Republic of Palau
Energy Efficiency Action Plan

Developed as part of the European Union's Assistance to the Energy Sector in Five ACP Pacific Islands (REP-5)

February 2008

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List of abbreviations

ADO	Automotive diesel oil
BoA	Bureau of Agriculture
BPW	Bureau of Public Works
CFL	Compact fluorescent light
EDF	European Development Fund
EEAP	Energy Efficiency Action Plan
EU	European Union
GoP	Government of Palau
LPG	Liquefied petroleum gas
OEK	Olbiil Era Kelulau (Palau's National Congress)
PECS	Palau Energy Conservation Strategy
PIEPSAP	Pacific Islands Energy Policies and Strategic Action Planning
PPUC	Palau Public Utilities Corporation
PV	Photovoltaic
REP-5	Assistance to the Energy Sector in Five ACP Pacific Islands
SOPAC	Pacific Islands Applied Geoscience Commission

1. Introduction

The Energy Efficiency Action Plan (EEAP) for the Republic of Palau was developed under the Support to the Energy Sector in 5 ACP Pacific Island States (REP-5) programme, funded by the 9th European Development Fund. It provides actions for reducing the Republic's energy consumption, both in the public and private sector. As part of the REP-5 programme funding for Palau, an Energy Planner has also been hired to implement the actions contained within the EEAP. The Energy Planner will work within the Palau Energy Office for a period of two years, after which the Government of Palau is expected to fund the position permanently.

2. Current energy consumption

2.1. Electricity

Access to the national electricity grid in Palau is near-universal on the islands of Koror, Babeldaob, Kayangel, Angaur, and Peleliu. The Palau Public Utility Corporation (PPUC) owns and maintains the grid and is responsible for the generation of electricity in Palau. Power generation is accomplished solely by diesel engines using automotive diesel oil (ADO). The grids on the islands of Koror and Babeldaob are interconnected by a 34.5 kV intertie, with distribution done at 13.8 kV.

The generating capacity on the islands of Kayangel, Angaur, and Peleliu exceeds demand by as much as 300% (e.g. Kayangel has two 120 kVA generators but a peak load of only 50 kW). This oversizing of generators leads to an increase in their specific fuel consumption, since they are only operated at part-load. PPUC has proposed installing smaller generators on Kayangel and moving the existing generators to Angaur, those on Angaur to Peleliu, and those on Peleliu to Koror, in order to increase fuel efficiency of the overall system. However, this has so far not been done.

Annex 1 provides the electricity tariffs for residential, government, and commercial customers, the amount of energy consumed by each hamlet and state in 2006, the number of customers on the PPUC grid, the amount of fuel consumed by each power plant, and the amount of electricity generated by each plant.

Palau's Southwest Islands, which are 300-500 km from the main archipelago and are composed of the states of Sonsorol and Hathohobei, do not have any reliable means of electricity generation. In 2002 solar home systems were installed on the islands of Sonsorol, Pulo Ana, Merir, and Tobi, but they have since failed due to the inappropriate choice of system components and lack of maintenance. Currently the installation of a diesel-powered electricity grid with buried transmission lines is underway on the island of Sonsorol, but there are no plans to rehabilitate the solar home systems installed under the 2002 project.

Solar home systems were once installed in Kayangel, but have now been abandoned since the island was provided with grid electricity. There is a reluctance to move back to solar home systems since the ones that were installed in the 1990s were inadequate and did not meet users' expectations. PV power is still used for remote communication stations, however.

Hot water is heating is primarily accomplished with electricity, with some larger installations using diesel fuel (e.g. the Belau National Hospital) and some commercial installations using solar hot water heaters. The largest consumer for water heating is the tourism sector.

2.2. Fuel

Almost all of Palau's diesel consumption is for power generation, with the rest being used for transport. Most of the diesel consumed for transport is used by fishing vessels and state-owned ferries, with little used for road transport. The public perception that diesel vehicles are more polluting than gasoline ones, the higher price of diesel fuel at pumping stations, the lack of diesel engine mechanics, and the limited availability of diesel vehicles at dealerships may explain why diesel fuel for road transport is not as widespread in Palau as in other Pacific Island Countries (PICs).

Gasoline is primarily used for road transport, with some being used by the tourism industry for the outboard engines on dive boats. Although exact figures are unavailable, many of the outboard engines in Palau are two-stroke, and use more fuel and pollute more than four-stroke engines but cost less to purchase. There are currently no diesel- or gasoline-electric hybrid vehicles in Palau.

Diesel and gasoline are both taxed at a rate of $0.05/gal., and as there are no price controls, retailers are free to set their own prices. The two importers of fuel are Shell Palau and Mobil Oil Micronesia.

Liquefied petroleum gas (LPG) is used almost uniquely for cooking, and is slowly replacing electricity for that purpose. Figures on the proportion of residential LPG cookstoves are unavailable. Wood is still used for cooking, but data on the number of woodstoves in Palau are not available either.

The Bureau of Agriculture has started a biogas pilot project for small piggeries, but so far the project is only a few months old and the design of the digesters needs to be refined. However, the Bureau believes that there is potential for expanding the project to most piggeries across the Republic. The resulting biogas is to be used for cooking pig feed, and will thus displace the LPG or wood currently used.

3. Energy efficiency actions

Several opportunities exist for reducing energy consumption in Palau from fossil fuels, mostly as energy efficiency upgrades or purchasing incentives, although renewable energy opportunities also exist. Many of these actions may be completed by the Energy Planner within the two-year period that he will be working at the Energy Office. The majority of the actions should be accompanied by an information campaign, in order to raise overall awareness of energy efficiency and renewable energy.

