CHAPTER 7

SOLAR POWER GENERATION

Chapter 7　Solar Power Generation

7.1　Solar power generation policy of the Solomon Islands

According to the Solomon Islands National Policy and Guidelines, the solar power generation policy of the Solomon Islands is to maintain a readiness to utilize renewable energy technologies where possible, provided they:

- are economically and environmentally sustainable,
- are technically and commercially proven,
- provide the least cost solution to the demand requirement,
- require only low recurrent manpower and financial investment, and
- can be operated and maintained with existent technical capability.

As for the solar power generation, it is understood that it actively promotes the following items:

① Accurate quantification of the Solomon Islands' solar resource by upgrading monitoring equipment,

② Promotion of the solar generation use as an energy source where economically and technically viable, particularly in larger public institutions and commercial groups;

③ Promotion of the rural electrification in close cooperation with the implementing agencies and rural authorities.

7.2　Solar Power Generation Development Methods

7.2.1 The electrification by SHS

The areas where electrification by grid extension or by mini-hydropower are not economically suitable, will be electrified by Solar Home System (hereinafter SHS). Also, pertaining to the areas where implementation of the grid extension or mini-hydropower development will take a long time, the promotion of the electrification is to be considered in such a way that electrification using SHS is firstly implemented, and then, it is changed to the grid extension or to mini-hydropower, wherever is possible.

7.2.2 The electrification area by NGOs

This master plan does not include the areas where electrification by the non-government organizations (hereinafter NGOs) such as GREA[1] or APACE[2] are already implemented.

(1) Electrification by GREA

The villages where GREA has implemented electrification by the end of January 1999 are

1 Guadalcanal Rural Electrification Agency
2 Appropriate Technology Community & Environment

Sukiki Village, Gatokae Island, and Makaruka Village. In addition to these, GREA receives applications for electrification by SHS from several non-electrified villages. In particular, there is an application for the electrification of 1,000 houses from East Kwar'ae Community. (Refer to Table 7-2-1)

Table 7-2-1 Rural Electrification by GREA

Name of Area	Households	Existing/ Application	Remarks
Sukiki Village	50	Existing	Guadalcanal
Gatokae Island	7	Existing	Western
Makaruka Village	25	Existing	Guadalcanal
Gzza Community	More than 100	Application	Guadalcanal
Gheghde Community	More than 100	Application	Guadalcanal
Viru Community	90	Application	Western
Haznaz Community	--	Application	Guadalcanal
Titiana Village	--	Application	Gizo
Wanderer Bay Village	100	Application	Western
Kuma Village	45	Application	Guadalcanal
East Kwar’ae Community	1000	Application	Malaita

(Information: GREA, as of the end of January 1999)

At the time of this survey, the applications are not concretely carried forward due to lack of funds. GREA expressed a desire to have included East Kwar’ae Community in the electrification under this Master Plan because the community is considered to be too big. However, the selection of the electrification technology, grid extension, mini-hydropower or SHS, is to be included in a global analysis. It is noted that GREA is not carrying a rural electrification plan.

(2) Electrification by APACE

As shown in Table 7-2-2, APACE has electrified or planning electrification of some villages by mini-hydropower. (Refer to section 11.1.4(2)) Electrification by SHS is not included in these villages.

Table 7-2-2 Rural Electrification by APACE

Name of Village	nominal/planned load (kW)	Existing/Plan	Remark
Iriri	5	Existing	Kolombangara
Vavanga	5	Existing	Kolombangara
Ghatere	5	Existing	Kolombangara
Manawai	50	Existing	Malaita
Bulelavata	10	Under construction	New Georgia
Bisuana	4.16	Plan	Vangnu Island
Kavolavata	3.276	Plan	Nggaatokae Island
Lolovoro	2.6	Plan	Vangnu Island
Laubu	5.72	Plan	Vella Lavella Island
Keara	4.108	Plan	Ranongga Island
Baniata	6.708	Plan	Rendva Island
Monda	5.356	Plan	Ranongga Island
Eleoteve	7.8	Plan	Vella Lavella Island

(Information: APACE, as of the end of January, 1999)

7.2.3 Electrification Scheme

The electrification method that one SHS is installed to each one of the consumers is called a distributed method. The method that supplies electric power to a consumer through the distribution lines by using a large-sized PV facility in the center of the demand is called a centralized method. The former is a method suitable in the areas where consumers are dispersed, and the latter is a suitable method not only for the area where consumers are concentrated but also where consumers are dispersed as well. However, due to the fact that a centralized method has several disadvantages as mentioned in following points (a) to (d) raised by the first field survey results, it is considered to apply this method to public facilities where they are located close to each other. The SHS to be used for domestic electrification in the Solomon Islands are considered as a distributed method.

(a) The power supply to all consumers is cut off if or when there are problems at the facilities.

(b) The equipment to limit demand of each consumer becomes necessary. Otherwise, electrical power might be used out of order, and this may result in a daily lack of adequate charge of batteries. Consideration could be given to the installation of a load shedding equipment at the side of the power source, but even though it operates as a peak suppressor, it would be difficult to restrain the energy amount. If the load shedding equipment is installed at the consumer side, it is questionable whether it would be possible to control the power consumption of the consumers since the load may be very small.

(c) The distribution lines sometimes pass over private properties. In other cases, distribution lines passes over plantations among fast-growth trees.

(d) The maintenance of distribution lines is necessary.

7.3 Confirmation and Evaluation of Existent Solar Systems

7.3.1 Solar generation system in Sukiki Village

In the Solomon Islands, GREA, a NGO, has implemented the electrification of two villages with SHS in addition to Sukiki Village, as mentioned above. Almost the same facilities are installed at each village. The outline of these SHS, their maintenance procedures and operation problems is presented below.

(1) System Outline

(a) SHS are installed in 50 houses out of a total of 60 houses.

(b) The photovoltaic module (hereinafter PV module) capacity is 40 Wp or 53 Wp.

(c) The battery is a deep cycle flooded type, similar in appearance to a car battery. Capacity is 75 Ah and expected lifetime is 3-5 years.

(d) Lighting is provided by three fluorescent lamps each one of 11W, with DC 12V inverters and switch incorporated.

(e) Daily use of lamps is 3-4 hours.

(f) The charge controllers have incorporated over-discharge protection feature, that disconnects the loads when the battery voltage drops to a preset level.

(g) PV module tilt angle:

According to the survey of four houses selected from a total of 50 houses with SHS, one house had a module at a tilt angle of 20 degrees, two houses at 23 degrees and the other at 34 degrees. The above tilt angles were approximated since a protractor was not available.

(h) PV module orientation angle:

The modules faced north in all cases.

(i) Supporting structure:

The module is installed at the top part of a wooden pole (3.6 m x 0.1 m x 0.1 m). These poles are made by the villagers, by cutting down timber trees (hardwood commercial tree), from a mountain plantation that the Sukiki Village possesses, and forming them using a chain saw. Labor power and timber were provided for free by the villagers.

(2) Maintenance procedures

(a) Three technicians are in charge of the maintenance.

(b) The batteries are replenished with pure water three times per year.

(c) The pure water is made by evaporating rainwater inside a glass-covered box, exposed to the sun, and then by collecting the water condensed on the inner glass surface.

(d) The technicians check the cleanliness of the PV module glass covers once a month.

(e) The technicians check the specific gravity, the water level, and the voltage of the batteries once a month.

(f) When the charge controller gets damaged, the PV module is connected directly to the battery.

(g) When SHS is the property of GREA, GREA is obligated to replace batteries and to repair any faults, but when the ownership is transferred to the villagers, they have agreed to pay by themselves any expense incurred for the replacement of the battery and for any other repair.

(h) The disposal of used batteries is not especially considered at present.

(3) Operation problems

(a) Since the SHS was originally installed in 1997, there have been problems with the charge controller a couple of times. As a consequence, one battery became over-discharged. The battery was brought back near Honiara and charged.

(b) The battery charging became insufficient because of 3-4 consecutive non-irradiation days, so that the fluorescent lights could not operate longer than one minute after switching them on.

(4) Evaluation

(a) Judging from the fact that the battery got discharged after 3-4 consecutive non-irradiation days, capacity of module and batteries are presumed to be appropriate.

(b) The batteries and the modules are appropriately maintained.

(c) Although the 15 degrees tilt angle seems to be appropriate when considering the latitude of Guadalcanal Island, this angle seems to be somewhat high for the Sukiki Village.

(5) The influence of ethnic tensions

Seven SHS sets were destroyed in the Sukiki Village by confrontations between Malaita and Guadalcanal groups in 1999. (Refer to 11.1.4(1))

7.4 The First Field Survey

JICA Master Plan Study Team surveyed the present situation of the areas proposed for electrification by SHS. These areas include prospective villages to be investigated in detail during the second field survey. The surveyed villages were Komunibaibai and Tina, in Guadalcanal Island, Mandou and Nusa Roviana villages in New Georgia Islands, Poroporo and Sipokana villages in Choiseul Island, Poro and Goveo village in Santa Isabel Island and Dala North and Boboitolo village in Malaita Island. Kerosene lamps are used for illumination light in all the villages. Location of these villages is shown in Appendix 7-5-1.

There were 12 villages planned to be investigated during the first survey, following recommendations from the counterpart of the Solomon Islands, but due to unexpected cyclones and security problems raised, only the above mentioned 10 villages could be investigated in the first field survey.

Illumination of more than 140 klx was recorded on sunny days at each village. Considering the facts that 100 klx are equivalent to 1 kW/m^2, and that the rated output of a PV module is given at 1 kW/m^2, it can be concluded that these locations are suitable for photovoltaic generation, based on illumination measurements. Villagers use kerosene lamps for illumination, and the cost to operate the lamps is about SB$5-38 per month. In connection with the electrical appliances the users wanted to access most, after the village got electrified, they expressed that lighting is their first priority, followed by an outlet to connect their radio cassette recorders. Most of the villages listed bedrooms and sitting rooms as the places where lighting is a priority.

The electric appliances that villagers currently use are limited to flashlamps and portable radio cassette recorders. A church in one of the surveyed villages was electrified by using a diesel generator. A church was found in each village.

The monthly cash income of villagers, derived from agriculture or fishery activities, is in average SB$100-200. This income level implies that SHS should be designed as cheap as possible but maintaining a good quality level.

7.5 Selection of Villages

7.5.1 Selection factors

It is desirable that the villages to be investigated in detail during the second field survey are representative villages of the Solomon Islands. It is also essential that villagers want to be electrified by SHS and that the field survey can be carried on without considerable problems. Also, villages where electrification is already present or can be implemented in the future, by mini-hydropower or by grid extension, should be excluded. Several other factors that are desirable for the selection of prospective villages are as follows:

(a) There is a potential application for solar generation.
(b) There are public facilities in the villages such as school, church, etc.
(c) The village has a certain number of households.
(d) There is basic infrastructure to transport equipment and materials.
(e) The villagers want to be electrified.
(f) Electrification by other means is not planned, or if electrification is planned, where implementation takes more than 10 years.

After evaluation of the above factors and recommendations from the Counterpart, 12 villages were surveyed. Concerning to the selection of the 12 villages investigated in the second field survey, 5 villages previously investigated in the first field survey were excluded and 7 villages were newly added. The reasons for exclusions of villages are listed below.

Komunibaibai Village and Tina Village in the Guadalcanal Island: Both villages were excluded because the investigation in Guadalcanal Island was dangerous due to the ethnic tension between Guadalcanal and Malaita groups.

Poroporo Village in Choiseul Island: Since a promissory hydropower site was identified in the area, electrification by hydro generation is considered to be a good solution.

Poro Village in Santa Isabel Island: The Poro Village was excluded as it is not an standard village and also because of the danger involved in the 90-minute motor boat travel from Buala, required to get to the place.

Dala North Village in Malaita Island: Near to this site there is a large village, Dala South Village, that in combination with Dala North Village, seem to be more appropriate to be electrified by another method instead of solar photovoltaic generation.

Results of the survey conducted on the 12 villages are as described in the next section.

7.5.2 Detailed Survey of Villages

The 12 surveyed villages are listed as below. Map location is referred in Appendix 7-5-1.

(a) Malaita Province

Boboitolo Village: Located at the northwest part in Malaita Island (Fauabu Ward).

(b) Isabel Province

Hovukoilo Village: Located along the seashore of the South Pacific Ocean in the center of Santa Isabel Island, the northwestern part of the provincial capital Buala (Hovikoilo Ward).

Goveo Village: Located along the seashore of the South Pacific Ocean in the center of Santa Isabel Island (Kokota Ward).

(c) The Western Province

Mandou Village: Located at the southernmost tip of Vonavona Island (Novanova Ward).

Nusa Roviana Village: Located along the beach in Roviana Island (Nusa Roviana Ward).

Sageragi Village: Located at the northwest tip of Gizo Island (Gizo Ward).

(d) Choiseul Province

Sipokana and Loemuni Village: Located at the northwest tip of Choiseul Island（Batava Ward）

(e) Makira Province

Ngoragora Village: Surveyed by the Preliminary Study Team. Located next to Kirakira Airfield (Bauro Central Ward).

Arohane Village: Surveyed by the Preliminary Study Team. Located in the east of Kirakira Airfield (Bauro Central Ward).

(f) Temotu Province

Malo Village: Located on Trevanion Island (Neo Ward)

(g) Central Province

Vunuha Village: Located at the southernmost tip of Florida Island (SouthWest Gela Ward).

7.5.3 Survey and analysis results

Technical and economical data were collected, and was used to form a base for the SHS design.

The results found are as follows:

(１) Places requiring electrification by SHS

a. Village houses, clinic, and teacher’s houses

Kerosene lamps are used for illumination at these places. After electrification is implemented, villagers want to install lamps, as their first needs. As the demand of these places is small, electrification by SHS would be suitable.

It was found that kerosene lamps are used for 3 to 4 hours per day by villagers and by the teachers. At the Health Aid Post, kerosene lamps, that are brought by the patients when they visit the clinic to get medical attention, are used just for a short time. At the Rural Health Center, which has some attention rooms, there are provided some kerosene lamps are provided but are not used regularly.

b. School

The elementary school gives a supplementary lesson to Standard 5 and 6 groups for the secondary school entrance examination. Kerosene lamps are used for these activities.

Most of the elementary schools finish their supplementary lessons by sunset, but there is one school that gives the supplementary lesson 5 days per week using kerosene lamps at night. Supplementary lessons usually last for 1-2 hours.

As the demand from schools is comparatively low, they are suitable to be electrified by SHS.

Also, the community high school gives classes for 2 hours at night using kerosene lamps. It is evident that the requirement of illumination increases when the building is larger but it seems that electrification by SHS is possible by installing more than one SHS set of.

c. Meeting Hall and Church

There is a meeting hall in the village and one to three churches. Kerosene lamps or fluorescent lamps powered by a small diesel generator are used in these buildings. It seems that the electrification by SHS is possible by installing more than one SHS set.

In the church, nightly worships are made for about 2 hours. The day of the week worship is made depends on each village. Also, it seems to be difficult for one of the churches to have the whole building electrified by SHS since it is too big.

(2) Electric appliances to be considered

a. Load supply time by the SHS

Load use time for the clinics, houses, and teacher’s houses are 3 to 4 hours a day. For the church, the meeting hall, and the school, use time is about 2 hours per day.

b. Number of lighting fixtures

Clinics, houses, and the teacher’s houses are comprised of 2-3 bedrooms and 1 sitting room, being the number of the necessary fixtures 1 to 3. Villagers recall that when only one fixture is installed, they want to have it at a place where all rooms can be illuminated.

Concerning to the private houses and the teacher's houses, there is a cooking room separated from the main house. Kerosene lamps are used when cooking but villagers do not think the cooking room needs a lighting fixture. The teacher's houses, built by the village, are the normal residence place of teachers. The church, meeting hall and the school need 4 to 8 lighting fixtures. Since the SHS is to be installed in a large place, a wiring method to minimize power losses is required

c. Used electric appliances

The electric appliances that villagers usually have are a flashlight, a radio, and a radio cassette recorder. All of these are battery operated.

Two types of flashlights are used. One is of the type used for fishing and the other is used for footsteps lighting. As the flashlight and the radio cassette recorder are the items to be assisted by electrification, lighting fixtures and an electric outlet are necessary for this purpose. DC 9V or DC 12V radios or radio cassette recorders are used. The 12V type is suitable because it has the same voltage as the SHS, but the 9V types could be used if a dropper to change from 12V to 9V is prepared.

