choice; we must learn to deal with a monopolistic bureaucracy that does not fit into or answer to the traditional leadership structure. The people do not retain any ownership of the means of production, and do not have recourse to traditional forms of conflict management for redress of grievances. On the other hand, small decentralized energy systems designed for

significant new technical knowledge or skills.

The large central power generators in Micronesia should not be neglected when we consider uses for VCO. UNELCO Vanuatu is blending 5% coconut oil into its diesel fuel, and Electric Power in Samoa is testing blends as high as 20%. However, planning to continue burning the same amount of fuel, and farming enough coconut to produce that fuel, will probably take more land than Micronesia can spare. Even with coconut plantation yields as high as 230 gallons per acre, we will probably have to choose between reducing central power consumption and keeping enough land in food production.

Manual VCO production is probably most valuable in the outer islands. The technologies described earlier - ram press, Lister CS, pressure stove & lamp, diesel outboard engine - can provide nearly all the energy needed by outer islanders, and do it from a source and through a process that is almost completely under their control.

Assuming the equipment is not simply gifted through a grant, it should be possible to pay for the new VCO processing hardware by bartering the excess oil produced. Perhaps a smart entrepreneur would price the equipment in gallons of oil rather than dollars. VCO has a definite market value, locally, to a ship that can burn it as fuel, and to other ports where it is a commodity. An outer island may be able to barter for more frequent field trip boat visits by producing fuel for the boats - the equivalent of 'working passage.'

Watermotor Turbine powers Woodworking Tools www.watermotor.net, www.homepower.com

medicinal product, VCO is bringing up to $50 per gallon in some areas. At least, it is a substitute for diesel fuel that on Pohnpei in August 2006 was selling for $4 per gallon.

VCO can replace kerosene as a cooking and lighting fuel. VCO will not travel through a wick as kerosene does, so wick-based kerosene appliances can't use VCO. However, VCO will burn in pressure lamps and stoves. Over ten years ago, Dr. Oliver Kennedy and his students at the University of Wollongong, Australia, modified standard Coleman pressure lamps to burn 100% VCO. More recently, Elmar Stumpf and Dr. Werner Mühlbauer at Hohenheim University, Germany, designed a durable, simple-to-build vegetable oil pressure stove capable of burning 100% VCO.

The Stumpf-Mühlbauer Vegetable Oil Stove

VCO can provide mechanical power and electricity generation through a simple, proven, inexpensive stationary diesel engine. The Lister Cold Start (CS) engine has been in production for over 75 years, and some of them have run continuously for over 40 years without significant maintenance. The Lister CS was originally designed for use on farms and plantations, running on whatever vegetable oil was produced locally. It will run on VCO without any modification. The Lister CS runs at a low 650 RPM so it will last a long time and can power most agricultural equipment directly. It is also available with an electrical generator. Listers were originally manufactured in Britain, but clones (called Listeroids) are still being built in India, and are available from dozens of manufacturers.

Japanese-made Yanmar diesel outboard motors have been run on VCO in the Marshall Islands. The Yanmar D27 and D36 models have a reputation for reliability under heavy use, just what is needed in Micronesia. Boat operators here already know how to use and repair outboard motors; changing over to diesel engines will not require

the needs of a village can be put into the hands of the village leaders, to be managed as other village resources are, using traditional cultural means. The energy systems can also be used by the villagers as tools for change, to modify traditional culture to adapt successfully to changing circumstances. Small distributed systems place the control and decision-making in the hands of the villagers rather than those of a monopolistic utility corporation.

Micronesia: Where Technology Comes To Die

One of the failures of 'expert' advice from outside Micronesia is that most advisors are not aware of the unique challenges this environment presents for any technology more advanced than a rock. When someone recommends a "fail-safe, fool-proof, 25-year warranty" gadget that will supposedly solve all of Micronesia's energy problems, ask them how much maintenance they've done in an equatorial rain forest surrounded by ocean.

Most imported technology is designed for use in temperate climates, with ambient temperatures averaging 65ºF or so, and relative humidity of 40 to 60 percent. Micronesia has significantly higher temperatures; higher humidity; higher ultraviolet (UV) radiation; corrosive salt spray or sea air; and aggressive molds, mildews, fungi, bacteria, and vermin that don't exist elsewhere. A device that would last three years anywhere else is lucky to last eighteen months here. In Micronesia, bacteria eat glass, stainless steel rusts, plastic crumbles from the sunlight, and concrete grows blackish-green coatings of slime. If you check the warnings in the owner's manual for your camcorder or digital camera, you are likely to find that the Micronesian climate voids the warranty. Paper is snack food for local vermin; if you want a technical manual to last, you must keep it in air conditioning (as the vermin will eat through plastic bags, too).