3.1. CFL Distribution campaign for households

Summary: Energy Star-certified CFLs are to be distributed to each household in Palau, in partnership with PPUC and local hardware stores.	**Initial cost:** $15,000 - $20,000
	Expected savings: 820 MWh/$180,000 (electricity bills); 110,000L fuel (generation)
	Timeframe: Approximately 4 months

Description: Incandescent lights are widely used throughout Palau due to their lower initial cost relative to Compact Fluorescent Lights (CFLs) and their ability to withstand the voltage and frequency fluctuations of the PPUC grid. There have been many negative experiences in the past with low-quality CFLs failing prematurely, which reduced the public's confidence in the technology. However, as CFLs use only one quarter of the power of incandescent bulbs for the same luminous output, distributing them is a cost-effective solution to reducing Palau's electricity consumption.

There are approximately 5,000 residential PPUC customers in Palau, of which 300 are in the outlying states of Kayangel, Angaur, and Peleliu. In order not to compete with hardware stores, there are to be no more than two or three CFLs distributed per customer. The Energy Office is to purchase the CFLs in bulk in order to lower the unit price, and will oversee their distribution.

Distribution is to be accomplished through PPUC for Koror and Babeldaob, and through state governments for the outlying states. Each PPUC customer is to be allocated two or three lights, which can then be bought from PPUC or the state government. The lights are not to be given out at no cost because a) customers may come to expect more free lights in the future, and b) giving lights out defies the concept that an investment in energy efficient appliances leads to long-term savings. Instead, the lights are to be sold at the same cost at which they were purchased, with funds collected going back to the Energy Office's program budget.

In order to gain user support for the lights, high-quality CFLs must be purchased, as low-quality CFLs fail prematurely due to the grid's poor power quality. The lights must also be of a pleasing colour that closely matches the colour of incandescent bulbs. Since the majority of incandescent bulbs in Palau use 60W, the CFLs are to be 60W-equivalent lights. Therefore the lights that would be appropriate for the distribution campaign are to be 60W-equivalent, Energy Star certified, and have a colour temperature of 2700 K.

An information campaign is to precede the distribution campaign, so that customers are made aware of the availability of the low-cost CFLs and distribution may be rapid.

Finally, monitoring and evaluation of the success of the project is necessary to determine if it should be extended to the commercial sector (e.g. by distributing T8 lights and ballasts as well as CFLs). Data collected from PPUC by the Energy Planner will quantify the energy and power reductions resulting form the distribution programme.

Initial cost: Assuming a unit cost of $1 per CFL, a total project cost of $15,000 - $20,000 is expected, including shipping and the information campaign preceding the distribution.

Expected savings and benefits: Assuming that each household receives two CFLs (power factor of 0.5) and uses them for 5 hours per night, an annual reduction of 820 MWh (550 MVAh) is expected, which translates into roughly 29,000 gal. (110,000 L) of fuel saved for PPUC and $180,400 saved for customers on electricity bills. An added benefit of this project is to create a market for CFLs for hardware stores.

Timeframe: One to two months are expected to organize the distribution of the CFLs, find a supplier, and purchase the lights. Two weeks before the lights are received, the information campaign is to be launched to notify the public of the project. The distribution is to take one to two months.

3.2. Solar hot water heater/instant water heater rebates

Summary: A fund is to be set up to partially refund the cost of purchasing a solar hot water heater or an instant water heater. Both home and business owners would be eligible to apply.	**Initial cost:** $20,000
	Expected savings: Unable to quantify on a national level.
	Timeframe: Two months for planning, then ongoing

Description: Water heating in Palau is accomplished primarily by electric water heaters, and is a major expense in residential and commercial electricity bills: according to PPUC, water heating accounts for roughly a quarter of residential electricity bills. Many residences do not have hot water since the mains water is not cold and water heating is expensive, but tourism-related businesses such as hotels, restaurants, and dive shops are large consumers of hot water.

Solar hot water heaters could almost eliminate the need for electricity to heat water, and instant water heaters can use up to 20% less energy than conventional water heaters. In many hotels water is centrally heated and continually circulated in the building's plumbing system; installing instant water heaters in each room would dramatically reduce electricity consumption by reducing heat losses through the piping system and standing losses in the water tank.

Solar hot water heaters are currently not available at stores in Palau; the ones that are installed have been imported piecemeal. Instant water heaters, however, are available in local hardware stores. In order to encourage the purchase of solar or instant water heaters, a certain percentage of the purchase cost of a solar or instant water heater could be refunded up to a specified amount. As the purpose of this programme is to reduce the use of conventional storage water heaters and not increase the usage of hot water, higher rebates should be given to customers who already have hot water but want to upgrade their system, and lower rebates given to customers who currently do not have hot water.

The Energy Office is to be the entity that will give out the after-purchase rebates and determine whether a customer is eligible under the programme. Customers will also have to provide the Energy Office with their monthly electricity bills before and after the upgrade, in order to measure project success. To assist the public in purchasing the heaters, the Energy Planner is to compile a list of suppliers that are willing to ship their products to Palau.

Initial cost: $20,000 should be set aside for the programme initially, with the possibility of renewing the funding if the programme has shown sufficient success.

Expected savings and benefits: Electricity and fuel savings (for generation) are difficult to quantify without having an estimate of how much hot water is used in Palau.

Timeframe: Two months are expected for the Energy Planner to research and find suppliers, establish an information campaign, and draft eligibility criteria and refund allowances. The project is to be ongoing until funds run out.

3.3. National Government energy efficiency demonstration building

Summary: Implement the recommendations of the energy audit of the Bureau of Public Works building that was undertaken in August 2007. An information campaign regarding the efficiency upgrades would also be launched.	**Initial cost:** $9,200
	Expected savings: $340 per month on electricity bill
	Timeframe: Two months for procurement of equipment, one month for works.