(3) Capacity of SHS

When considering the results of the detailed village survey, the following three options are evaluated:

a. one light and one electric outlet for the radio or radio cassette recorder

···・ PV module capacity: 36 Wp

(Applies to the clinic, the private houses, and teacher's houses).

b. Three lamps and one electric outlet for the radio or radio cassette recorder

···・ PV module capacity: 55 Wp

(Applies to the clinic, the private houses, and teacher's houses).

c. Four lamps and one electric outlet for the radio or radio cassette recorder

···・ PV module capacity: 75 Wp

(Applies to the church, the meeting hall, the school, and the clinic; 1 - 2 sets according to the area).

(4) Villagers payment capacity

a. Income

The villages that are near to big consumption centers sells vegetables and fishes in the markets and get a comparatively high income (SB$100-500 /month). In case of the villagers from Vunuha, in the Florida Islands, since they sell vegetables and fishes at good prices in Honiara they can earn about SB$800 /month.

The income of the villages far from markets is less than SB$100 /month.

b. Kerosene expenses

The amount of money that householders pay for the kerosene is SB$5- 38 /month.

c. Dry batteries expenses

The villagers buy a battery for the radio cassette recorder when they have some surplus. Payments incurred for dry batteries is SB$15 - 30/month, as heard by informants.

d. Payment for SHS

The amount of money that seems possible to be paid by villagers for the SHS is about SB$20/month, making assumptions from above points a and b. The payment to SHS seems to be possible by villagers contributing to the church and the meeting hall through the Community Fund.

e. The reaction of villagers about the SHS payment

When the trial calculation of the SHS payment was shown to the villagers, their reaction is that even the cheapest system of 36 Wp is expensive for them. The trial calculations that the villagers were shown are described in the following points (a) to (c).

(a) PV module capacity: 36 Wp system

(ⅰ) Option to pay the SHS owner a rental charge

Down payment: SB$750, monthly payment: SB$75 (The owner maintains)

(ⅱ) Option which makes the villager owner of the SHS after paying a rental charge for 5 years

- Down payment: SB$750, monthly allowance: SB$100 (for the first 5 years)
- Monthly expenses after the villager owns the SHS: SB$45 (maintenance expenses are covered by the villager)

(b) PV module capacity: 55 Wp system

(ⅰ) Option to pay the SHS owner a rental charge

Down payment: SB$750, monthly payment: SB$95 (The owner maintains)

(ⅱ) Option which makes the villager owner of the SHS after paying a rental charge for the first 5 years

- Down payment: SB$750, monthly payment: SB$125 (for the first 5 years)
- Monthly expenses after the villager owns the SHS: SB$50 (maintenance expenses are covered by the villager)

(c) PV module capacity: 75 Wp system

(ⅰ) Option to pay the SHS owner a rental charge

Down payment: SB$750, monthly allowance: SB$110 (The owner maintains)

(ⅱ) Option which makes the villager owner of the SHS after paying the rental charge for the first 5 years

- Down payment: SB$750, monthly allowance: SB$150 (for the first 5 years)
- Monthly expenses after the villager owns the SHS: SB$55 (maintenance expenses are covered by the villager)

(5) Influence that the environment causes on the SHS

- Depending on the village, high trees around the village shade the modules, causing some effects on the SHS energy generation.(The usable electric power quantity decreases).
- It is possible that the fallen leaf cause some generation reduction.
- Also, there is some possibility that falling coconuts damage the PV modules.

(6) Basis information on construction expenses

・Manpower	SB$10 - 30 a day Free for public benefit work.
・Motor boat	SB$50 - 116 to the main city for a round-trip (Honiara-Vunuha: SB$300 for a round-trip)
・Car	SB$53 per hour, SB$50 - 150 for a round-trip, SB$200 for one way (The 3t-car)

(7)Characteristics of the surveyed villages

(a) Boboitolo Village

Boboitolo Village is located in Malaita Island, at 10 minutes by car from Dala North Village, and is composed of 45 houses and has a population of 400 people. There is one church. Cash income depends totally on agriculture. The average cash income is SB$100 per month. Daily usage of the kerosene lamp is 4 hours for the house and 1.5 hours for the church. The expense for kerosene lamps is in average SB$15 per month per house.

(b) Hovikoilo Village

Hovikoilo Village is located in Santa Isabel Island, at 45 minutes by motor boat from Buala. It is composed by 120 houses and has a population of 700 people. There are a church, a kindergarten and a meeting hall. Cash income depends totally on agriculture. Average cash income is SB$230 per month. Daily usage of the kerosene lamp is 4 hours for the house and 1-2 hours for the church. The expense for kerosene lamps is in average SB$6 per month per house. Gunuha is located at 2 km from the village. There are a community high school, an elementary school and a clinic in Gunuha. At the community high school, a class is done using a kerosene lamp from 7 p.m. to 9 p.m. Also an elementary school gives a supplementary lesson to the Standard 6 for the entrance examination to the secondary school from June to August using a kerosene lamp from 7 p.m. to 9 p.m.

(c) Goveo Village

Goveo Village is located in Santa Isabel Island, at 2 hours by motor boat from Buala. 52 houses are distributed along the beach. The village has a population of 358 people. There are an elementary school and a clinic. Cash income depends on agriculture for 90%. Average cash income is SB$100 per month. Daily usage of the kerosene lamp is 4 hours for the house and 1 hour for the church. There is an icebox powered by kerosene in the clinic, used for medical purposes. The expense for kerosene lamps is in average SB$30 per month per house. The elementary school gives a supplementary lesson to the Standard 6 for the entrance examination to the secondary school using a kerosene lamp from 7 p.m. to 8 p.m.

(d) Mandou Village

Mandou Village is located in New Georgia Islands, at 60 minutes distance by motor boat from Noro. Mandou Village is composed of 200 houses and has a population of 1,000 people. There are a church and an elementary school. Cash income depends on agriculture by 70%.

Average cash income is SB$500 per month. Daily usage of the kerosene lamp is 4 hours for the house and 3 hours for the church. The expense for kerosene lamps is in average of SB$38 a month per house.

(e) Nusa Roviana Village

Nusa Roviana Village is located in New Georgia Islands, at 15 minutes by motor boat from Munda. The village is composed of 83 houses and has a population of 500 people. There are three churches, a elementary school, a clinic, a meeting hall and a dining hall. Cash income depends on agriculture by 50% and on fishery by 50%. Average cash income is SB$500 per month. Daily usage of the kerosene lamp in the houses is 4 hours. The expense for kerosene lamps is in average SB$21 a month per house. The village possesses a small diesel generator (240V, 1.7 kW) that is supplying power to the church, the meeting hall, and the dining hall. There is a villager who personally possesses a diesel generator. There is a SHS of 40 Wp installed for communication purposes.

(f) Sageragi Village

Sageragi Village is located in New Georgia Islands, at 45 minutes by motor boat and 1 hour by car from Gizo. The village is composed of 39 houses and has a population of 350 people. There are two churches and a clinic. Cash income depends on agriculture by 80%. Average cash income is SB$150 per month. Daily usage of the kerosene lamp is 3 hours for the house and 1.5 hours for the church. The expense for kerosene lamps is in average SB$8 a month per house. The acceptance of the electrification by SHS is high. When introducing SHS into the village, it is accepted that the village will be in charge of the maintenance.

(g) Sipokana Village

Sipokana Village is located in Taro Island, Choiseul Province, at 45 minutes by motor boat from Taro. The village is composed of 26 houses and has a population of 110 people. There are a church and a meeting hall. Cash income depends on agriculture by 90%. Average cash income per month is unknown. Daily usage of the kerosene lamp is 3 hours for the house and 1.5 hours for the church. The expense for kerosene lamps is an average of SB$5 a month per house. The village is planning to buy a diesel generator for electrification of the church but there are not enough funds.

(h) Loemuni Village

Loemuni Village is located in Taro Island, Choiseul Province, at 60 minutes by motor boat from Taro. The village is composed of 36 houses and has a population of 336 people. There are a church, a elementary school, a clinic and a meeting hall. Cash income depends on agriculture by 80%. Average cash income is SB$50 per month. Daily usage of the kerosene lamp is 3.5 hours for the houses and 1 hour the church. The expense for kerosene lamps is unknown. A SHS (40Wp) for communication is installed in the clinic.

(i) Ngorangora Village

Ngorangora Village is next to the Kirakira airport. There are 39 houses and the population is

500 people. There are two churches and a kindergarten. Cash income depends totally on agriculture. Average cash income is SB$200 per month. Daily usage of the kerosene lamp is 3 hours for the houses and 1 hour for the church. The expense for kerosene lamps is in average SB$12 a month per house. Elementary school gives a supplementary lesson to the Standard 5 and 6 for the entrance examination to the secondary school using a kerosene lamp from 7 p.m. to 9 p.m.

(j) Arohane Village

Arohane Village is located at 20 minutes by car from Kirakira. There are 40 houses and the population is 280 people. There are an elementary school and a church. Cash income depends totally on agriculture. Average cash income is SB$160 per month. Daily usage of the kerosene lamp is 2 hours for the houses and 2 hours for the church. The expense for kerosene lamps is in average SB$6 a month per house.

(k) Malo Village

Malo Village is located in Trevanion Island, Temotu Province, at 5 minutes by motor boat from Lata. The village is composed of 125 houses and has a population of 630 people. There are three churches, an elementary school and a clinic. Cash income depends on agriculture by 90%. Average cash income is SB$200 per month. Daily use of the kerosene lamp is 4 hours for the houses. The expense for kerosene lamps is in average SB$15 a month per house. The village possesses small diesel generators (240V, 2kVA) that are supplying power to the churches. There is a villager who owns a SHS (35Wp) for his lighting. This villager was trained on SHS for two weeks in Honiara. The training contents were:

①Wiring diagram, ②Work principles of SHS, ③Functions of charge controllers, ④Field practice on installation and ⑤Field practice on maintenance.

(l) Vunuha Village

Vunuha Village is located on the Florida Islands, at 1.5 hour by motor boat from Honiara. The village has 86 houses located along the beach and has a population of 500 people. There are one elementary school and one kindergarten. Cash income depends on fishery by 70%. Most of the caught fish is sold at markets in Honiara. Average cash income is SB$800 per month. Daily usage of the kerosene lamp is 4 hours for the houses. The expense for kerosene lamps is in average SB$20 a month per house. There is a villager who owns a small diesel generator (240V, 4.3 kW) that provides power supply to the church for free. As villagers have a relatively high income, it seems that a monthly payment of about SB$100 for a SHS is possible. Map locations are included in Appendix 7-5-1.

7.5.4 Determination of electrification areas by SHS

The results of village surveys showed that the present economical and geographical situations, such as solar resource, transportation and maintenance issues, differ largely depending on local conditions. Although the Study Team and the counterpart personnel in charge from the Energy

Division of the MNR tried to select villages for SHS electrification, it was found to be difficult. Therefore, the Study Team and the counterpart, the Energy Division of the MNR, agreed to determine the electrification villages based on the evaluation of the Pilot Scheme, once this scheme finishes. The Pilot Scheme and the Nationwide Scheme are shown in section 10.3.4 Area electrified by Solar Energy.

7.6 Pyranometer and sunshine recorder installation and operation

7.6.1 Installation of pyranometer and sunshine recorder

A pyranometer and a sunshine recorder were installed during the second field survey at the Vavaya Ridge Upper Air Observatory that is at the top of a mountain at the back of the Diet, in Guadalcanal Island. This equipment was acquired in Japan by JICA Study Team and then shipped to the Solomon Islands.

Technology transfer sessions were implemented, in which the JICA Study Team detailed the installation, operation and data analysis of this measurement equipment.

7.6.2 Operation of pyranometer and sunshine recorder

Personnel of the Vavaya Ridge Upper Air Observatory is in charge of data collection; results are sent to the Meteorological Office to be analyzed and recorded.

7.7 Data collection and analysis

7.7.1 Sunshine duration

In the Solomon Islands, sunshine duration is recorded at Taro, in Taro Island, Henderson Airport in Guadalcanal Island, Lata in Nendo Island, Santa Cruz Islands, and Munda in New Georgia Island.

7.7.2 Sunshine duration data analysis

(1) Consecutive non-sunshine days

From the sunshine data recorded in the Solomon Islands, the number of consecutive non-sunshine days from each recording station is as shown in Table 7-7-1. The number of two non-sunshine consecutive days is 1.3 times the annual mean of all the recording stations. The number of three or more non-sunshine consecutive days is 0.7 times and similarly the number of five or more non-sunshine consecutive days is 0.1 times the annual mean of all the recording stations.

Concerning to the SHS design, it is considered that 5 non-sunshine consecutive days would be enough.

Table 7-7-1 Number of non-sunshine consecutive days

Non-Sunshine consecutive days	Guadalcanal (‘88-’97)	Santa Cruz (‘88-’96)	New Georgia (‘88-’96)	Mean (times/year)
2	12	10	14	1.3
3	5	6	1	0.4
4	1	2	3	0.2
5	0	1	0	0.04
12	0	1	0	0.04

(Source: Daily Sunshine Hours, Solomon Islands Meteorological Service)

(2) Sunshine duration daily average

The daily average sunshine duration recorded at Henderson Airport in Guadalcanal Island, from 1981 to 1998, is 6.6 hours. Records from other stations are as follows: 5.5 hours at Lata, Nendo Island, Santa Cruz Islands, 5.6 hours at Munda in New Georgia Island and 5.4 hours at Taro in Taro Island, Choiseul Province. A low value of the sunshine duration is found in July for each measurement station. The average of the sunshine duration data from all the recording station is 5.8 hour.

Table 7-7-2 Sunshine duration daily average

Place	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Guadalcanal	86-98	6.0	6.0	6.3	6.6	6.7	6.9	6.2	6.7	6.6	7.2	7.6	6.6	6.6
Santa Cruz	88-96	5.6	5.4	5.1	5.8	5.0	5.3	5.4	5.3	5.3	6.0	6.4	5.7	5.5
New Georgia	81-96	5.9	5.0	5.8	5.6	5.5	5.3	4.6	5.4	5.5	5.9	6.5	6.2	5.6
Choiseul	88-97	5.9	5.6	5.7	5.9	5.0	4.9	3.9	4.5	5.3	5.5	6.4	5.9	5.4

(Source: Monthly Mean Sunshine Hours, Solomon Islands Meteorological Service)

7.7.3 Data collection from the new meteorological equipment

Results from the four months measurement from the pyranometer and sunshine recorder installed at the Vavaya Ridge Upper Air Observatory on November 22nd, 1999, are presented below.

Data measured from April 2000 has not been summarized. Refer to Appendix 7-7-1.

Table 7-7-3 Measurement Results (Average)

Year/month	Sunshine duration (h/day)	Irradiation energy (kWh/m^2-day)	Conversion coefficient (kW/m^2)
1999/12	6.55	4.76	0.73
2000/1	4.64	4.11	0.89
2000/2	6.18	4.56	0.74
2000/3	5.96	4.51	0.76
Average	5.83	4.49	0.78

Source: Vavaya Ridge Upper Air Observatory

The solar irradiation from December 1999 to April 2000 is 4.49 (kWh/m^2-day) in average, and sunshine duration for the same period is 5.83 hours in average. The conversion coefficient, which is the solar irradiation divided by the sunshine duration, is 0.78 (kW/m^2) in average.

Since measurement of the solar irradiation is not made in the Solomons, the solar irradiation is estimated from the conversion coefficient and the sunshine duration. The conversion coefficient of 0.7 kW/m^2 used in this master plan is considered to have enough slack.

7.8 Design and Specifications

7.8.1 Calculation of the solar irradiation

Since the solar radiation is not measured in the Solomon Islands, it is calculated from the sunshine duration and the conversion coefficient, as mentioned before. The solar irradiation on a tilted surface is found using the following equation:

Qt = Sh x Cf x 3.6 x Kt（MJ/m^2-day）

In this equation,

- Qt Solar irradiation on a tilted surface (solar irradiation on the PV module surface), in MJ/m^2-day
- Sh Sunshine duration (depends on the location), in h/day
- Cf=0.7 Conversion coefficient, to get the solar irradiation from the sunshine duration, in kW/m^2 (refer to section 7.7.3)
- Kt Coefficient related to the latitude, PV module inclination angle and solar declination

The solar irradiation on a tilted surface depends on the latitude, the inclination of the PV module, and season (month), even if having the same sunshine duration. The inclined solar irradiation is calculated using the sunshine duration (Table 7-7-2), the latitude of recording station and the solar declination, and is shown in Fig. 7-8-1 to 4 and Appendix 7-8-1 to 4. The inclined solar irradiation for a surface tilted 12.5 degrees and facing north is shown in Table 7-8-1.