The obvious and most common recommendation for outer island power is the solar photovoltaic (PV) panel. This is actually not a bad idea; the PV panel itself has no moving parts, and the latest

amorphous cells can produce usable electricity even on cloudy days. The problems arise from two sources: 1) slime grows over the glass if is not cleaned off regularly, and 2) PV systems are inevitably designed to charge batteries that die prematurely in the Micronesian climate.

Problem #1 is a consequence of traditional culture. Until the arrival of Europeans, Micronesian technology consisted of volcanic stone, coral, plant fiber, and animal tissue. With the exception of stone and coral, those materials rot into uselessness in a fairly short span of time. Maintenance - the idea that regular care of an inanimate object will cause it to remain useful longer - is an idea that simply didn't make a lot of sense in Micronesia. Traditional Micronesian cultures rarely include the idea of maintenance, favoring instead the practice of abandoning and replacing whatever (inevitably) stops working. If imported technologies such as solar panels are to succeed in Micronesia, caring for them must become 'work worthy of respect' within the local traditions.

Problem #2 is partly one of maintenance, and partly one of inappropriate technology. Batteries turn electricity into chemical energy, store that chemical energy, then turn it back into electrical energy on demand. The problem is that the chemistry of batteries is designed for a specific range of temperatures, and using batteries outside that range makes them fail prematurely. Automotive batteries designed for a three-year useful life in North America fail so quickly here that they have longer useful lives as outdoor furniture. Disposable batteries for flashlights and portable electronics run down sooner, and don't last as long on the shelf. Even lithium-ion rechargeable batteries will self-discharge in a week or so, giving the appearance of failure. These failures can be prevented or put off, but they require some technical knowledge and a proactive maintenance attitude.

The consequences of early battery failure are serious. Batteries contain lead, cadmium, mercury and other poisonous materials. Throwing a used battery away poisons the environment. The heavy

on the copra trade. Copra has numerous disadvantages: producing it is dirty, hard work; the product is locally useless if it is not sold; the price is extremely volatile; and most of the final product's sale price goes to the processor, not the farmer. This is not a production model that is good for Micronesia.

Local production of coconut oil avoids copra's problems. There are many local uses for virgin coconut oil (VCO). It is a high-quality food product, with significant medicinal benefits, and it is used traditionally as a cosmetic. As an energy source, VCO can be burned directly in unmodified diesel engines and in modified kerosene pressure lamps and pressure stoves. In this one source, we can meet Micronesia's needs for ground and marine transportation, lighting, cooking, mechanical power, and electricity generation.

Production of VCO does not require a large central processor or a huge investment in complex technology. The most promising technology is the manual ram oilseed press, a mechanically simple and low-cost device that can be manufactured in any shop with a lathe and an arc welder (all four states of the FSM have at least one such shop). The basic design has been in use in Africa since its invention in 1985, and improved models are now being used by thousands of individuals and cooperatives. Current models sell for less than $400, and production averaged over 2,400 liters (634 gallons) of oil per individually owned press in Tanzania in one year.

The ram press can be operated continuously, producing oil and high-protein 'seedcake' fodder from freshly harvested coconut kernel. It takes two to three dozen nuts to make a gallon of VCO. It is necessary to separate the oil from the excess water in the pressed liquid, either by letting the oil and water separate naturally or by centrifuging. An appropriate technology for this operation is the hand-crank milk separator.

Note that this process does not require drying of the kernel or any other heat or chemical treatment. The product is pure, food-grade VCO, with all its natural nutrients and properties intact. As a

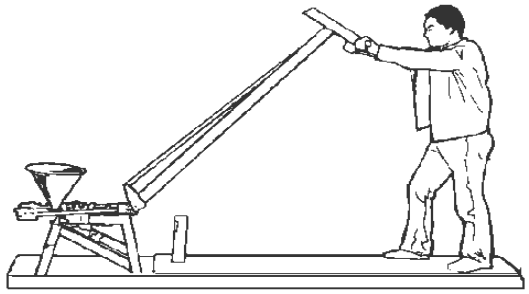
Gasoline is poisonous, dangerous, expensive and cannot be produced with Micronesian resources. Diesel engines can run on locally-produced fuels. The national government should consider a ban on the importation of gasoline engines over five horsepower (Smaller gasoline engines are a necessary evil, because very small diesel engines for weedwhackers or chainsaws are not practical). If the ban is phased in over five years, it gives everyone time to make the changeover to diesel engines with a minimum of economic upset.

> "It is better to teach one idea to hundreds of people rather than hundreds of ideas to one person," writes Roland Bunch in *Two Ears of Corn.*

Micronesian individuals and societies have a variety of options to produce energy. It is usually a mistake to try too many options at once; it is better to choose one best option, and pursue that with full attention and all the resources that can be spared. Here are a few of the options most likely to be successful.