Description: As part of the PIEPSAP-funded Palau Energy Conservation Strategy (PECS) project, the Government designated the Bureau of Public Works (BPW) building as a demonstration building for energy efficiency upgrades. To that end, an architect was hired to do an energy audit of the building in August 2007. The resulting audit report provided recommendations to upgrade the lighting system and the building envelope of the BPW building, namely replacing all T12 lights and magnetic ballasts with T8 lights and electronic ballasts and painting the roof white. The report did not mention sealing air leaks around doors and window frames and installing closers on doors, but these measures should also be taken.

If the budget allows, ceiling fans should be installed in office rooms, and current air-conditioners replaced with Energy Star (or equivalent) certified ones.

The roof of the BPW building is to be replaced in the near future, so the efficiency upgrades will have to wait until renovations are complete. However, it would be wise to install white pre-painted sheet metal roofing rather than unpainted sheet metal, in order to avoid the additional expense of painting the roof after renovation. The REP-5 funds could be used to offset the additional cost of purchasing pre-painted roof cladding.

A simple information campaign in the form of leaflets and posters to be located in the BPW building is to be undertaken once the efficiency upgrades are complete. Newspaper ads would also be published inviting the public to visit the building.

Initial cost: The audit report estimated a cost of $8,000 to upgrade the lighting systems and painting the roof white. An additional $700 would be necessary for sealing door frames and window frames against leaks and installing door closers, and roughly $10,000 for ceiling fans and air conditioners. The information campaign would require $500.

Expected savings and benefits: The audit report estimated savings at $340 per month on the BPW electricity bill.

Timeframe: Finding suppliers, and purchasing and receiving equipment is expected to take two months. Once roof renovations are complete, work should be completed in less than one month.

3.4. Energy efficiency upgrades for Capitol Complex

Summary: Implement the recommendations of the energy audit of the Capitol Complex that was undertaken in August 2007.	**Initial cost:** $20,000
	Expected savings: <$117,000 per year
	Timeframe: Two months for purchasing equipment, one month for installation

Description: As part of the PIEPSAP-funded Palau Energy Conservation Strategy (PECS) project, an energy audit of the Capitol Complex was carried out (the report is available at the Energy Office). It found that although the building was generally energy efficient, some improvements to the air conditioning system could be done at little cost but with a substantial reduction in the Complex's electricity bill and an improvement to the comfort of the building occupants.

The room temperatures in the Capitol Complex are generally quite low: in some rooms workers must wear long-sleeved shirts in order to stay comfortable, and condensation regularly appears on some windows. Approximately 130 thermostats are spread across the four buildings and are accessible to office workers. The audit found that some thermostats were turned down to their minimum setting of 65°F/18°C. Lock boxes are to be purchased and installed on all thermostats, and accessible only to maintenance personnel, who are to set them such that the working environment is comfortable.

The air handling units in the Complex buildings must be turned on and off manually. As there are no maintenance workers permanently on-site, the units are left running at night. As the Capitol Complex experiences occasional brownouts and blackouts, the air handling units must all be turned on individually when power is restored. Timers should be installed on the air handling units' control boxes in order to turn them off after working hours and on weekends. The timers must be capable of being able to function even when there is no power from the building grid.

The audit report also recommended that the ventilation systems reduce the amount of outside air introduced into the buildings, in order to decrease the amount of cooling necessary. To that end, timers and controllers are to be installed on the intakes for outside air.

Initial cost: The lockboxes are expected to cost $6,000, and the controllers and timers $14,000.

Expected savings and benefits: The audit report estimated electricity cost savings on the order of $80,000 to $120,000 annually, but since this project will not implement all the report's measures due to budget constraints the savings are expected to be lower. A benefit of this project is an increased comfort level for the workers in the buildings

Timeframe: Two months for the Energy Planner to source the components necessary for the upgrades and contract a company for their installation. One month is expected for installation of the upgrades.

3.5. Lighting retrofits for Government of Palau buildings

Summary: Replace all incandescent lights in GoP buildings with CFLs, and replace all T12 lights and magnetic ballasts with T8 lights and electronic ballasts	**Initial cost:** $40,000
	Expected savings: $20,000 per year
	Timeframe: Five months

Description: Energy audits conducted during the PECS project revealed that lighting in GoP buildings is accomplished mainly by T12 lights and magnetic ballasts, and that many offices and common areas (e.g. hallways, reception rooms) are overlit.

Several measures are to be taken to reduce the amount of electricity used for lighting of GoP buildings:

- Replacing T12 lights and magnetic ballasts with high-efficiency T8 lights and electronic ballasts will reduce the amount of energy used for lighting by 20%.
- Removing unnecessary lights in overlit areas will provide the greatest savings at zero cost and would not result in a reduction of comfort for workers if properly done.
- Since the diffuser on a light fixture becomes opaque as it ages, the light output of that fixture suffers. Replacing old diffusers is to be done on all fixtures that require it.
- Replacing incandescent bulbs with their CFL equivalents will reduce energy consumption of those fixtures by approximately 75%.

The Energy Planner is to assess the number of T8 lights and electronic ballasts, CFLs, and diffusers necessary to undertake a Government-wide lighting retrofit. The number of fixtures to be removed or de-lamped is also to be determined. The ballasts that are to be purchased must be able to withstand the low power quality of the PPUC grid.

An information campaign aimed at government employees and businesses is to be undertaken a few months after the results of the retrofits can be quantified using PPUC bills. The campaign is to be done in conjunction with local hardware stores.

Initial cost: The audit of the BPW building estimated the cost of replacing one two-light fixture (T12 lights and magnetic ballasts with T8 lights and electronic ballasts) at $32, including labor, bringing the cost of upgrading all fixtures in the building to $2,800. Therefore approximately $40,000 should be budgeted for upgrading the lighting system across the Government. Some form of co-financing with the GoP could be arranged in order to ensure that all buildings are improved.