Table 7-8-1 Inclined solar irradiation (MJ/m^2-day） tilt angle:12.5 degree

Place	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
Honiara	14.10	14.56	15.95	17.48	18.44	19.37	17.26	18.05	17.03	17.77	18.05	15.37	16.95
Munda	13.80	12.08	14.62	14.76	15.06	14.80	12.74	14.48	14.13	14.50	15.37	14.37	14.23
Taro	13.69	13.43	14.26	15.44	13.58	13.56	10.71	11.97	13.52	13.42	15.01	13.56	13.51
Lata	13.23	13.17	12.97	15.44	13.84	14.97	15.12	14.36	13.75	14.88	15.28	13.35	14.20

7.8.2 PV module tilt angle

It is desirable that the selected PV module tilt angle corresponds to a maximum annual solar irradiation and also to a bigger minimum value of inclined irradiation during the year. These considerations lead to a PV module tilt angle of about 0 degrees for Honiara, about 7.5 degrees for Munda, about 15 degrees for Taro, and about 10 degrees for Lata, facing north. Since the cleaning effect of the PV module front cover by rain is reduced when the tilt angle is very small, a minimum of about 15 degrees has been broadly recommended. However, as a considerable amount of dust is not found at rural locations in the Solomons, a tilt angle of 12.5 degrees facing north, that leads to a high inclined solar irradiation, is selected. A small reduction of 2 % from the optimum tilt angle is found for the selected tilt angle of 12.5 degrees. (Refer to Fig. 7-8-5 to 8 and Appendix 7-8-1 to 4)

7.8.3 PV module capacity

The required capacity of the PV module is found from the following equation:

Pm = 3.6 x As x Pl/(Qt x K0)

In this formula,

Pm	Capacity of the module, in Wp/(kW/m^2)
As=1	Design factor
Pl	Daily power consumption (Wh/day)
Qt	Inclined solar irradiation (MJ/m^2-day)
K0	K0 = K1xK2xK3xK4xK5xK6xK7xK8xK9xK10
K1=0.83	Output reduction due to the temperature rise of the PV module
K2=0.99	Output reduction due to dirtiness on the surface of the PV module
K3=0.80	Average battery charge/discharge efficiency
K4=0.91	Power loss at cables and controller
K5=1.00	Inverter power loss coefficient
K6=0.80	Loss coefficient due to deviation of the actual operating point from the maximum power point of the PV module
K7=0.95	Coefficient due to variations of the solar irradiation (annual variations)
K8=0.95	Shade coefficient
K9=0.97	Reduction coefficient due to deviation of the orientation angle from the optimum value
K10=0.95	Reduction coefficient due to performance decrease with age

Concerning to the selection of above coefficients K1 and K6, it is supposed that the surface temperature of the PV module rises up to 65 ℃. Also, a field measurement[3] of the output reduction of a PV module when the surface temperature rises to 60 ^{o}C was found to be about 70 %. K5 is selected as 1.00 because the power consumption of the fluorescent lamp to be use in the SHS, already includes the inverter loss. Considering the fact that high trees surrounded

[3] Study on the Promotion of Photovoltaic Rural Electrification in the Republic of Zimbabwe Final Report

some villages in the Solomons, K8 coefficient was selected as 0.95. General values were given to the remaining coefficients.

(1) Load Size

Kerosene lamps are used in the village of the Solomon Islands, for 3-4 hours in houses and for about 2 hours at churches. Fluorescent lamps of 7-11W to fit the SHS are commercially available in markets. The following three cases as considered as load usage patterns:

① One 9-11W fluorescent lamp, 3-4 hours of daily use (private houses, etc.)

② Three 7W fluorescent lamps, 3-4 hours of daily use (private houses, etc.)

③ Four 11W fluorescent lamps, about 2 hours of daily use (public facilities as churches)

(2) PV module capacity

The PV module capacity necessary for the loads listed in the previous section is calculated and then a commercially available PV module with the closest capacity is selected. Results are shown in Table 7-8-2. It has been considered that for public facilities, such as churches, the SHS with four fluorescent lamps of 11Wwill be installed, and the number of these units will depend on the size of the area to illuminate (Refer to Appendix 7-8-1 to 4).

Table 7-8-2 PV Module Capacity

Load	PV Module Capacity
1 Fluorescent light of 9-11W	36 Wp
3 Fluorescent lights of 7W	55 Wp
4 Fluorescent lights of 11W	75 Wp

(3) Open circuit voltage of PV modules

Due to the fact that the climate in the Solomons is hot during the year, PV a module with an open circuit voltage (Voc) is of about 21V is selected.

7.8.4 Effective output of PV modules

The effective output, that is the amount of power possible to be supplied to the load, for three PV modules that have the nominal capacity mentioned in section 7.8.3, depends on the locations where the system is to be installed, and will also show seasonal and monthly variations. These changes are because the solar irradiation depends on the location and shows variations during the year. The results of calculating the energy possible to be supplied are shown in Table 7-8-3 (Refer to Appendix 7-8-5 to 8).

Table 7-8-3 Average effective output of PV Modules (Wh/day) (tilt angle: 12.5)

Month	36Wp PV module				55Wp PV module				75Wp PV module			
	Honiara	Munda	Taro	Lata	Honiara	Munda	Taro	Lata	Honiara	Munda	Taro	Lata
Jan.	56.3	55.1	54.6	52.8	86.0	84.1	83.4	80.7	117.2	114.7	113.8	110.0
Feb.	58.1	48.2	53.6	52.5	88.7	73.6	81.8	80.3	121.0	100.4	111.6	109.5
Mar.	63.6	58.3	56.9	51.8	97.2	89.1	86.9	79.1	132.5	121.5	118.5	107.8
Apr.	69.7	58.9	61.6	61.6	106.5	90.0	94.1	94.1	145.3	122.7	128.3	128.3
May	73.6	60.1	54.2	55.2	112.4	91.8	82.8	84.4	153.2	125.2	112.9	115.0
June	77.3	59.0	54.1	59.7	118.0	90.2	82.7	91.2	161.0	123.0	112.7	124.4
July	68.8	50.8	42.7	60.3	105.2	77.6	65.3	92.2	143.4	105.9	89.0	125.7
Aug.	72.0	57.8	47.8	57.3	110.0	88.3	73.0	87.5	150.0	120.4	99.5	119.3
Sept.	68.0	56.4	53.9	54.8	103.8	86.1	82.4	83.8	141.6	117.5	112.4	114.3
Oct.	70.9	57.9	53.5	59.4	108.3	88.4	81.8	90.7	147.7	120.5	111.5	123.7
Nov.	72.0	61.3	59.9	61.0	110.0	93.7	91.5	93.2	150.1	127.8	124.8	127.0
Dec.	61.3	57.3	54.1	53.2	93.7	87.6	82.6	81.4	127.7	119.4	112.7	110.9
Avg.	67.6	56.8	53.9	56.6	103.3	86.7	82.4	86.5	140.9	118.2	112.3	118.0
Max.	77.3	61.3	61.6	61.6	118.0	93.7	94.1	94.1	161.0	127.8	128.3	128.3
Min.	56.3	48.2	42.7	51.8	86.0	73.6	65.3	79.1	117.2	100.4	89.0	107.8

(1) Electric appliances and usage hours

The possible numbers of hours that loads can be used per day are summarized per module capacity in Tables 7-8-4 to 6. Calculations are based on the minimum monthly solar irradiation (Refer to Table 7-8-3).

Table 7-8-4 Electric appliances and use time (36Wp module)

Place	Fluorescent light (11W)		Fluorescent light (9W)		Fluorescent light (7W)		Radio cassette (6W)	
	Number	hours	Number	hours	Number	hours	Number	hours
Honiara	1	4					1	2
Munda	1	4					1	0.7
Taro			1	4			1	1.1
Lata	1	4					1	1.3

Table 7-8-5 Electric appliances and use time (55Wp module)

Place	Fluorescent light (11W)		Fluorescent light (9W)		Fluorescent light (7W)		Radio cassette (6W)	
	Number	hours	Number	hours	Number	hours	Number	hours
Honiara					3	3.5	1	2
Munda	1	4	1	1.5	1	1.5	1	0.9
Taro					3	3.1	1	0
Lata	1	4	1	2	1	1	1	1.67

Table 7-8-6 Electric appliances and use time (75Wp module)

Place	Fluorescent light (11W)		Fluorescent light (9W)		Fluorescent light (7W)		Radio cassette (6W)	
	Number	hours	Number	hours	Number	hours	Number	hours
Honiara	4	2.5					1	1
Munda	4	2.25					1	0.23
Taro	4	2					1	0.17
Lata	4	2.34					1	0.8

7.8.5 Battery Selection

In a stand-alone PV system, the battery is the most expensive item after the PV module, and moreover, it has a short life. Therefore, in order to minimize maintenance and operation costs of the PV system, it is important to have battery lifetime as long as possible. In order to achieve a battery long lifetime in a SHS, it is necessary to ensure that the battery withstands repeated charge/discharge cycles, and also is given an appropriate maintenance. However, it is considered that at present, appropriate maintenance can not be done in all the villages in the Solomon Islands.

Also, considering environmental issues, it is essential to reduce the amount of disposed batteries by selecting batteries with operation life as long as possible.

The following specifications of batteries to be used for SHS in the Solomon Islands reflect these considerations.

- Sealed gel battery, that do not require addition of distilled water and do not need equalization charges.
- More than 3,200 cycles lifetime, at daily discharges of 10 % of the battery capacity at 20h rate (remaining capacity to be 90 % , at an operation temperature of 20 ^{o}C).

7.8.6 Selection of battery capacity

The capacity of the battery is found by using the following equation:

Bc = Kn x Pl / (12 x Kd x Kh)

In this formula,

Bc Battery Capacity (Ah)

Kn Number of consecutive non-sunshine days. Taken as 5 days.

Pl Energy consumption per day (Wh/day)

Kd Maximum depth of discharge. Taken as 0.5.

Kh Maintenance factor. Taken as 0.9.

The battery capacity is calculated using the above formula, and then, a commercially available battery with the closest capacity is selected. Results are shown in the following table.

Table 7-8-7 Battery Capacity

PV module	Battery Capacity
36 Wp	56.5 Ah (100h rate), 50.6 Ah (20h rate)
55 Wp	80 Ah (100h rate) , 73.6 Ah (20h rate)
75 Wp	108 Ah (100h rate) , 97.6 Ah (20h rate)

(1) Average daily discharge

The ratio of the average daily discharge to the battery capacity (at 20h rate) is shown in Table 7-8-8. (Refers to Table 7-8-3)

Table 7-8-8 Daily depth of discharge (Depth Of Discharge: DOD)

Place	56.5Ah battery for 36Wp module		80Ah battery for 55Wp module		108Ah battery for 75Wp module	
	Avg. Load (Wh/day)	DOD (%)	Avg. Load (Wh/day)	DOD (%)	Avg. Load (Wh/day)	DOD (%)
Honiara	67.6	11	103.3	12	140.9	12
Munda	56.8	9	86.7	10	118.2	10
Taro	53.9	9	82.4	9	112.3	10
Lata	56.6	9	86.5	10	118.0	10

(2) Expected lifetime

Since the ratio of the average daily discharge to the battery capacity (20h rate) is about 10%, the expected lifetime of the battery at an operation temperature of 20 ^{o}C is, according to Federal's technical data, 3,200 cycles (8.7 years). Supposing that the lifetime decreases to 80 % at 27 ^{o}C (refer to section 6.6.1), the annual average temperature in the Solomon Islands, it is concluded that the battery expected lifetime, to be used as a design value, is 2,560 cycles (7 years).

7.8.7 Actual consecutive non-sunshine days and recovery days

(1) Number of the consecutive non-sunshine days the system can operate

Although the design value of consecutive non-sunshine days is 5 days, as explained in section 7.8.6, the actual average number of consecutive non-sunshine days that it is possible to afford by the selected battery is shown in Table 7-8-9. Refer to Appendix 7-8-5 to 12 for details.

(2) Number of battery recovery days

The number of days the battery needs to recover its capacity after being discharged to 50 % of capacity, during several consecutive non-sunshine days, is shown in Table 7-8-9. It is supposed that during recovery charging, the battery is not used at all by electric appliances, such as lighting. Refer to Appendix 7-8-5 to 12 for details.

Table 7-8-9 Actual consecutive non-sunshine day and recovery days

Place	56.5Ah battery for 36Wp module		80Ah battery for 55Wp module		108Ah battery for 75Wp module	
	non-sunshine days	recovery days	non-sunshine days	recovery days	non-sunshine days	recovery days
Honiara	5.1	4.3	4.7	4.0	4.6	4.0
Munda	6.0	5.1	5.6	4.8	5.5	4.7
Taro	6.3	5.4	5.9	5.0	5.8	5.0
Lata	6.0	5.1	5.6	4.7	5.5	4.7

7.8.8 Charge controller selection

The following characteristics are required for charge controllers to be used in SHS.

①Small losses

・Self current consumption less than 10 mA

Since the charge controller operates 24 hours a day, a controller with a small self-current consumption is important. Even if the self-current consumption is 10 mA, the daily energy consumption is as much as 2.9 Wh, that is a high percentage of lost energy when compared with the energy supply from a 36 Wp module.

・Small voltage drop

Besides of being a cause of energy loss, the voltage drop may also influence on the battery charging. The automatic disconnection of the PV module when it does not generate electricity is a function desirable in the charge controller.

②The battery charging voltage must be appropriate according to the kind of the battery to be used. Also it must match the recommended value from the battery manufacturer. It is normal that the charging voltage of a sealed-type battery is somewhat lower than the voltage for a flooded-type battery.

③Must have battery overcharge and overdischarge protection features

・The overcharge protection is to limit the charge from the PV module when the battery increases to a preset value.

・The overdischarge protection is to separate the load from the battery when the voltage of the battery gets below a preset value, and to reconnect the load when the voltage of the battery increases to a preset value.

④ Because the proper charging voltage of the battery decreases when the temperature rise, it is desirable that the charge controller has included temperature compensation of the charging voltage.

⑤ The type of charge controller with a timer is desirable to prevent the overuse of loads such as fluorescent lamps.

7.9 Systems and installation

Three systems, with capacity of 36 Wp, 55 Wp, and 75 Wp, are designed for use as SHS. The system to be used is selected taking into account the size of the building and the payment ability.

(1) 36 Wp system

Supplies one fluorescent lamp of 9W-11W and also an electric outlet for the radio cassette recorder. The use of the fluorescent lamp is about 3-4 hours. A radio cassette recorder of 6W can be used for about 0.7-2 hour. This system will be installed in private houses and teacher's houses. The system configuration is shown in Fig. 7-9-1.

(2) 55 Wp system

Supplies 3 fluorescent lamps of 7W and also an electric outlet for the radio cassette recorder. The three fluorescent lamps can be used for 3-4 hours. A radio cassette recorder of 6W can be used for 0-2 hours. This system will be installed in the clinic, private houses, and the teacher's houses. The system configuration is shown in Fig. 7-9-2.

(3) 75 Wp system

Supplies 4 fluorescent lamps of 11W and also an electric outlet for the radio cassette recorder. The four fluorescent lamps can be used for about 2 hours. A radio cassette recorder of 6W can be used for about 0.2-1 hour. This system will be installed in the public facilities. The system configuration is shown in Fig. 7-9-3. Several systems can be installed depending on the building size.