Coconut Oil

Production of coconut oil as a renewable energy source for Micronesia has many advantages. Traditional knowledge for growing coconut is extensive, and cultural traditions value its cultivation. It has many uses, including food, and is well suited to the local climate and soils. Technology for extracting the oil can be simple, durable and affordable. With the appropriate technology, coconut oil can be used to meet most if not all of Micronesia's energy needs. Coconut oil fuel is also safer than fossil fuels.



Manual Ram Oilseed Press

Previous commercial cultivation of coconut has centered

metals collect in the fatty tissues of fish, and then in the tissues of people who eat those fish, with severe health consequences. Used batteries must be collected and recycled to prevent pollution of Micronesia's soil and water, and poisoning of Micronesian people, animals, fish and plants.

Small distributed systems place the control and decision-making in the hands of the villagers rather than those of a monopolistic utility corporation.

To reduce both pollution and costs, rechargeable batteries can replace disposable batteries in radios, flashlights and other portable equipment. These batteries can be recharged with small, inexpensive chargers powered by solar panels or other renewable energy systems. Some batteries can be recharged up to 1000 times. They are more expensive to purchase, but they pay for themselves many times over their useful lives. However, users need to understand how to care for them, or the batteries can quickly lose their ability to accept and hold a charge. Again, this new technology requires a change in habits.

If photovoltaic solar power - one of the simplest and most reliable renewable energy systems - has problems in Micronesia, how can we hope to solve our energy problem? The solutions lie in fitting renewable energy systems into traditional Micronesian ways of life.

Subsistence Energy Production

Wisdom, knowledge and technologies from all over the world can be adapted for Micronesia. The most 'modern' technologies are not always the best solution to a problem. Many systems for using wind and water power were highly developed over centuries, then abandoned when fossil fuels were discovered. Those wind and water technologies are still viable, and information on building renewable energy systems is freely available. Micronesia has a rich heritage of traditional skills and crafts, which can be adapted to produce and

maintain renewable energy systems. If you can build a traditional canoe, you can build a windmill or watermill.

As we search for solutions to our energy problem, focusing exclusively on the cash economy will cause us to overlook many viable opportunities for subsistence workers to generate their own energy. A hand-built windmill may be less efficient than imported solar panels or a manufactured wind turbine, but it can be made and maintained by subsistence workers for no cost but their labor. A large percentage of the FSM population engages in subsistence agriculture and household production. We are told that production has an estimated value of $50 million, or 25% of the national GDP. Micronesia already produces much of its own food and housing from local resources; it is not unreasonable to propose that we can also produce our own energy, using the same means of production and traditional organization. Subsistence energy production could replace a major portion of expenditures for imported fossil fuels.

If Micronesians are to produce energy as part of the subsistence sector, we need vocational education for appropriate technology. New jobs for millwrights or energy systems maintenance workers present opportunities for Micronesians to stay home rather than emigrate to find work. As in many traditional societies, Micronesians generally learn better from hands-on demonstrations than from reading. Education in renewable energy systems should concentrate on pilot projects and hands-on workshops, rather than simply the dissemination of printed material.

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Building energy systems for local needs could be a successful Micronesian industry, but vocational education for energy systems must also include how to make a living in Micronesia with the new

skills. The use, care and repair of renewable energy systems require a new set of traditional activities and attitudes.

How Can We Get To Where We Want To Be?

If Micronesians want to improve quality of life, expand economic opportunities, and preserve traditional cultural values, there is more than one energy path we can choose to follow. There are a few guidelines that we all would do well to follow, but the details of technology and public policy will vary from one subculture to the next.

The national and state governments can help most by supporting Micronesians who want to produce their own energy as part of the subsistence sector. Some of this assistance can be in the form of getting out of the people's way. Renewable energy systems and components should be made tax- and duty-free. The systems are already expensive to begin with; increasing that price only discourages people from investing in them. The revenue generated from taxes and duties is worth far less than the benefits these systems bring to Micronesia.

National and state governments often act as middlemen for foreign governments and NGOs who sponsor renewable energy projects. It is crucial that governments not simply hand over these new resources to an existing energy monopoly. Renewable energy grants must transfer ownership of the systems to the end-users, not guarantee a monopoly's revenue stream. A central utility monopoly on renewable energy is the wrong approach. This is comparable to a storekeeper retaining ownership of a machete, and charging the farmer a monthly fee for its use forever.

Expansions and new installations of fossil fuel-powered generators are not in the best interests of Micronesia. They should not be underwritten with public funds. Whenever possible, public utilities should be prohibited from spending more on fossil fuel systems, and directed to put those funds into renewable energy systems.