Expected savings and benefits: The audit of the BPW building found a 2-year payback period for this project. However, since de-lamping of fixtures was not included in the calculations, the payback period is expected to be lower. Savings are to be on the order of $20,000 per year if $40,000 are spent on this project.

Timeframe: Two to three months would be required to assess the number of lights to be upgraded/removed, find a supplier, and have them shipped to Palau. One to two months are expected for the lights to be installed. The installer may be either the Government or a private company, depending on the capacity of the Government to undertake such a project.

3.6. Roof painting of Government of Palau buildings

Summary:	Initial cost: $5/m^2, $50,000
Paint the roofs on all air-conditioned GoP buildings white in order to reduce solar heat gain, thereby decreasing the amount of air conditioning necessary.	**Expected savings:** Unable to accurately quantify
	Timeframe: Four months

Description: Most of the GoP buildings have unpainted concrete roofs or sheet metal roofs painted in dark colors. These roofs therefore absorb much of the incoming solar radiation, leading to higher room temperatures inside the building. If the building is air-conditioned, this high absorption of solar radiation translates into high monthly electricity bills.

Since the absorption of sunlight by a roof depends largely on its color, painting the roofs of all Government buildings with white roof paint will decrease the amount of solar heat absorbed. This in turn will decrease the amount of air conditioning necessary, and thus lower monthly electricity bills.

The Energy Planner is to assess the total roof area of air-conditioned Government buildings, in order to estimate the amount of paint necessary. School classrooms are not air-conditioned, so painting schools roofs white would not save money but would increase student comfort. Co-financing with the Ministry of Education would be expected for the roof painting of schools.

Several buildings, most notably the ones that are not air-conditioned, are to have indoor air temperatures monitored by the Energy Planner for one month before and one month after the painting of the roof. The results are to be used in a public information campaign.

Initial cost: The PECS audit of the BPW building estimated a painting cost of $5/m^2, using paint bought locally. However, due to the scope of the project, it would be more economical to buy the paint from abroad. A rough estimate, pending a survey of the roof area of government buildings, is $50,000 for the project.

Expected savings and benefits: Savings are hard to quantify, as they depend on several factors, including air leaks through the building frame, temperature setpoints on air conditioners, and the efficiencies of the individual air-conditioning units. However, anecdotal evidence suggests a reduction in indoor temperatures by two to three degrees Centigrade. Once the upgrade of the BPW building is complete a better estimate of the savings across Government may be established. The BPW audit report estimated a payback period of 2 years for painting the roof white.

A side benefit of this project is an increased level of comfort in buildings that are not air-conditioned. However, as painting the roofs in these buildings will not result in energy savings, co-financing from the GoP is expected.

Timeframe: One to two months for surveying the surface area that is to be painted, finding a supplier for the paint, and securing GoP funds for co-financing of non air-conditioned buildings. Depending on the capacity of the GoP maintenance staff, a company may have to be contracted to paint the roofs. This is expected to take up to two months, depending on the capacity of the Government and the company.

3.7. Window and door sealing and upgrades of Government of Palau buildings

Summary: Install weather stripping on doors and windows to reduce infiltration of warm air into air-conditioned GoP buildings.	**Initial cost:** $7,000
	Expected savings: Unable to quantify
	Timeframe: Two months

Description: Many doors in GoP buildings have leaks around the frames, and louvered windows are common in some buildings with air conditioning. These small individual leaks, when taken together, are likely responsible for a significant portion of the air-conditioning bill of the Government. An immediate and measurable impact is expected by installing weather stripping around door frames, caulking around window frames and air-conditioner openings, seals on louvered windows, and door closers on doors that lead to air-conditioned spaces.

The Energy Planner is to conduct a survey of the types of windows in Government buildings, as well as the number of doors requiring closers, weather stripping, and thresholds. The amount of caulking necessary for window frames and air-conditioner openings is also to be assessed. To obtain maximum benefit, this project is to be done in conjunction with the white roof painting project.

Initial cost: This project is not expected to cost very much, as caulking, weather stripping, and thresholds are not expensive. A better estimate will be available once the survey is complete. However, the materials and labour for this project should require no more than $7,000.

Expected savings and benefits: Unable to quantify energy and cost savings, for the same reasons as the white roof painting project.

Timeframe: One month for determining the material needed and finding a supplier. Many of the materials are available locally, so there will be no need to wait for shipping. Installation of upgrades is expected to take one month, and should be within the capacity of Government maintenance crews.

3.8. Audit Koror-Airai potable water and sewage pumping system

Summary: Determine location of leaks in water distribution system, as well as charge tariffs for potable water and sewage treatment that would allow cost recovery.	**Initial cost:** To be determined
	Expected savings: Dependant on results of audit
	Timeframe: Dependant on scope of audit

Description: Currently, residential customers in Koror and Airai can choose to pay a flat rate of $10 for their water and not be metered. Commercial customers must have meters at their water connections, and pay a rate of $0.85 per 1000 US gallons. As water and sewage pumps account for 32% of the GoP's electricity use[1], reducing their consumption and recovering the cost of treating and pumping potable water and sewage should be made a priority. The amount of electricity used to pump potable water is expected to increase, as there are plans to install a water treatment facility on the Tabecheding River in the state of Ngatpang that will service Koror and Airai.

In 2003 a consulting firm was hired by the Bureau of Public Works to draft water use regulations for the Koror and Airai water system, in view of reducing water consumption, currently at 4 million gallons per day (15.5 million liters – roughly 1,000 L/person/day). However, the regulations have not been adopted.