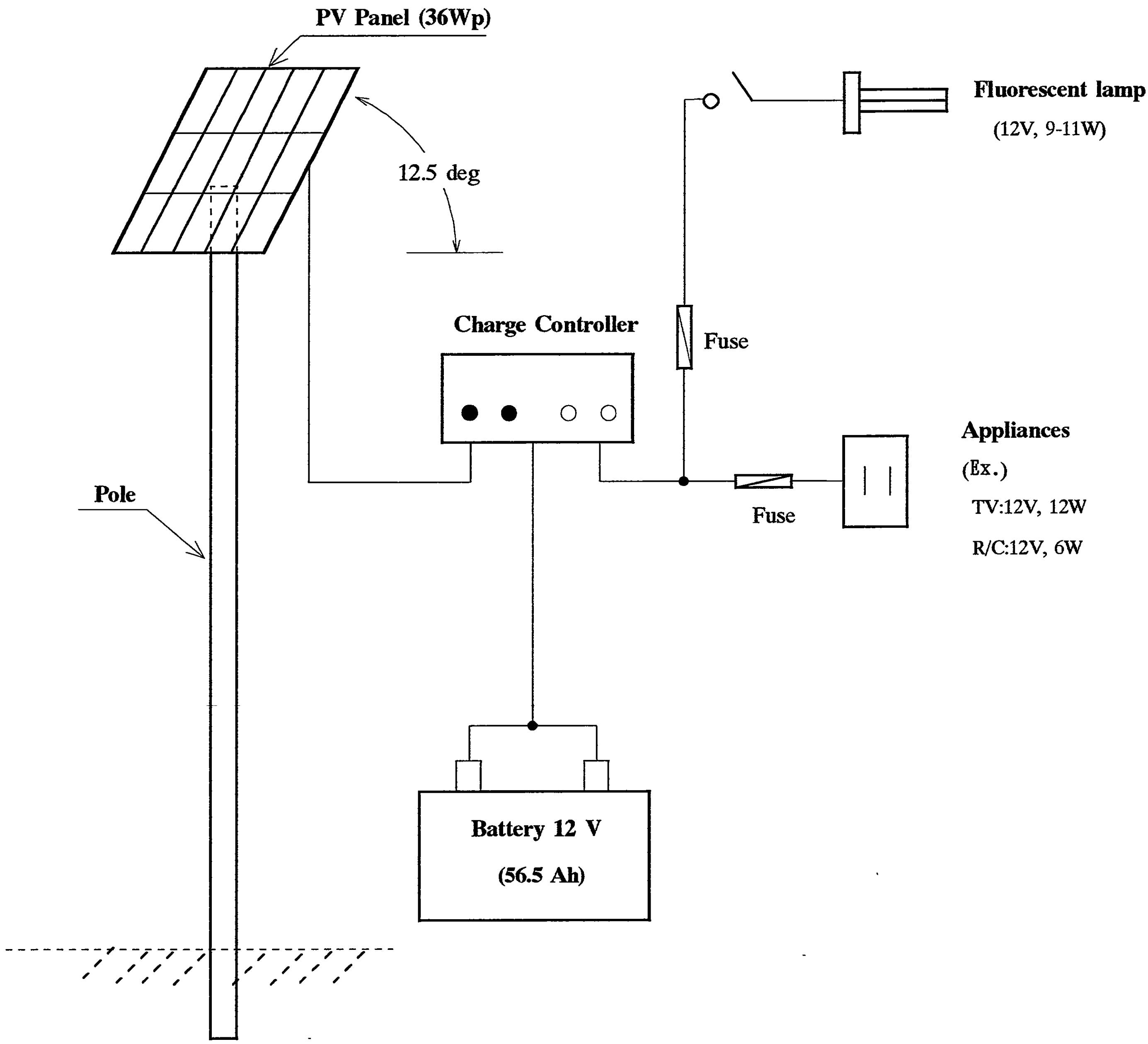

Fig. 7-9-1 SHS system for private houses (36Wp system)

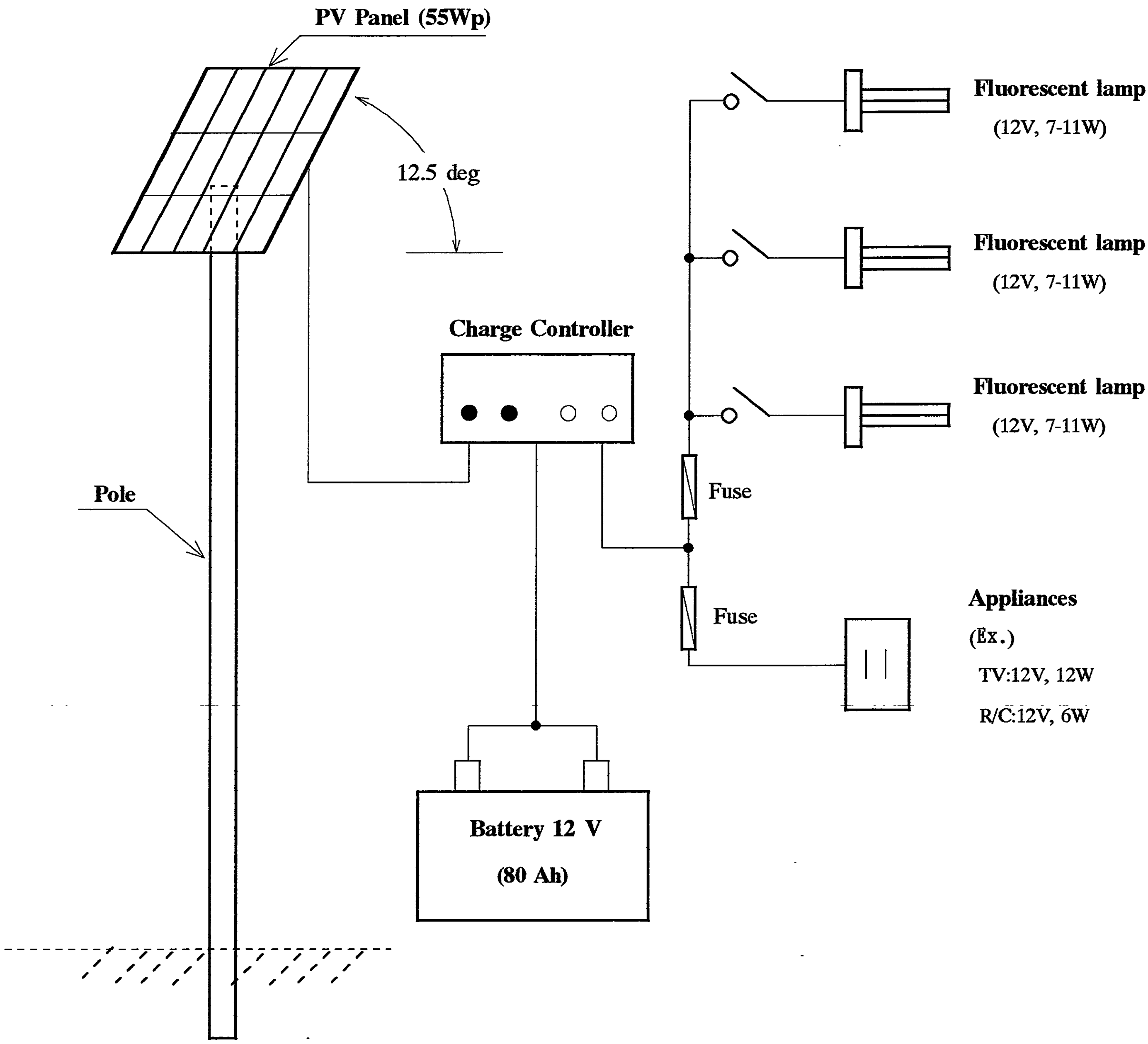

Fig. 7-9-2 SHS system for private houses (55Wp system)

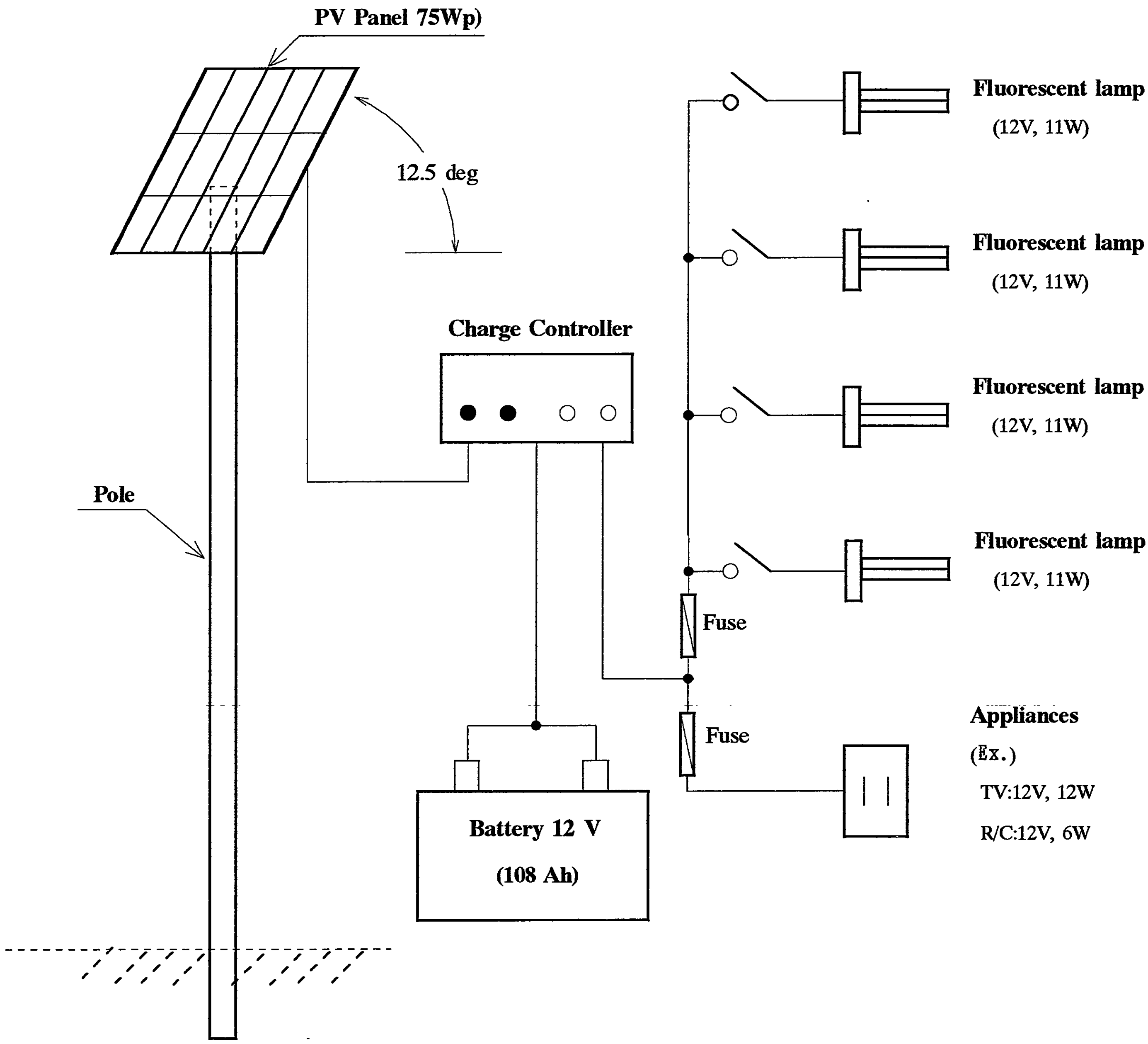

Fig. 7-9-3 SHS system for public facilities (75Wp system)

7.10 Construction costs

The SHS construction cost depends on the number of purchased sets. As for the cost that was used in this investigation, it is supposed that 500 SHS sets will be purchased. Also, it is supposed that SHS will be imported from Brisbane, Australia. Estimated construction costs for two cases, with and without import duties and goods tax, are considered.

When PV module, battery and charge controller are independently purchased, it is possible that their characteristics do not match between them and also it is possible that optimum power can not be obtained from the system. Moreover, there is a possibility that the lifetime of the battery decreases too. These considerations are the reason to decide that the SHS will be purchased as a kit. SHS rental charges depend on the construction cost.

Import duties of SHS are calculated as CIF x 1.3 x 0.05(1+0.05), and the goods tax is calculated as CIF x 1.3 x 0.15. Also, expenses from the agency that imports and installs SHS are 15% of the CIF price. Concerning to installation works, services are to be provided by the villagers. Also poles and battery storage boxes will be purchased in the Solomons.

7.10.1 Specification of the main components

(1) PV module

Table 7-10-1 PV module specifications

	36 Wp	55 Wp	75 Wp
Rated power Pmax	36 W	55 W	75 W
Rated current Impp	2.1A	3.15A	4.4A
Rated voltage Vmpp	17.0V	17.4V	17.0V
Short circuit current Isc	4.7A	3.45A	4.8A
Open circuit voltage Voc	21.7V	21.7V	21.7V

(Source: Siemens Catalogue)

(2) Battery

The battery is a 12V sealed gel type for deep cycling use. Recommended charging voltage should be between 13.8V and 14.1V. Battery expectation lifetime should be more than 3,200 cycles (discharge capacity per day to be 10 % of the battery capacity (at 20h rate), or equivalent to 90 % of remaining capacity, at an operation temperature of 20 ^{o}C).

a. 56.5 Ah (100h rate) for the 36 Wp system

Capacity (20h rate) 50.6 Ah

b. 80 Ah (100h rate) for the 55Wp system

Capacity (20h rate) 73.6 Ah

c. 108 Ah (100h rate) for the 75Wp system

Capacity (20h rate) 97.6 Ah

(3) Charge controller

Type Semi-conductor type (with timer)

Rated load/Rated solar input	6～10A
Self-current consumption	Less than 10 mA
Low-voltage load disconnection	11.5～11.7V (LVD)
Low-voltage load reconnection	12.6～12.8V (LVR)
Constant voltage control	14.1V
Temperature compensation coefficient	about -27 mV/ ^{o}C

(4) The supporting structure

Since SHS are to be installed in locations close to the sea, it is needed that the supporting structure to be strong enough against corrosion. Therefore, the pole is to be made of galvanized steel pipe, 2.5 inches diameter and 6.5 m length, acquired in the Solomon Islands, and an aluminum frame is to be used as the metal fittings to support the PV module. Also, stainless steel wires with turnbuckles are attached to the pole from 3 directions to avoid falls during strong winds. The pole will have a buried depth of 50 cm and a height above ground of 4 - 5 m.

(5)Wiring and accessories

The wiring and other accessories needed are: 20 m cable for module wiring, cable for indoor wiring (36Wp: 12m, 55Wp: 30m, 75Wp: 40m), one set of accessories for aerial wiring, 1 to 4 lamp switches, to be installed on walls, 1 to 4 joint boxes, one fuse block for 2 circuits, 2 pin polarized outlet to be installed on wall, and saddles.

7.10.2 Construction costs

The estimated construction costs are referred to two cases, one includes import duties and goods tax and the other does not contain them. Results are shown in Table 7-10-2 to 3. For details refer to Appendix 7-10-1 to 3.

(1) Customs duties and goods tax included

Table 7-10-2 Construction cost of SHS with customs duties and goods tax

System	Cost (US$)
36 Wp System	1,195
55 Wp System	1,398
75 Wp System	1,640

(2) Customs duties and goods tax not included

Table 7-10-3 Construction cost of SHS without customs duties and goods tax

System	Cost (US$)
36 Wp System	996
55 Wp System	1,160
75 Wp System	1,301

7.11 Operation and maintenance costs

The SHS rental charge is estimated based on costs such as O&M and construction costs. The SHS rental charges are estimated for two cases, one including import duties and goods tax and the other not including them. Also, comparisons are made when the interest rates are 4% and 0%. The SHS rental charges include the maintenance expenses for 20 years, and also include twice the replacement of batteries and once the replacement of charge controller. The ownership of SHS is not transferred to the user and the owner is responsible for the maintenance during 20 years after installation even if payment of the rental charge has been completed. However, repair expenses, excluding twice the replacement of batteries and once the replacement of charge controller, are charged. Battery cost includes disposal expenses (US$4/unit).
Considered payment periods for the rental charge are 3 years, 5 years, 7 years, 10 years, 15 years, and 20 years. Payment in one lump sum is also considered. The user chooses the period of payment of rental charge from these options. Operation life of 20 years for PV modules, 7 years for batteries and 10 years for charge controller are considered. Replacement costs of fluorescent lamps are not included. The interest means rate being imposed on rental charges, presented in this section. Results of the rental charge estimation are summarized in Tables 7-11-1 to 8. Refer to Appendix 7-11-1 to 3 for details.

(1) Case including customs duties and goods tax

a. When a rental charge is paid during 20 years

Table 7-11-1 Rental charge for 20 years including O & M cost (With customs duties and goods tax)

System	4 % of interest (US$/month)	0 % of interest (US$/month)
36 Wp System	10.8	7.3
55 Wp System	12.4	8.4
75 Wp System	14.5	9.8

(Down payment:US$30)

b. When a rental charge is paid during 10 years

Table 7-11-2 Rental charge for 10 years including O & M cost for 20 years

(With customs duties and goods tax)

System	4 % of interest (US$/month)	0 % of interest (US$/month)
36 Wp System	18.0	14.6
55 Wp System	20.7	16.8
75 Wp System	24.2	19.6

(Down payment:US$30)

c. When a rental charge is paid during 5 years

Table 7-11-3 Rental charge for 5 years including O & M cost for 20 years

(With customs duties and goods tax)

System	4 % of interest (US$/month)	0 % of interest (US$/month)
36 Wp System	32.9	29.3
55 Wp System	37.7	33.6
75 Wp System	44.1	39.3

(Down payment:US$30)

d. When a rental charge is paid at the first time

Table 7-11-4 Paying the full amount of the rental charge at the first time including O & M cost for 20 years (With customs duties and goods tax)

System	4 % of interest	0 % of interest
36 Wp System	1,787	1,787
55 Wp System	2,046	2,046
75 Wp System	2,387	2,387

(Down payment:US$30)

(2) Case not including customs duties or goods tax

a. When a rental charge is paid during 20 years

Table 7-11-5 Rental charge for 20 years including O & M cost

(Without customs duties and goods tax)

System	4 % of interest (US$/month)	0 % of interest (US$/month)
36 Wp System	9.1	6.2
55 Wp System	10.4	7.0
75 Wp System	11.7	8.0

(Down payment:US$30)

b. When a rental charge is paid during 10 years

Table 7-11-6 Rental charge for 10 years including O & M cost for 20 years

(Without customs duties and goods tax)

System	4 % of interest (US$/month)	0 % of interest (US$/month)
36 Wp System	15.2	12.3
55 Wp System	17.3	14.1
75 Wp System	19.6	15.9

(Down payment:US$30)

c. When a rental charge is paid during 5 years

Table 7-11-7 Rental charge for 5 years including O & M cost for 20 years

(Without customs duties and goods tax)

System	4 % of interest (US$/month)	0 % of interest (US$/month)
36 Wp System	27.7	24.6
55 Wp System	31.6	28.1
75 Wp System	35.7	31.8

(Down payment:US$30)

d. When a rental charge is paid at the first time

Table 7-11-8 Paying the full amount of the rental charge at the first time including O & M cost for 20 years (Without customs duties and goods tax)

System	4 % of interest	0 % of interest
36 Wp System	1,508	1,508
55 Wp System	1,719	1,719
75 Wp System	1,940	1,940

(Down payment:US$30)

7.12 The market price investigation

There are 2 shops in Honiara where materials related to SHS are sold. Also, there are several shops where switches, electric outlets, DC12V fluorescent lamps and other accessories can be found. However, large amount of components is not available in the shops. Concerning to batteries, only car batteries are sold at the SHS shops.

(1) PV modules

Modules of 40 Wp and 80 Wp are sold in Honiara. Specification details are not clear.

Capacity	Brand	Country	Price (without Goods Tax)
40 Wp	Solarex	Australia	1,750 SB$
80 Wp	Solarex	Australia	2,495 SB$

（Information：ILAND ENTERPRISES LIMITED, Honiara）

(2) Batteries

Car batteries are sold in Honiara. Specification details are not clear. According to SIEA staff, inexpensive batteries are of poor quality. The electrolyte is not included in the battery price. Electrolyte for batteries is sold at around 12 SB$/liter and distilled water is sold at around 17 SB$/liter, and can be found in gasoline stations.

Capacity	Price (With Goods Tax)
50 Ah	240～337 SB$
60 Ah	235～325 SB$
70 Ah	335～445 SB$
100 Ah	448～506 SB$
120 Ah	559～610 SB$

（Storefront inquiry, Honiara）

(3) Charge controller

A semi-conductor type charge controller is sold at SB$638 (taxes included).

(Equalization: 14V, Float: 13V, LDV: 11V)

(4) Freight

Freight from Honiara is as follows. Loading fee is 15 SB$/$m^3$.

Destination	Freight (8feet*8feet*20feet container)
Brisbane, Australia	1,753 AU$
Manila, Philippine	1,875 US$
Bangkok, Thailand	1,725 US$

（Information：TRADCO SHIPPING LIMITED, Honiara）

(5) Others

Item	Price (with Goods Tax: 15%)
Fluorescent lamp (tube) DC12V, 8W	18.5 SB$
Fluorescent lamp (tube) DC12V, 10W	14.6 SB$
Fluorescent lamp (tube) DC12V, 13W	18.6 SB$
Switch with a outlet	38.8 SB$
Conductor 6 mm^2 double	7.35 SB$/m
Conductor 2.5 mm^2 double	4.15 SB$/m
Galvanized steel pipe (2inch, 6.5m)	38.25 SB$ (without tax)
Galvanized steel pipe (3inch, 6.5m)	63.69 SB$ (without tax)

（Storefront inquiry, Honiara）

7.13 Training

Training is indispensable in order to strengthen the dissemination of SHS. Concerning the training procedure in the Pilot Scheme, engineers from each province who are working at the Provincial Government will be trained at the PV Training Center in Honiara according to the program shown below. The PV Training Center will be established in REAC, Rural Electrification Advisory Committee.

After engineers completed the course, they would train at the provincial capital technicians from each village communities where pilot systems are be installed, in order to get qualification for SHS operation and maintenance. The engineers, who were trained in Honiara, as well as the community technicians, should participate in the pilot plant construction to improve their skills on SHS installation.

Regarding the Nationwide Scheme, and similarly to the Pilot Scheme, the engineers who completed the course in Honiara would train at the provincial capital technicians from each village community where SHS will be installed, in order to get qualifications for system operation and maintenance. In this Nationwide Scheme, also the community technicians should participate in the construction of SHS in their communities.

(1) The training contents

① Sunshine and solar radiation (one day): Understanding about the solar energy

② SHS equipment (a half day): Understanding system configuration

③ PV panel (1.5 days): Understanding about the PV module, and the relation between the electricity generation and the sunshine or solar radiation

④ Batteries (one day): Understanding about the characteristic of overdischarge, overcharge, capacity, and other parameters

⑤ Charge controllers (one day): Understanding charging voltage and protection features such as overdischarge and overcharge

⑥ System design (one day): Understanding the calculation of PV module and battery capacity, as well as limitation of the usable load and the importance of adequate wiring

⑦ Installation practice of SHS (three days): Installation and wiring activities during field works

⑧ Maintenance of SHS (half day): Understanding the maintenance of SHS

⑨ Maintenance practice of SHS (1.5 days): Inspection (measurement of voltage and current) and maintenance during field works

⑩ Four extra days

(2) Training period

・ 15 days (about 3 weeks)

7.14 Village maintenance and management organization

This defines the person to be in charge of the SHS installation, maintenance and management, in the village where SHS will be installed. This person in charge of maintenance and management should be a technician who has completed the training course mentioned in the above section 7.13. One qualified technician should be in charge of maintenance and management activities of 50 sets of SHS, and according to the number of SHS to be installed, more than one technician might be necessary. The technician should get into an agreement with the SHS owner to maintain and manage the systems, and will receive a monthly salary from the owner according to the number of SHS. The technician in charge of the maintenance management will record the results of the maintenance using a special SHS management ledger. The management ledger to be prepared for every SHS should be kept for 20 years.

(1) The main role of the maintenance and management technician

- Maintenance, management, simple repairs
- Collection of the SHS rental charges and delivery of collected money to the Development Bank of Solomon Islands (DBSI[4])
- Mediation between the SHS owner and the user
- Report to the SHS owner about inspection results

(2) Main contents of SHS maintenance and management

- Cleaning the surface of PV panel (once per month)
- Removal of foreign objects from the PV panel surface, such as leaves (regularly)
- External inspection of PV panel (once per month)
- Removal of objects that produce shade on the PV panel (regularly)
- Inspection of the PV panel supporting structure, such as loosing parts and pole conditions (once per month)
- Measurement of battery voltage (once per month)
- External inspection of battery and cleaning (once per month)
- Inspection of battery terminals, whether or not terminals are loosening (once per month)
- Confirmation of the charge controller setting value (once per month)
- External inspection of charge controller (once per month)
- Inspection of wiring and other points, such as loosening connections and insulation (once per month)

[4] Development Bank of Solomon Islands

7.15 Battery disposal

（1） Disposal procedure

The used batteries will be accumulated in Honiara and sent to Brisbane, Australia, in lots of 500 units, and entrusted to deliver them to a battery disposal company. The battery disposal company, located in Brisbane suburbs, refunds 2 AUcent/kg, when batteries are carried in for disposal (information: NENSYS New Energy Systems, 21 Coyne St Leichhardt QLD 4305 Australia).

（2） Disposal costs

The battery disposal costs are estimated at 4 US$/piece including transportation, and are considered in the original battery price. The breakdown of the battery disposal costs is as follows. The packing cost is estimated at twice the loading fee, and domestic transportation cost in Australia is estimated as one truck and three men-day labors. Other costs are based on survey results (refer to section 7.12).

Freight: 1,052 US$/500 units, packing cost: 200 US$/500 units, loading fee (Honiara): 100 US$/500 units, cost of domestic transportation in Australia: 500 US$/500 units, disposal refund: -150 US$/500 units.