An audit of the potable water distribution system should be carried out, as some of the pipes are 60 years old and may be in need of replacement. The pumps should be audited as well, and a cost-benefit analysis should be performed to determine which pumps should be replaced immediately with new, high-efficiency ones. Unfortunately, the water and sewage lines will not be inspected when the main road in Koror and Airai is renovated in 2008 and 2009. This is a lost opportunity for the assessment of the state of the pipes and their repair, as replacing them in a few years would require tearing up the new road and incur large expenses. The Energy Planner is to consult with the Director of Public Works to determine what audits on the piping system could be carried out. If need be, an external organization such as SOPAC may be contacted to draft the Terms of Reference for a consulting firm to undertake the audit.

Initial cost: To be determined, depends on the scope.

Expected savings and benefits: Depends on results of audit. A benefit of repairing any leaks found in the system would be enhanced water security in times of drought.

Timeframe: Consultations with the Director of Public Works can begin immediately, but the scope of the audit will determine how long this project will take.

[1] *Palau Energy Conservation Strategy (PECS)*

3.9. Decrease use of number of two-stroke gasoline outboard marine engines

Summary: Establish a fund to partially offset the difference in price between four-stroke gasoline outboard or diesel marine engines and two-stroke gasoline outboard engines.	**Initial cost:** $10,000
	Expected savings: 25% reduction in fuel use per two-stroke engine replaced
	Timeframe: Until funds run out

Description: Many of the boats used in the tourism industry are equipped with large two-stroke outboard gasoline engines, as these engines are smaller and cheaper to buy than four-stroke outboard or diesel engines of equal power output. However, two-stroke engines consume more fuel per distance traveled and are more polluting than other types of engines.

A fund is to be established to offset the additional cost of purchasing four-stroke or diesel engines, in order to give boat owners an incentive not to buy two-stroke engines. The money in the fund is to be used to partly refund the purchase of a new engine, and not as a pre-purchase subsidy. Using data provided by Koror State and the Bureau of Public Safety, the Energy Planner is to assess the number of two-stroke, four-stroke, and diesel engines used on boats in Palau. The prices of four-stroke engines at the various dealers in Palau are to be monitored in order to verify that they do not increase as a result of this incentive programme.

The Energy Planner is to determine what percentage of the purchase price of the four-stroke or diesel engines is to be refunded. Only new engines are to be eligible for the refund.

The Energy Planner is to advertise the programme and the benefits of using gasoline four-stroke / diesel engines over two-stroke gasoline engines in local newspapers and on the radio. Success of the programme is to be measured by collecting data on the monthly amount of fuel sold at docks or the amount of fuel used by dive and tour boat operators.

Initial cost: Fund is to be set at $20,000.

Expected savings and benefits: Four stroke engines use approximately 25% less fuel than two-stroke engines, and are the most likely engines to be purchased (diesel engines are unavailable as outboard motors, and thus not suitable for dive and tour boats). However, the potential overall fuel savings across the Republic will not be known until the number of two-stroke engines is determined. An additional benefit of this project would be reduced air and water pollution.

Timeframe: Once started, the programme is expected to run until funds are no longer available.

3.10. Rebate programme for Energy Star (or equivalent) certified appliances

Summary: Establish a fund for after-purchase rebates for Energy Star (or equivalent) certified appliances.	**Initial cost:** $30,000 fund, renewable
	Expected savings: difficult to quantify electricity reductions
	Timeframe: Until funds run out

Description: The US Department of Energy's Energy Star programme certifies appliances that meet stringent standards for energy efficiency and quality. Energy Star certified appliances are the most efficient in their class, but may cost more than non-certified appliances. However, the additional purchase cost pays for itself within the lifetime of the appliance, and is therefore worth the investment.

Anecdotal evidence in Palau shows that people tend to purchase appliances that have the lowest purchase price without considering running costs. A fund that would provide after-purchase rebates for Energy Star certified appliances is to be established in order to make these appliances more affordable. Other certification programmes are also to be accepted, as many of the products sold in Palau come from Asia where appliances may be efficient but not certified Energy Star.

Energy Star certified appliances are available at some hardware stores in Palau, but are not widespread. It is hoped that the rebate programme would increase demand for Energy Star certified appliances, and thus encourage stores to carry a wider variety of models; this would in turn increase demand.

The Energy Planner is to determine what appliances are covered under the programme, and the proportion of the purchase price that will be refunded. The Energy Planner is to visit local hardware stores and give presentations to the staff on energy efficiency and the Energy Star programme, so that they may be better informed to answer customers' questions. The rebate programme is to be advertised in local papers and on radio stations, and educational materials on energy efficiency and the Energy Star programme are to be distributed via hardware stores and PPUC.

Success is to be determined by collecting the number, type, and model of appliances that have applied for and received rebates. PPUC data is to be collected to monitor overall electricity consumption before and after the programme to measure its effectiveness on the national electricity demand.

In the 1990's Guam undertook a similar rebate programme. The Guam Energy Office is to be contacted in order to learn from its experience with its rebate programme.

Initial cost: The fund is to be set at $30,000 initially, to be renewed based on the success of the rebate programme.

Expected savings and benefits: A reduction in overall electricity consumption in Palau is expected, although it is difficult to quantify; the public would benefit from lower electricity bills.

Timeframe: The rebate programme is to continue until funds run out. Funds may be renewed if the programme proves to be successful.

3.11. Awareness campaign for the OEK

Summary: Conduct an awareness campaign for the OEK on the benefits of implementing energy efficiency measures and the costs of not doing so.	**Initial cost:** $1,000
	Expected savings: Unable to quantify.
	Timeframe: Two months

Description: Palau currently has few laws that deal specifically with energy, and the current taxes on fuel ($0.05/gal. of diesel or gasoline) have not changed since Trust Territory days when fuel was much cheaper. In order to reduce the energy consumption of the Republic, energy legislation needs to be adopted by the OEK (Olbiil Era Kelulau – Palau's National Congress). Such legislation could include higher taxes on fuel, lower import duties for fuel-efficient vehicles and higher duties for vehicles that are not fuel-efficient, limitations or bans on inefficient electrical appliances, adoption of a building code that includes energy efficient design aspects, etc.

Most members of the OEK are not familiar with energy-related issues and the cost of not adopting legislation that promotes energy efficiency. Therefore, the Energy Planner is to conduct an awareness campaign aimed specifically at the OEK. Such a campaign is to illustrate past experiences with energy legislation in other PICs and US Territories, studies of the expected impacts of certain legislation, and the costs to the Republic of not becoming more energy efficient. As the members of the OEK are quite busy, the campaign is to take the form of a presentation lasting only one or two hours.

Initial cost: The campaign is expected to cost $1,000 for catering and printing and ordering materials to be distributed.

Expected savings and benefits: The savings are not immediately quantifiable, since they depend on the legislation that is passed. The overall benefit is a greater understanding of energy-related issues within the OEK.

Timeframe: Two months would be required to do the research necessary for the campaign and organize the presentation.

3.12. Purchasing incentives for digesters for piggeries

Summary: Establish a fund for partially subsidizing the cost of installing digesters for piggeries, once the Bureau of Agriculture pilot project proves successful.	**Initial cost:** $10,000
	Expected savings: Small, but other non-financial benefits available
	Timeframe: Depending on digester design

Description: The Bureau of Agriculture (BoA) has started a biogasification pilot project for piggeries in Palau. The aim is to provide affordable digesters for pig farmers wishing to use the resulting methane gas for cooking pig feed. Currently, pig feed is cooked using wood, and the manure left in settlement tanks which occasionally leak into the soil. Collecting firewood is a labor-intensive and expensive operation, especially for the larger piggeries. Using the methane collected from pig manure would reduce the amount of wood required to cook the feed, and therefore save the farmers time and money.

There is currently only one digester that has been installed under the BoA project. It has been operational since early August 2007, but so far has not resulted in much gas being produced. This is likely due to the design of the digester and the proportion of materials fed into it. The process still needs to be refined before a working product can be promoted by the BoA.

The Energy Planner is to assist the BoA in the design of the digester and the process by which it is filled. Once a working solution is found, the Planner is to determine how much of the cost of the digester should be subsidized in order to make it more attractive to farmers. As with the other financial incentive programmes in the EEAP, the subsidy is to be given out only once installation of the digester is complete.

Initial cost: Depending on the cost of the digester. Initially, $10,000 could be set aside.

Expected savings and benefits: Financial savings are likely to be small, but this project does produce non-monetary benefits, such as reducing the amount of time necessary to collect firewood, reducing greenhouse gas emissions, and reducing the likelihood of diseases appearing in piggeries due to raw manure.

Timeframe: Depends on how quickly a working digester is designed and field-tested.

3.13. Electricity consumption reduction programme for outlying states

Summary: Reduce electricity consumption of Kayangel, Angaur, and Peleliu states through awareness campaigns, energy audits, and purchasing incentives.	**Initial cost:** $15,000
	Expected savings: 11,400 kWh ($2,500) per year per 1% reduction for PPUC customers; 1,250 gal. of fuel for PPUC.
	Timeframe: Three months for preparation, ongoing monitoring

Description: The three outer island states, Kayangel, Angaur, and Peleliu, each have diesel-powered electricity grids that are owned and operated by PPUC. However, the generating capacity on those islands is several times larger than the demand, with some generators being larger than twice the peak load. This oversizing leads to a high specific fuel consumption for those generators (50% higher than those on the main islands), and therefore high generation costs for the utility company.

The most effective measure to reducing this high specific fuel consumption is to replace the existing generators with appropriately-sized ones. PPUC has proposed moving the generators in Kayangel to Angaur, those in Angaur to Peleliu, and those in Peleliu to Koror, but so far this has not been done. In the meantime, demand-side energy efficiency measures should be undertaken to reduce the fuel used for electricity generation. Reducing electricity consumption on the outer islands would provide greater benefits than on the mainland because of the higher specific fuel consumption of the generators and the lower average household income. The energy efficiency actions to be carried out are to include:

- distribution of CFLs to all PPUC customers;
- painting of roofs on all public air-conditioned buildings;
- replacing of defective photocontrollers on street lights;
- energy audits of large energy users;
- community workshops on energy efficiency and conservation;
- other activities, as determined by the Energy Planner.

Using data provided by PPUC and by the energy audits, the Energy Planner is to determine which loads on the islands present the best opportunities for energy reduction, and which buildings consume the most energy.

This project is to be the first step in reducing the amount of fuel used by the outer islands. It is proposed that under EDF-10 the generators on the islands be replaced with ones sized appropriately (whether by implementing PPUC's plan to cycle the generators from island to island or by providing new ones) and have these generators supplemented by grid-connected PV systems. A prefeasibility study done by the Energy Office in 2006 recommended that funding should be sought for establishing a solar-diesel hybrid system on the island of Kayangel. However, further investigation is required to determine the cost-effectiveness of battery storage recommended by the study. Generator efficiency will decrease with a drop in electricity consumption, so replacing the generators should be done as quickly as possible. PPUC will already have the in-house capacity to maintain grid-connected PV systems as a result of maintaining the one to be installed at the Capitol under the current REP-5 project.

The efficiency activities are meant to have a lasting impact in reducing energy consumption. Monitoring of this project is to be done using data collected from PPUC and site visits.

Initial cost: $15,000 is to be budgeted for this project, which should include the activities listed above.