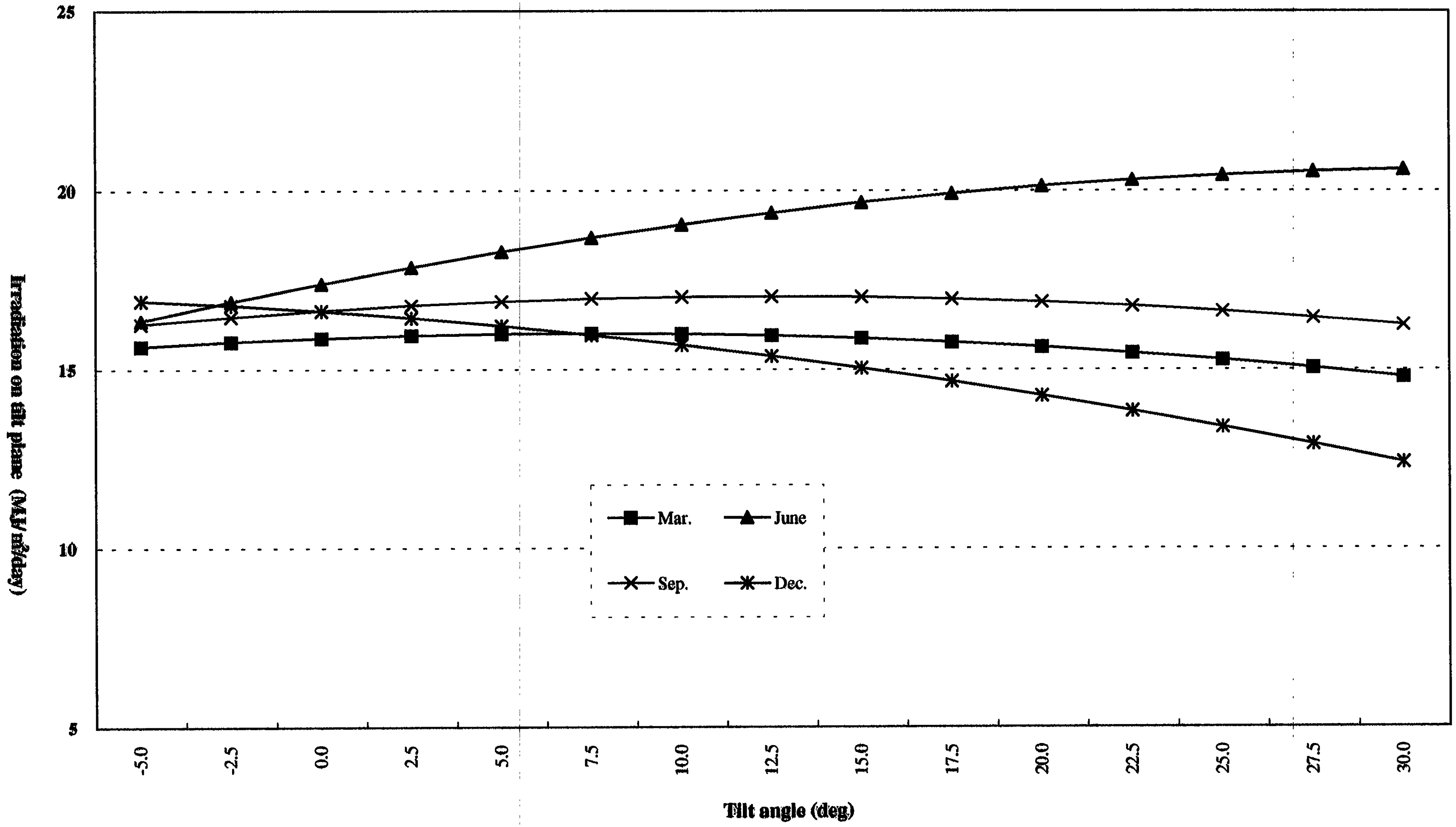

Fig. 7-8-1 Total irradiation in typical month in Honiara

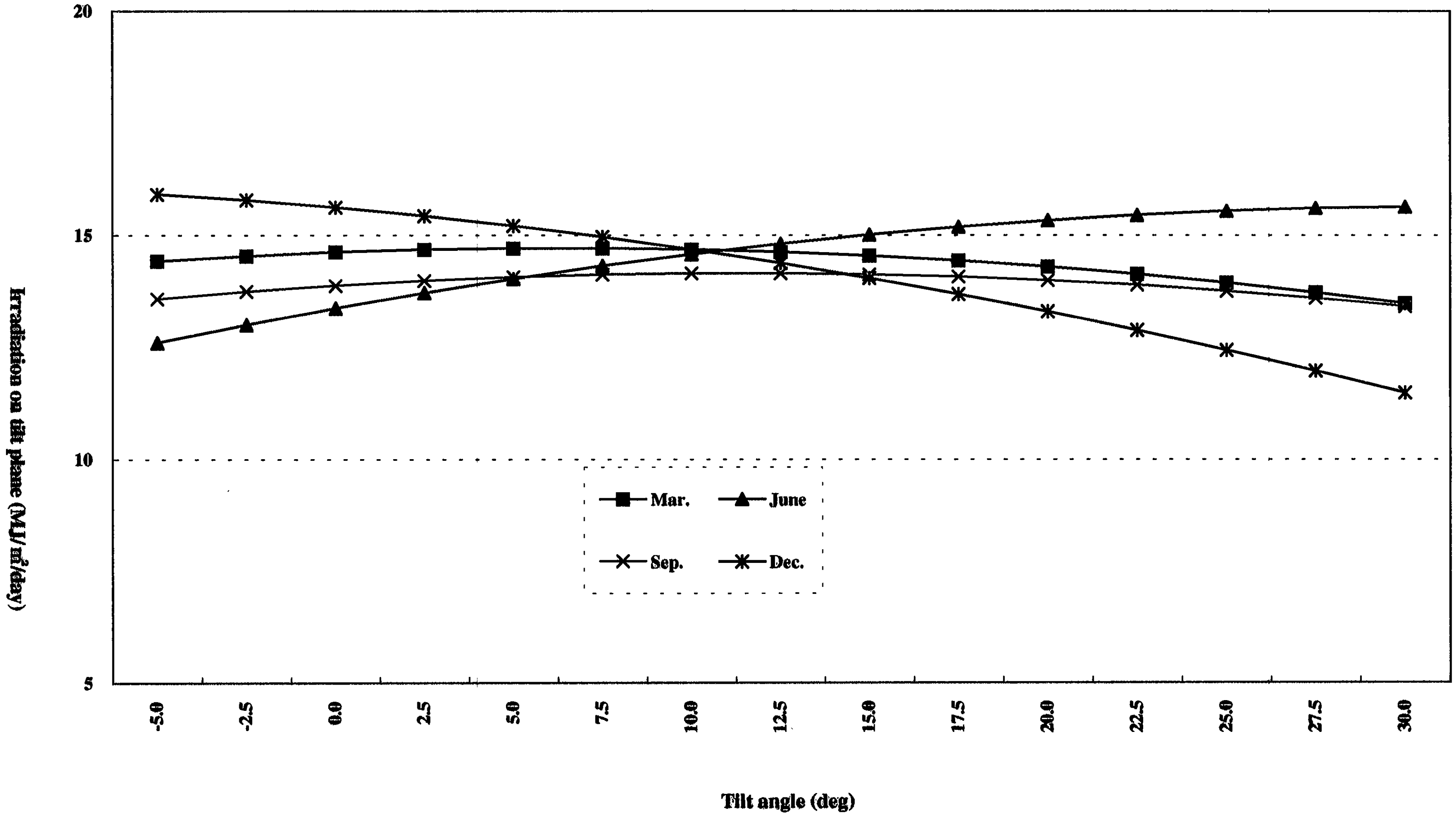

Fig. 7-8-2 Total irradiation in typical month in Munda

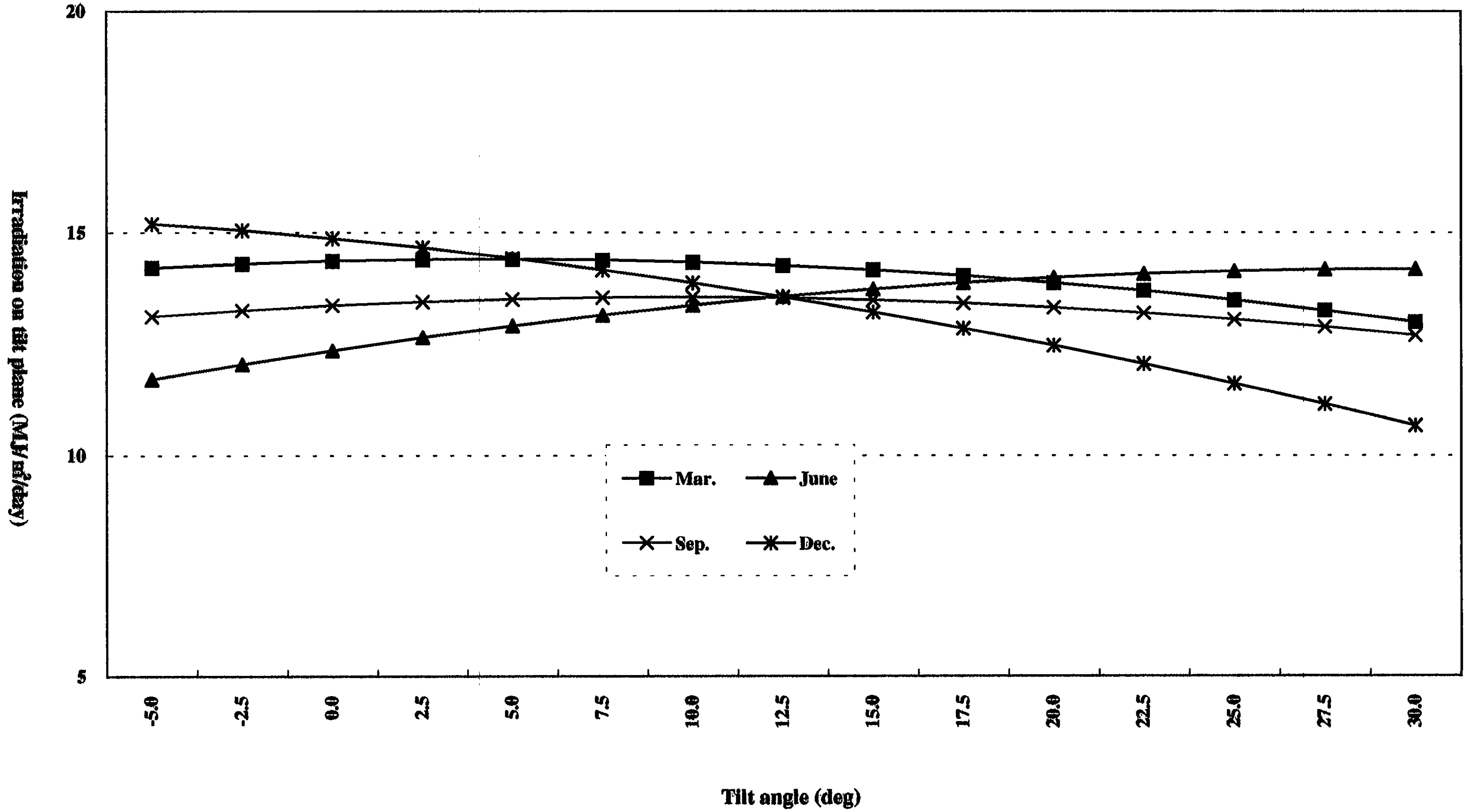

Fig. 7-8-3 Total irradiation in typical month in Taro

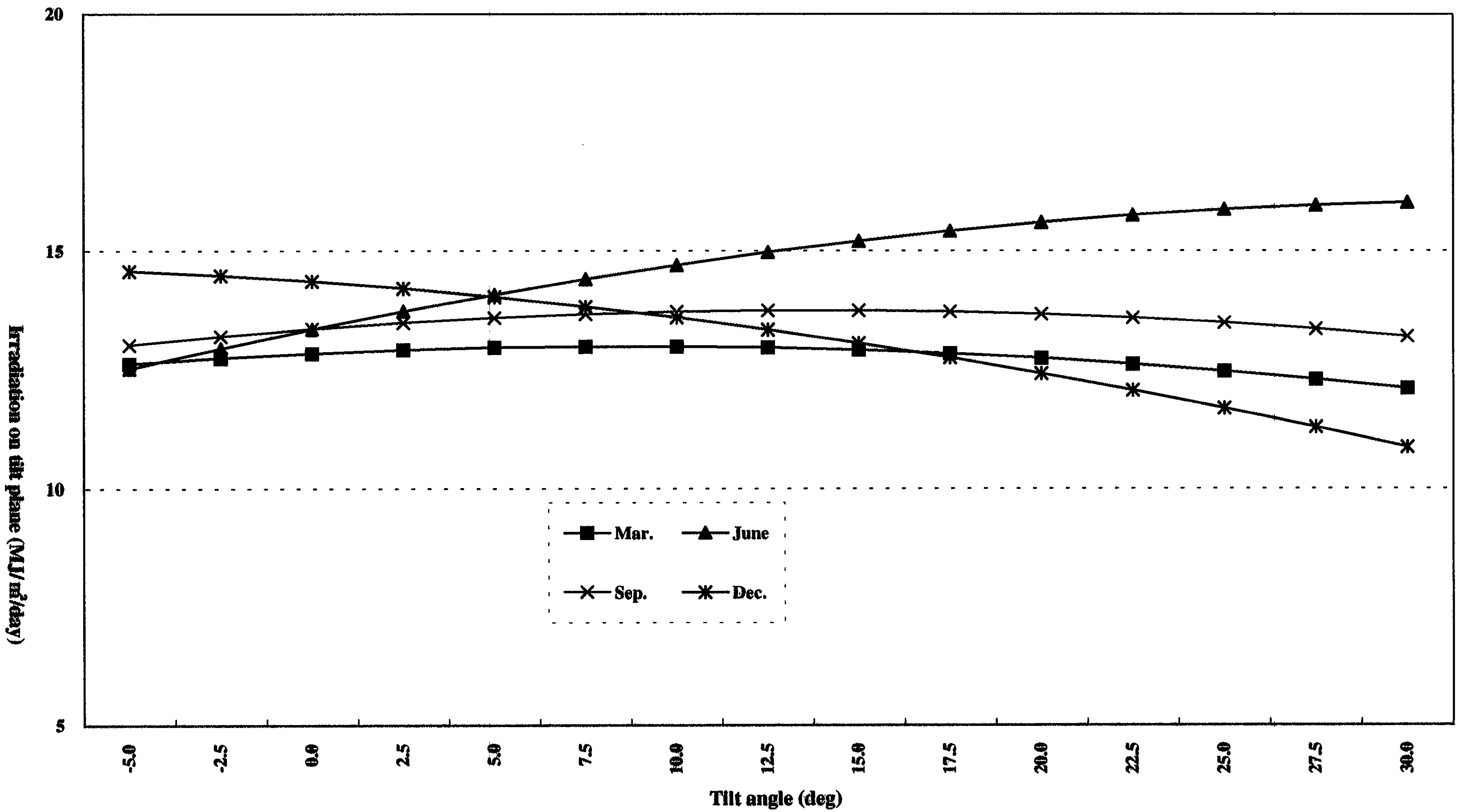

Fig. 7-8-4 Total irradiation in typical month in Lata

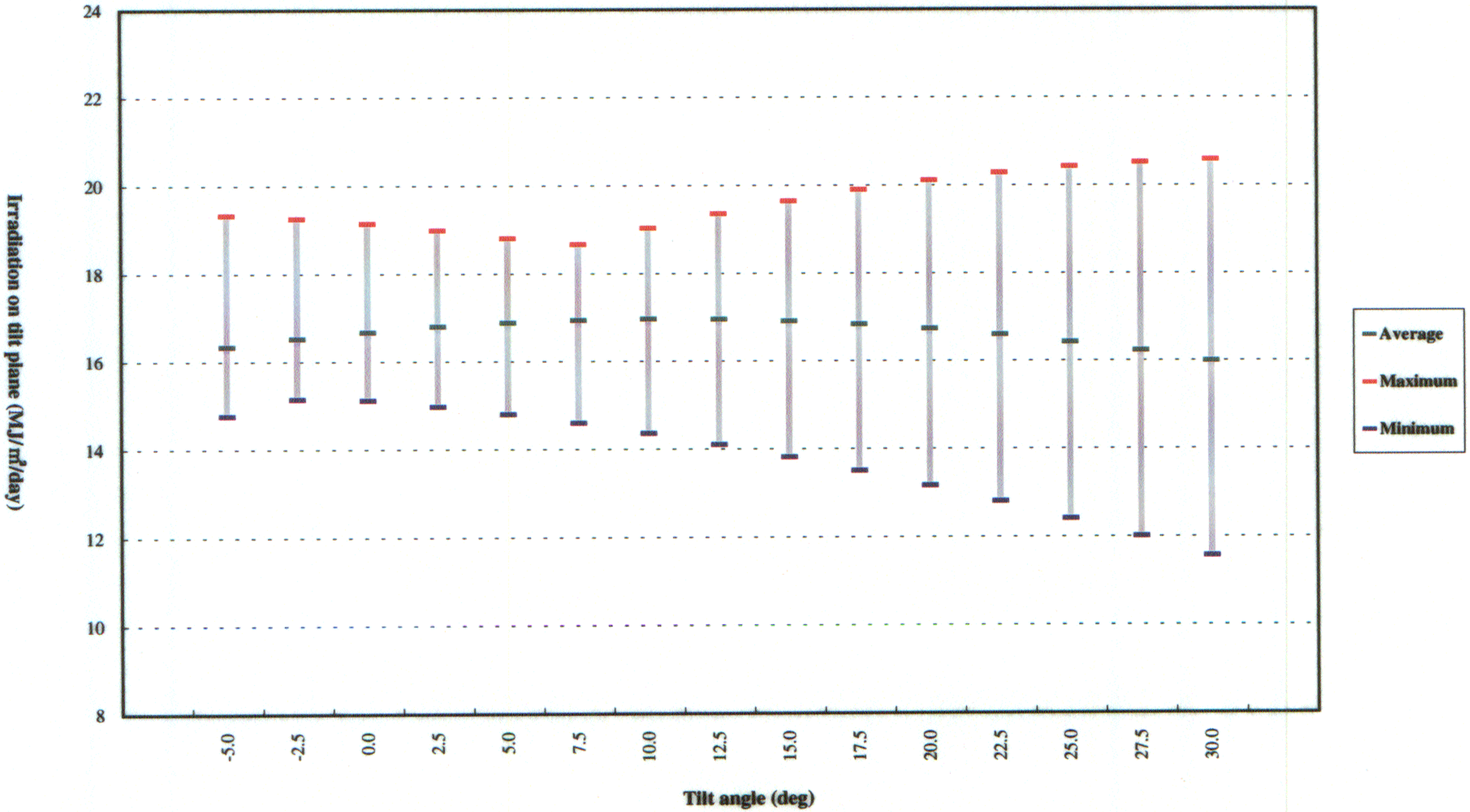

Fig. 7-8-5 Tilt angle & Total irradiation in Honiara

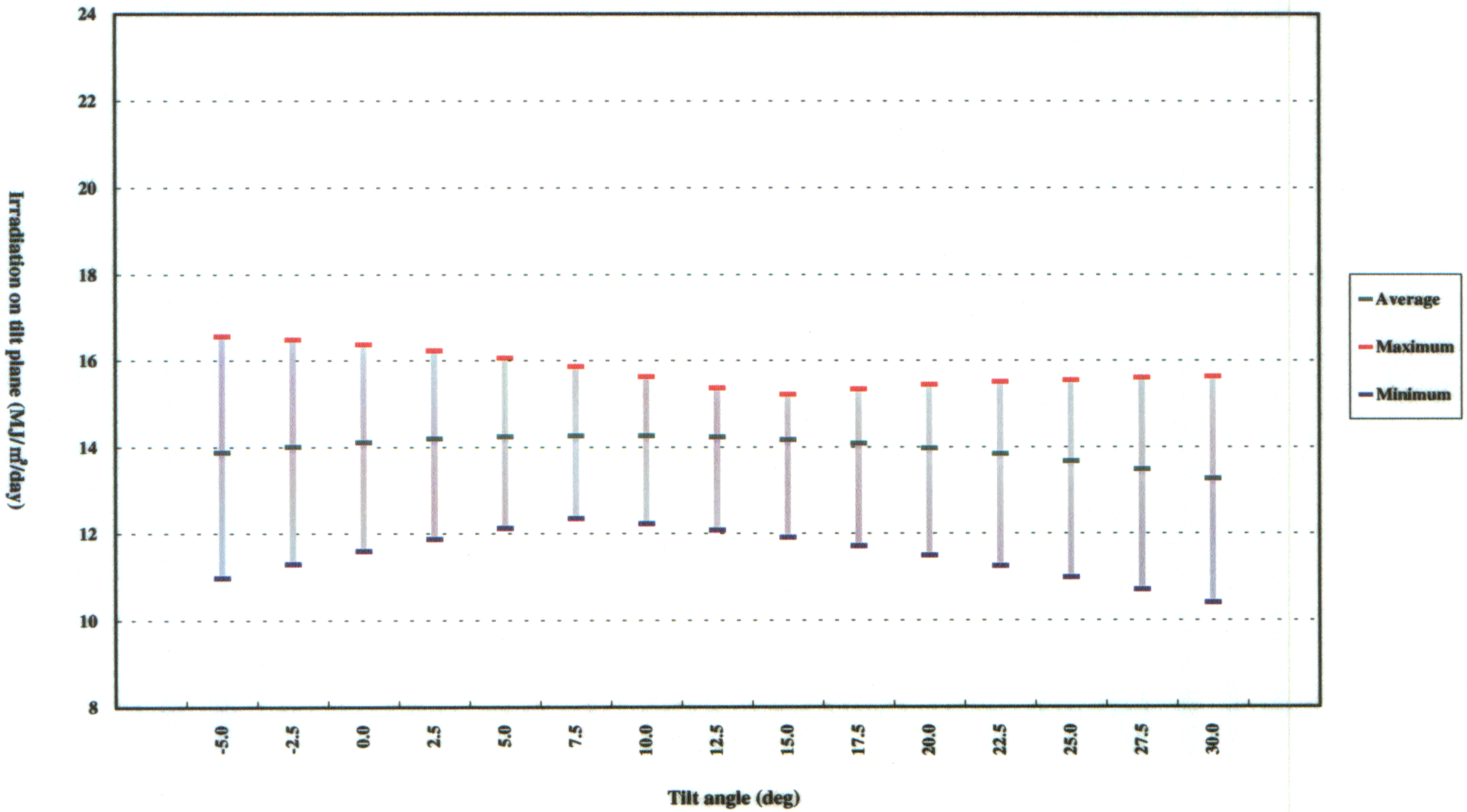

Fig. 7-8-6 Tilt angle & Total irradiation in Munda

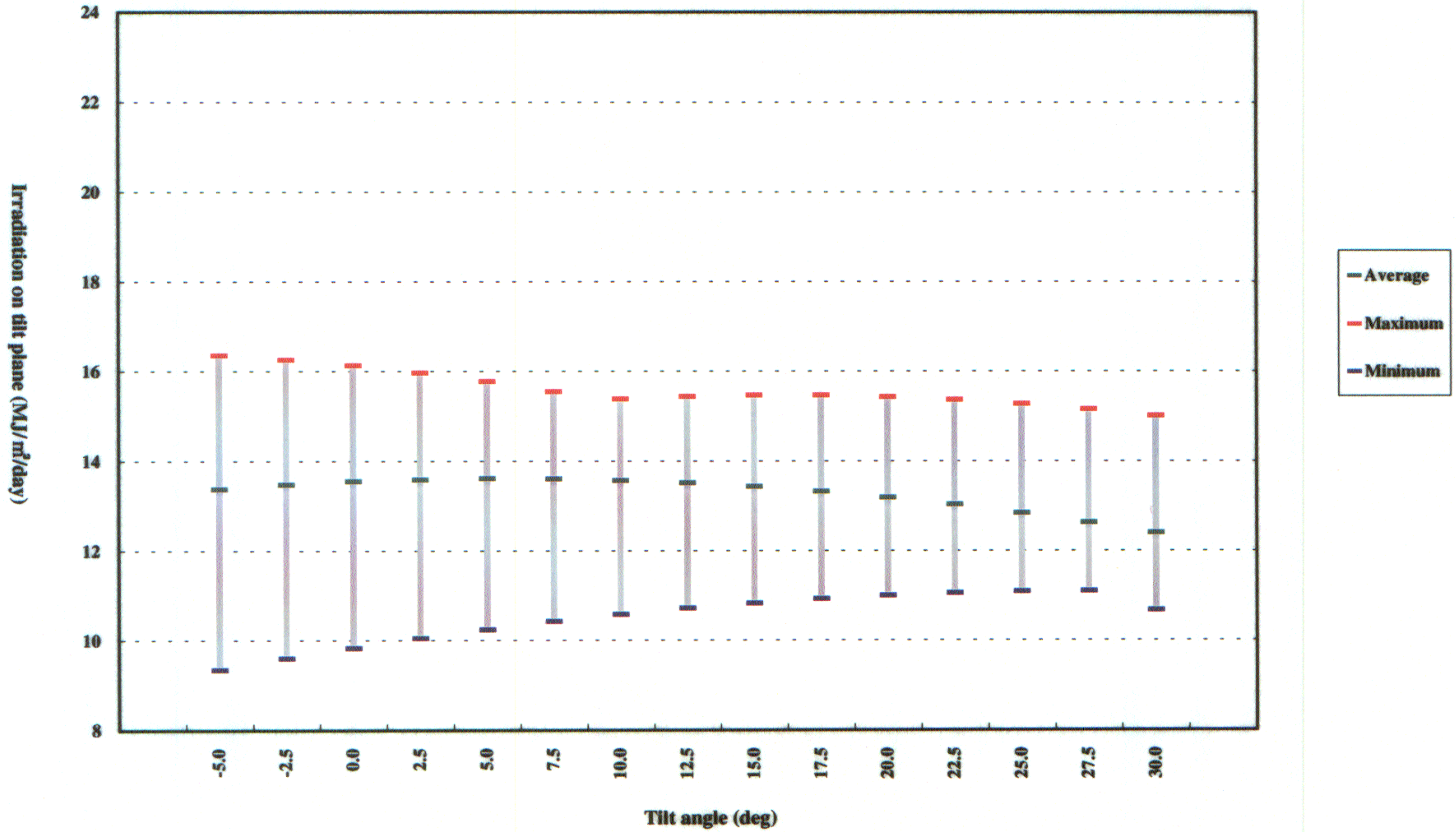

Fig. 7-8-7 Tilt angle & Total irradiation in Taro

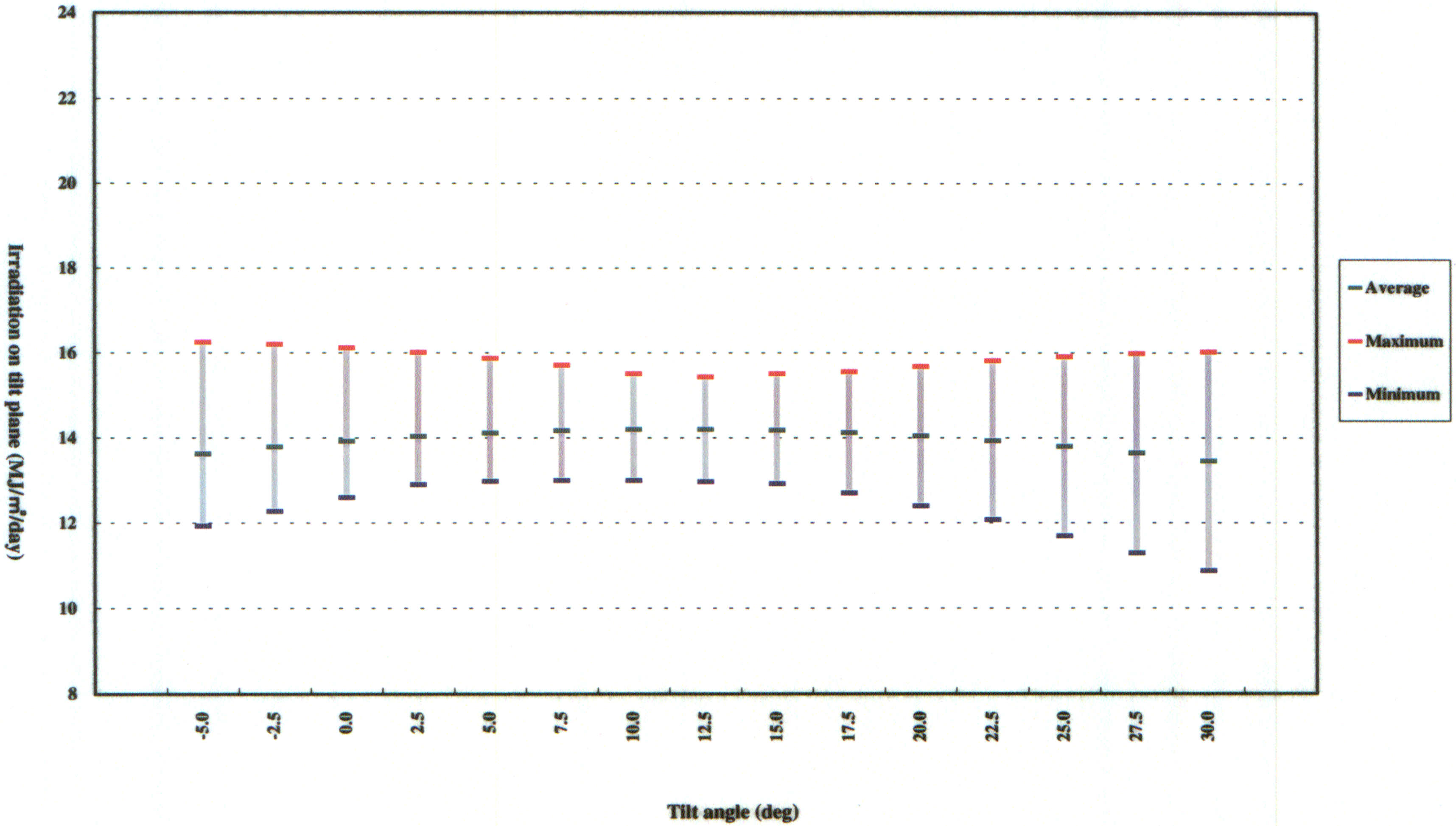

Fig. 7-8-8 Tilt angle & Total irradiation in Lata

CHAPTER 8

RURAL SOCIETY

Chapter 8 Rural Society[1]

This chapter intends to supply basic information in relation to rural society in the Solomon Islands, and, based on that information, to clarify and examine the character of rural society for promoting rural electrification.

With regard to the second field study, the study area was enlarged and the findings of the first field study were reviewed. Furthermore, eleven (11) potential sites for the hydropower station, which had been preliminarily selected through screening during the first field study, were surveyed in detail from the social and environmental point of view.

In this interim report, basic information found in the progress report about rural society has been slightly revised. The latter half of this chapter, concerning rural electrification and rural society, has been newly elaborated. The actual field study on rural society has been completed, so the findings in this report will be reflected in the final report.

8.1 Present State and Distinction

Traditional subsistence farming is the dominant mode of agriculture in rural society in the Solomon Islands. Clan and language group are essential factors for social identity. Christianity has been deeply embedded in, and merged with, their traditional lifestyle. However, the system that has supported their traditional lifestyle is rapidly changing or eroding, because villagers are increasing their dependence on the market economy (cash economy).

8.1.1 Present state of rural area

The precise range of dependence on traditional agricultural subsistence is not available, but, for example, about 62% of household consumption is estimated to come from such produce[2].

It is not easy to find reliable demographic data in the Solomon Islands for the period after the national census in 1986. However, from three surveys[3], 88% of the population, or 88% of the average household, resides in rural areas.

According to the "Village Resources Survey 1995/6", there are 4,174 villages, and rural areas have a population of 295,791 in about 52,405 households. The average number of members in one household in the rural areas is 5.6 persons. There are nine provinces in the Solomon Islands, and about a half of the rural population lives in Guadalcanal Province and Malaita Province. The average village population is 70.9 persons, but ranges from 46.8 in Choiseul Province to 110.7 in Western Province. 52% of villages is situated on the coast, and 15% in places less than 15 minutes walk from the sea.

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[1] The list of surveyed villages in the first and second field study is attached at the end of this capture. (Table8-0)

[2] According to "*Rural Areas of The Solomon Islands; Income and Expenditure Survey1993*", average monthly household expenditure is S$155.85, and the total monthly value of "own production" is S$253.30. So the total value of household consumption per month is S$409.15. Based on the above figures, 62% of household consumption per month comes from own production.

[3] *Honiara Housing and Population Survey1995, Provincial Centres Household Income and Expenditure Survey 1992* and *Rural Areas of The Solomon Islands; Income and Expenditure Survey 1993*

8.1.2. Distinction of rural society

Clan and language group are essential factors of social identity in the Solomon Islands. In other words, extended family (or kinship) and the *wantok* system are the core of society.

In particular, villagers are closely related through these systems. This system has sustained their egalitarian society, and the supply safety-net to disadvantaged people like the young, the sick and the old. It has also protected villagers from absolute poverty.

These systems are rooted in the subsistence economy – a system of high self-sufficiency. However, villagers are increasing their dependence on the market economy, and are under pressure to earn money. Traditional systems are rapidly changing or eroding. As compared with urban areas, the change is not obvious, but rural society is also in transition.

Christianity is another important factor to understand rural society in the Solomon Islands. 96% of Solomon Islanders is estimated to belong to the Christian religion. As mentioned above (8.1.1), one good example demonstrating the influence of Christianity is that 67% of rural people stay on the coast or in places less than 15 minutes walk from the sea. Before spreading Christianity through the Solomon Islands, rural people had lived in forested areas. However, after Christian missionaries started their activities, rural people moved from their native area to the coastal area, because of suggestions by missionaries that such a move would facilitate a convenient religious life.