Expected savings and benefits: According to data obtained from the Bureau of Statistics for 2006, every percentage point reduction in electricity consumption would save PPUC customers 11,400 kWh per year ($2,500 at current electricity rates) and PPUC 1,250 gal. of fuel per year. Reducing generator fuel consumption would reduce the losses that PPUC incurs by providing electricity to the islands, and thus allow it to divert money that would be otherwise spent on fuel to maintaining the generators.

Timeframe: A few days per island are expected to be necessary for the requisite energy audits. Distribution of the CFLs, painting of the roofs, and replacing the photocontrol switches on the street lights is to take three months, due to the schedule of the state ferries. Monitoring and information campaigns are to be ongoing.

3.14. Community workshops on energy efficiency and home energy audits

Summary: Conduct community workshops aimed at educating the public on energy efficiency and conservation around the home, as well as provide training for carrying out home energy audits.	**Initial cost:** $2,000
	Expected savings: Unable to quantify, but campaign will support other activities in EEAP
	Timeframe: Five months

Description: There is a general misconception in Palau that PPUC tariffs are excessive and that PV power is a cost-effective means of reducing electricity bills. The public is generally unaware of energy conservation practices and efficiency measures that can be taken to reduce energy costs, particularly concerning electricity consumption. As a result, many people consume much more electricity than necessary and pay high electricity bills.

The Energy Planner is to conduct community workshops in order to educate the public about ways to save energy (electricity in particular) around the home. These are to be conducted in the evenings on weekdays in each state or hamlet, and are to last one or two hours. Success of the awareness campaign is to be measured by analyzing PPUC data and by performing case studies of homes that have taken measures to reduce electricity consumption.

Initial cost: $1,000 for materials (e.g. pamphlets, projector, screen, digital camera), and a further $1,000 for placing ads in local newspapers.

Expected savings and benefits: Savings are difficult to quantify separately from the other actions proposed in the EEAP. However, the awareness campaign is expected to increase the effectiveness of the other actions, as well as create a culture of energy efficiency within communities.

Timeframe: Two months will be required for preparation and ordering of equipment. Conducting the workshops will require three months.

4. Implementation

Determining an accurate implementation schedule is difficult since many of the actions depend on factors that are beyond the Energy Planner's control (e.g. the rebate programme for piggeries depends on how soon a working digester can be developed, the GoP demonstration building depends on when the roof of the Public Works Building will be replaced, etc.). Furthermore, the Energy Planner has other responsibilities, such as monitoring and assisting the GoP's ministerial Energy Conservation Officers in performing their duties, monitoring the Capitol Complex PV generators, maintaining the solar street lights to be installed along the Compact Road, and any other task that the Energy Office is called to do.

Some projects, however, should be implemented as soon as possible. Immediate savings can be realized with the CFL distribution campaign, and the community energy workshops have started in December 2007 and will continue until May.

The GoP upgrades (roof, lighting, doors and windows) should all be done at the same time, in order to save costs on labour and to reduce disruption to office workers. The demonstration building should be upgraded at the same time, pending the repairs to the roof. The three rebate programmes do not need to happen simultaneously, but doing so will have a greater impact on the public's perception of the value of energy efficiency.

In order to allow continuity between the EDF-9 and EDF-10 programmes, the energy efficiency campaign for the outlying states should be completed by the end of 2009, and have little room for further energy reduction. This will allow immediate fuel savings and a lower project budget under EDF-10 if the generators are replaced with a PV-diesel hybrid system.

In all projects, the visibility of the EU as the main donor for funding must be assured. Furthermore, a public information campaign is to accompany each project in order to raise awareness of energy efficiency.

The table on the next page shows a provisional implementation schedule.

Table 1: Provisional implementation schedule

Activity		Task	March				April				May				June				July				August				September				October			
3.1	CFL distribution campaign	Find supplier and order																																
		Arrange logistics																																
		Information campaign																																
		Distribute																																
		Evaluate																																
3.2	Purchasing incentives	Draft eligibility criteria																																
3.9		Research eligible products																																
3.10		Information campaign																																
		Give rebates																																
3.4	EE upgrades for Capitol	Count thermostats/fans																																
		Order lockboxes																																
		Order fan timers																																
		Install lockboxes/timers																																
3.5	Government lighting upgrades	Inventory lights																																
		Find supplier and order																																
		Install lights																																
		Evaluate																																
3.6	Government roof painting	Inventory roof area																																
		Find supplier and order																																
		Paint roofs																																
		Evaluate																																
3.7	Government weather sealing	Invenotry doors/windows																																
		Find supplier and order																																
		Install sealing																																
		Evaluate																																
3.13	Reduce energy in outer islands	Awareness campaign																																
		Audits of homes																																
3.14	Community workshops	Conduct workshops																																

Annex 1: Electricity tariffs and consumption

The following table summarizes the current PPUC tariff schedule, as of August 2007, when charges increased by 1 cent per kWh. There are three categories of customers: residential, commercial, and government. The Energy Charge is fixed and incremental, depending on the amount of energy used in one month by a customer. The fuel surcharge varies every quarter, and is the same for all customers, regardless of consumption.

Table A1-1: PPUC Tariff Structure

Customer	Energy Charge		Fuel Surcharge	Total price
Residential	< 500 kWh/mo.	$0.08/kWh	$0.14/kWh	$0.22/kWh
	500-2,000 kWh/mo.	$0.10/kWh	$0.14/kWh	$0.24/kWh
	>2,000 kWh/mo.	$0.12/kWh	$0.14/kWh	$0.26/kWh
Commercial	Up to 2,000 kWh/mo.	$0.10/kWh	$0.14/kWh	$0.24/kWh
	>2,000 kWh/mo.	$0.12/kWh	$0.14/kWh	$0.26/kWh
Government	Up to 2,000 kWh/mo.	$0.10/kWh	$0.14/kWh	$0.24/kWh
	>2,000 kWh/mo.	$0.12/kWh	$0.14/kWh	$0.26/kWh

A different tariff schedule exists for customers with a high maximum demand and with a consumption exceeding 100,000 kWh/month, and is applied at PPUC's discretion. Under this schedule, the customer is charged $18.60 per kW of maximum demand and $0.095/kWh of energy consumed. A penalty is applied for customers with poor power factor (below 0.8 lagging). kVA metering is available, and customers are charged 85% of the kW rate to encourage them to increase their power factor.