It is no exaggeration to say that Christianity is the central value of their life. So many activities in rural areas have some relationship to Christianity. The church is the most important public building in the village. If the church building is a bush-type structure, villagers will put their first priority on improving it to make it into a permanent structure[4]. For the purpose of Christian activities, the consensus for regular and irregular donations are easily established among the community.

8.2 Village Structure

For rural people, communal rule is superior to that of the nation, and the village still enjoys a highly independent existence in the Solomon Islands. The identity of rural people may be more associated with the village than with the nation.

In this study, the following organizations have been identified as central to the social infrastructure of the people: the village committee, the church committee, the school committee, the health committee, the water committee, the women's club, the men's club and the youth club.

Village committees play a primary role as social arenas for villagers' to articulate their opinions on matters that affect their life. In many cases, a village chief heads a village, and under the village chief the village committee functions. Apart from the village committee, there is a church committee. It is questionable to consider the church committee and the village committee as

[4] A bush house is made of materials that are available around a village and in the bush. A permanent house is made of artificial materials like cement, galvanized iron, paint, etc.

independent. According to some village chiefs and village committee members, village committee members and church committee members sometimes overlap. Since villagers put high priority on church activities, the village committee ends up being responsible for such church activities.

The school committee is also an active organization. Villagers get used to contributing to the community primary schools. However, only 12% [5]of villages own primary schools. Therefore, school committees are not always organized in each village.

In the study, the activities of health committees, water committees[6], women's clubs, men's clubs and youth clubs were investigated. Except when such groups are organized to serve church activities like the church service and fund raising, they don't seem to be fully active.

The groups that are related to the church and community primary school function well. A church building and community primary school[7] are maintained independently. In this study, several churches were found to be equipped with diesel generators for lighting and other electrical goods. So, in the case of electrification by the Solar Home System (SHS), it would be advantageous to introduce such facilities to churches and community primary schools[8].

When any project is to be implemented in rural areas, existing social structure should be respected. Village chiefs and village committees are important stakeholders in rural society, so it is crucial to promote their participation and reach consensus with them on the project from the beginning. However, through the study, a gender gap was identified. Except in one case, village chiefs and village committees consist of only men. In most cases, the main speakers in front of people are men. Considering this, the process of implementing the project should include some mechanism to reflect women's opinion and promote women's participation.

8.3 Village Livelihood

Self-sufficiency is still the basis of rural people's life in the Solomon Islands. However, cash is already indispensable even for rural life. Various kinds of income generating activities are recognized throughout the Solomon Islands. In those activities, the most general and basic income sources are copra production, garden products and cocoa growing.

The amount of cash income varies from area to area. The northern part of Guadalcanal where the national capital is located, the western part of Malaita Province and the area around and between Gizo and Noro in the Western Province are guessed to be relatively higher cash income areas.

For promoting rural electrification, SB$20.00 per month is expected to be a feasible amount, born by beneficiaries in such areas where certain income generating activities are viable. However, it is difficult to estimate a possible maximum payment for electricity actually, because the cash income

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[5] See Table 8-4-1

[6] According to foreign experts related to the Rural Water and Sanitation Project supported by the Australian Government through the Ministry of Health & Medical Services, it was pointed out that the maintenance of installed water supply had not been done well in rural areas due to the lack of ownership and responsibility.

[7] Teachers in community primary schools are dispatched by the Government, but school buildings, accommodation for teachers and other related facilities should be prepared by villages.

[8] Please refer to *Chapter 11 Institutional Building in Electricity Sector*

situation varies so much in the Solomon Islands.

8.3.1. Villagers' cash income

The following charts show the flow of cash income in rural areas. Fig.8-3-1 reflects information recorded from a typical village, and Fig.8-3-2 reflects information recorded from a village located nearby the provincial capital. The village seems to have plenty of income sources, yet, due to the limited labor available in each family, these sources cannot be fully exploited.

Fig. 8-3-1

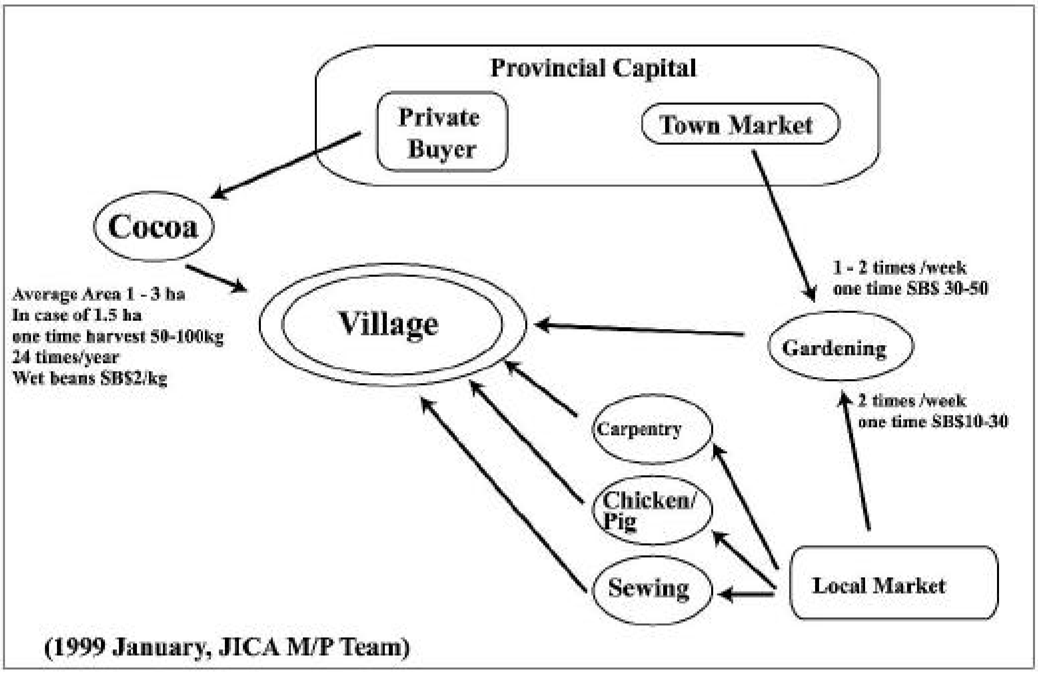
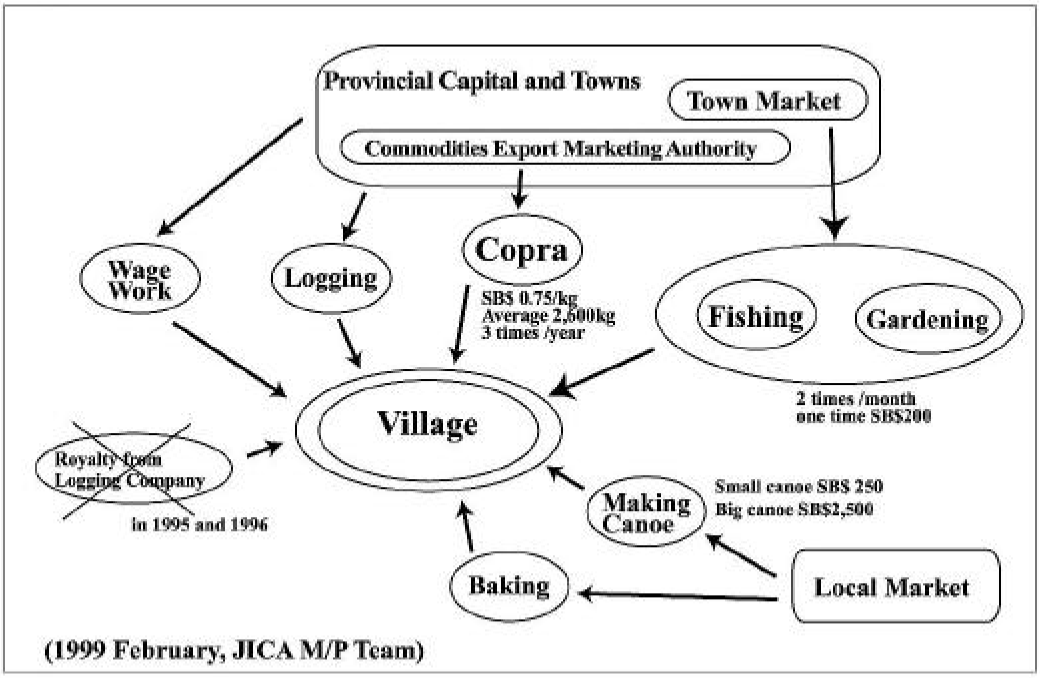


Fig.8-3-2



As a result of this survey, copra production, garden products and cocoa growing are thought to be the most influential and general sources for cash income in rural areas.