As of August 2007, no government customers are charged under the high-demand tariff schedule.

The fuel surcharge increases/decreases by $0.01 for every $0.127 increase/decrease in the price of one US gallon of fuel. The base price on which the surcharge is calculated is $0.6336/gal.

Table A1-2: 2006 Electricity Consumption for Residential, Government and Commercial PPUC Customers, in kWh

Hamlets and States	2006			
	Total	Commercial	Government & Public Buildings	Residential
Total	114,284,020	31,720,302	55,805,483	26,758,235
Koror	*60,013,210*	*27,564,939*	*12,490,917*	*19,957,354*
Meketii	2,911,501	1,902,750	145,930	862,821
Ikelau	4,049,316	3,114,535	37,773	897,008
Madalaii	18,020,231	9,343,618	4,912,521	3,764,092
Ngerbeched	8,627,288	2,799,273	2,835,533	2,992,482
Idid	1,617,119	341,782	63,531	1,211,806
Dngerongr	7,705,860	6,784,144	33,792	887,924
Iyebukl	1,847,234	437,741	288,056	1,121,437
Ngerkesouaol	1,250,846	262,656	9,208	978,982
Ngerchemai	3,747,688	732,970	286,527	2,728,191
Meyuns	7,453,897	1,409,383	3,645,005	2,399,509
Ngermid	2,782,230	436,087	233,041	2,113,102
Other States	*54,270,810*	*4,155,363*	*43,314,566*	*6,800,881*
Aimeliik	1,596,729	59,984	1,109,706	427,039
Ngatpang	244,826	8,640	84,733	151,453
Airai	46,752,365	3,101,243	40,423,352	3,227,770
Ngchesar	287,473	4,205	72,939	210,329
Melekeok	1,707,546	308,366	606,008	793,172
Ibobang	163,431	20,728	76,005	66,698
Ngeremlengui	525,812	74,509	198,792	252,511
Ngiwal	341,296	35,811	94,456	211,029
Ngardmau	200,317	51,405	27,421	121,491
Ngaraard	973,178	376,203	180,077	416,898
Ngerchelong	336,904	8,214	107,375	221,315
Peleliu	773,146	78,466	190,938	503,742
Angaur	248,837	27,589	85,531	135,717
Kayangel	118,950	-	57,233	61,717

Table A1-3: Electricity Consumption by Type of PPUC Customer, 2002-2006, in kWh

Type of Consumers	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
Total	78,573,052	81,832,380	81,866,029	89,204,446	114,284,020
Business/Commercial	32,004,364	32,896,938	31,963,579	37,656,011	31,720,302
Government & Public Buildings	18,570,048	20,037,943	20,766,980	21,686,223	55,805,483
Residential Areas	27,998,640	28,897,499	29,135,470	29,862,212	26,758,235

Table A1-4: PPUC Electricity Generation by Generating Station, 2002-2006, in kWh

Generating Station	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
Total	102,636,931	104,069,266	107,672,480	N/A	N/A
Malakal	55,582,481	57,701,414	59,572,796	N/A	N/A
Aimeliik	45,812,820	44,432,510	46,314,980	N/A	N/A
Peleliu	1,241,630	1,270,230	1,125,795	N/A	N/A
Angaur	-	437,863	433,857	N/A	N/A
Kayangel	-	227,249	225,052	N/A	N/A
% Billed	76.6	78.6	76.0	N/A	N/A

Note: N/A = data not available

Table A1-5: PPUC Generating Station Fuel Consumption, 2004-2006, in gal.

Generating Station	FY 2004	FY 2005	FY 2006
Total	7,662,784	8,089,541	7,423,132
Malakal	3,932,613	3,969,282	3,194,352
Aimeliik	3,512,882	3,884,286	4,001,132
Peleliu	146,211	157,290	137,125
Angaur	47,319	44,483	60,961
Kayangel	23,759	34,200	29,562

Table A1-6: Number of PPUC Customers by Hamlet and State, 2006

States and Hamlets	Total Number of Customers	Customer Type		
		Commercial	Government & Public Buildings	Residential
Total	6,342	913	622	4,807
Koror	*4,299*	*770*	*354*	*3,175*
Meketii	230	63	17	150
Ikelau	198	52	2	144
Madalaii	931	297	131	503
Ngerbeched	643	80	74	489
Idid	202	25	7	170
Dngeronger	217	60	4	153
Iyebukl	261	27	19	215
Ngerkesouaol	198	22	5	171
Ngerchemai	519	40	22	457
Meyuns	538	58	52	428
Ngermid	362	46	21	295
Other States	*2,043*	*143*	*268*	*1,632*
Aimeliik	128	8	30	90
Ngatpang	48	2	11	35
Airai	707	84	48	575
Ngchesar	100	2	14	84
Melkeok	137	17	16	104
Ibobang	42	3	17	22
Ngeremlengui	124	7	24	93
Ngiwal	90	3	14	73
Ngardmau	66	3	7	56
Ngaraard	154	3	23	128
Ngerchelong	129	1	20	108
Peleliu	201	7	22	172
Angaur	69	3	11	55
Kayangel	48	-	11	37

All figures in Annex 1 were obtained from the Bureau of Statistics.