Table 8-3-1
Small Holder Copra Production per Household

Central	0.55
Choiseul	1.04
Guadalcanal	0.40
Isabel	0.60
Makira	0.67
Malaita	0.33
Rennell	N/A
Temotu	0.50
Western	0.86

(t)

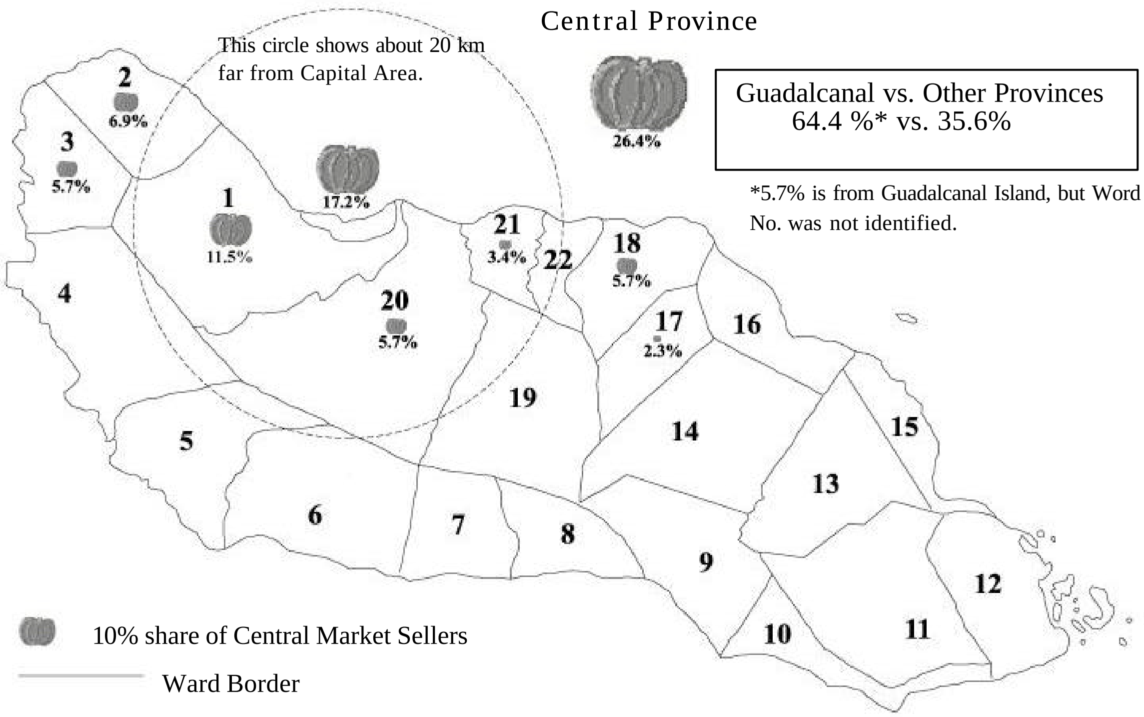
(Source : Based on Copra Production January-December 1997)

Copra production, which is the most popular income source throughout the Solomon Islands, is a labor intensive activity, and family members are required to assist in these activities during the process. If the area of coconut plantation is more than sufficient, the crucial factor restricting production is available family labor. The Commodity Export Marketing Authority (CEMA) monopolizes domestic marketing of copra, and keeps production records from ward level through to the national level. Table 8-3-1[9] is based on the report[10] issued by CEMA.

Another popular activity is to sell garden products. Garden products are important resource for self-sufficiency, but also for cash income. However, the location of villages is the influential factor. If the village is located in a remote and dispersed area, income from garden products is not promising. In such villages where rural people participate in barter and sale in their local market, cash income from garden products is around SB$10.00 per week. The villages located near the provincial capital possibly get cash income of S$50.00 to SB$200.00 per excursion to the market, and excursions can occur more than once a week. In particular, the Central Market in Guadalcanal, Capital City of the Solomon Islands, attracts many villagers from the outskirts of the city. The number of sellers depends on the day of the week, yet it can be stated that there are between 250 and 300 sellers constantly. SB$855.00 [11]per month is the median income per seller in the Central Market. Fig.8-3-3 shows the percentage of seller's per ward coming from various hometowns in Guadalcanal Province and other Provinces. Obviously, the northern part of Guadalcanal Province and Central Province, which is located in the north of Guadalcanal Province, is the main origin of sellers.

[9] The buying price of copra is about SB$0.75 per kg. (1999, December-present)
[10] Copra Production January-December 1997, C.E.M.A. Statistical Bulletin (No.1/97), Volume:2, April 1998
[11] Those data were corrected directly in the Central Market by 10% sampling.

Fig.8-3-3 Percentage of Central Market Seller per Ward, Province



Gizo and Munda in the Western Province also have relatively big market places. Thus, around and between towns is th advantageous location to get cash income from garden products.

Table 8-3-2
Small Holder Cocoa Planting Area

Central	81
Choiseul	78
Guadalcanal	1284
Isabel	417
Makira	523
Malaita	1345
Rennell	2
Temotu	60
Western	233
	(Ha)

(Source: Ministry of Agriculture and Fisheries)

Cocoa growing without any processing is also a worthwhile income source for rural people. This is because labor input is smaller, and the price for producers is more attractive than copra production. Actually, in the first field survey (in January 1999) the price of wet (unprocessed) cocoa bean was SB$2.00/kg, though copra was about SB$0.75/kg. In the middle of 1999, the price of wet cocoa bean dropped from SB$2.00/kg to SB$0.60/kg, thus the producers who concentrate on cocoa growing have suffered losses. However, the region where people grow cocoa is still assumed to be favorable, because it is possible to manage copra production together with cocoa growing. Table 8-3-2 shows that Guadalcanal Province and Malaita Province has larger cocoa planting areas than the other provinces. And, it is remarkable that cocoa growing is concentrated from the northwest to the west in Malaita Island.

Other income generating activities, like private logging, wage work, marine products, fishing, poultry and pig raising are observable throughout the nation. However, they are not as principal generally.

The royalty from logging conducted by foreign companies brings a huge amount of money to rural people. In some cases, such income is more than enough for villagers to rebuild village houses and public facilities. However, it will not be sustainable and stable.

Then, the next discussion is on the amount of cash income per household in rural areas. Here are two data tables. Although the data source is not the very latest, the following Table 8-3-3 is based on the report, *"Rural Area of The Solomon Islands ; Income and Expenditure Survey 1993"*. The other table is Table 8-3-4 and is based on our field survey. The data on Table 8-3-4 is assumed to be rather higher than the real situation, because the locations where data were collected are a little biased regionally. Considering this limitation on data validity, Guadalcanal Province, West Province and Malaita Province are relatively higher cash income provinces than the others.

Table.8-3-3 Average Houshold Income per Month in Rural Area (SB$)

	Choiseul	Western	Isabel	Central	Guadalcanal	Malaita	Makira/Ulaw	Temotu
Income per Household	146	429	211	127	707	310	220	96

(Source: Based on Rural Areas of Solomon Islands; Income and Expenditure Survey 1993)

Table 8-3-4 Household Cash Income per Month (SB$)

	Choiseul	Western	Isabel	Guadalcanal	Malaita	Makira
Average	476	664	392	1,330	813	569

(Source:JICA M/P Team)

Thus, the following conclusion is deducible from the above data.

The northern part of Guadalcanal Island, especially such areas where the Central Market in Honiara is accessible, coastal areas from the north-west to west in Malaita Island and regions located around and between Gizo and Munda in the West Province are higher cash income areas. As such they are relatively promising for the cost sharing project with beneficiaries.

8.3.2 Villagers' expenditure for energy

The range from SB$10.00 to SB$20.00 per month was the most popular range for the payment of electricity suggested by rural people in this field survey.

It seems that most rural people had some experience utilizing electricity from the grid in the capital and/or provincial capitals directly, and sensed the convenience of electricity. However, the difference between the grid and SHS would not be surely understood. For example, in the case of the SHS, the capacity of electricity generation is not enough for unlimited supply due to expensive unit cost and service conditions being affected by weather. In addition, the rural people nearby the area served by the Solomon Islands Electric Authority (SIEA) assume that electricity is cheaper energy than Kerosene and SB$5.00 is enough only for lightening purposes[12]. These are influential factors for rural people considering actual reasonable payment for electricity.

The following two (2) tables are based on this field survey. Table 8-3-5 shows the rural household expenditure of Kerosene consumed mainly for lightening, and Table 8-3-6 shows the rural household expenditure of Kerosene and dry batteries, mainly consumed for radios with cassette players and torches. Actual payment per rural household for electricity based on the records of the SIEA, Malu'u Branch Office in Malaita[13], is reflected in Table 8-3-7. The average expenditure for Kerosene varies from SB$10.0 to SB$36.4, and for Kerosene and dry batteries from SB$16.4 to SB$59.7. The actual monthly payment for electricity by rural households is SB$20.4. Considering the above data, the range from SB$10.00 to SB$20.00 suggested by rural people is a reasonable amount. In addition, the data come from SIEA Malu'u Branch Office supports SB$20.00 as an affordable amount for rural people who have certain cash income sources.

Table 8-3-5 Monthly Expenditure for Kerosene per Household (SB$)

	Choiseul	Western	Isabel	Guadalcanal	Malaita	Makira
Average	14.5	14.4	36.4	29.0	30.2	10.0

(Source: JICA M/P Team)

ıble 8-3-6 Monthly Expenditure for Kerosene and Dry Battery per Househo (SB$)

	Choiseul	Western	Isabel	Guadalcanal	Malaita	Makira
Average	31.5	16.4	59.7	46.8	47.0	24.9

(Source: JICA M/P Team)

Table 8-3-7 Monthly Household Payment in Malu'u Area (SB$)

	Sep.98	Oct.98	Nov.98	Dec.98	Average
Average	16.8	19.5	24.8	23.0	20.4

(Source: JICA M/P Team)

In the case of electrification by the SHS, the quality of lightening, which is assumed to be the main use of electrification in rural life, will be improved when compared with Kerosene lamps. Many villages were observed to be equipped with pressure lamps or diesel generators for church and other public facilities. Therefore there is a certain incentive for additional payment to improve the quality of lightening. Extra payment, in addition to current expenditure for Kerosene lamps, will be expected in such areas where certain cash income is available. However, as stated above (8.3.1), cash income varies from province to province. For example, between Guadalcanal Province and Santa Isabel Province the income gap is estimated to be more than twice, and preferable extra payment will be far different accordingly.

[12] At present, the minimum electric tariff per month is SB$5.00. According to the brochure prepared by the SIEA, SB$5.00 is enough for using two (2) small fluorescent lamps per month. Thus, the rural people's understanding is reasonable.

[13] The payment records of ten (10) sample households, which are apparently villager's houses, were selected out of whole records randomly.

8.4 Electricity in Rural Areas

Although over 85% of the population in the Solomon Islands live in rural areas, investment for infrastructure is highly concentrated on Guadalcanal Province. In terms of infrastructure, electricity is thought to be one of the areas of most disadvantage for rural residents. Only about 15% of the total population in the Solomon Islands is able to utilize it, and, if this percentage is considered based on the rural population, it decreases to less than 5%.

At the same time, there are certain needs for electricity in rural areas, even though it appears that rural people do not generally put their first priority on rural electrification. Discussing only rural electrification, the church and other public facilities are prioritized and the household is next.

Considering the relationship between electricity and rural development, electrification will not be the cause of rural development. Yet, it will be an important driving force for rural development. This is reflected by the fact that the increase in population is accelerated in electrified areas.

8.4.1 Infrastructure in rural areas

In the Solomon Islands, maintaining the existing infrastructure in good condition and implementing new infrastructure has been limited due to the shortage of the funds and implementation capacity. Under this situation, the "Medium Term Development Strategy 1999-2001" reports that total infrastructure in the country is highly concentrated on Guadalcanal with 80% of ports, 40% of the roads and 40% of road maintenance funds. However, over 85% of the population lives in rural areas. Recent status of infrastructure that is essential for villagers' lives is shown in Table 8-4-1.

Table 8-4-1 Infrastructure in Rural Area

Infrastructure	Church	Primary School	Health Service	Installed Water Supply	Market	Wharf	Radio Telephone Wireless	Postal Agencies
Number/Village Number	65%	12%	8%	54%	3%	2%	8%	3%

(Source: Based on Village Resources Survey 1995/6)

8.4.2 Electricity in rural areas

Electricity is one of the types of infrastructure for rural residents around which there is the most disadvantage. "The Solomon Islands National Energy Policy and Guideline" reports that only about 15% of the total population has (1996) access to power, and, if this number is to be obtained from only the rural population, the proportion will be as low as 5%. In addition, the guideline mentions that the difference between people with and without access to electricity is not just a question of comfort, labor saving and productivity; it is more profound because it has to do with knowledge and perception.

Table 8-4-2 is a summary of survey results for one sample village in Choiseul Province. Participants were asked to list their needs for their village, and prioritize their preference by voting[14]. The number of stones in Table 8-4-2 shows the relative preference. In the table, needs

[14] The participants with holding three (3) stones voted by putting their stones from one (1) to three (3) freely on their favorable items listed in advance.

for rural electrification is recognized. However, it is not highly preferred. Looking into only rural electrification, their concern is on public facilities, especially the church, and households are next. The same tendencies were observed in other villages.

Table 8-4-2 Result of Needs Survey

Needs	Additional Explanation	Preference	Number of stones
Water Supply		1	28
Water tank	Big tank for community	2	15
Sanitation	Latrine for each house	3	6
Electricity	1st for Public House (Church, Woman's Hall, Rest House), 2nd for individual house	4	5
Sewing Machine	Making clothes for sale and training	4	5
Pre-School	Nursery	5	3
Clinic		6	2
Lawnmower		7	1

(Source:JICA M/P Team)

A detailed survey about the merits and demerits of rural electrification was also done in one village of the Malu'u region in Malaita Province where a hydropower station has been constructed and rural electrification has been implemented. A summary of this survey is seen in Table 8-4-3. Considering gender gap, men and women were interviewed separately. (The order of items in Table 8-4-3 has nothing to do with priority)

Table 8-4-3 Merit and Demerit from Electrification

Woman's group

Merit	Demerit
1. In case of big gatherings and church service.	1. Blackout
2. In case of funeral	2. Each house should install an electric
3. Cheaper and more convenient than a kerosene lamp.	

Man's group

Merit	Demerit
1. Cheaper and brighter than a kerosene lamp.	1. Constructing houses and planting coconut trees are prohibited under the grid line.
2. A power saw, plane and drill are possible to use.	
3. A refrigerator is possible to use for fish , vegetable and water.	
4. Power music instrument for church service is possible to use.	

(Source: JICA M/P Team)

The economic factor (cheaper) was pointed out by both groups as the merit. Specifically, if they want to enjoy the same quality of lighting, electricity is far cheaper and more convenient than other forms of energy. It is interesting that the women's group commented that they saw the merit from electrification in cases of big gatherings and funerals. Some benefits of electrification seem to have been spread throughout the village, though small only parts of households in the village have been electrified. As for the demerits, the men's group comments that they can't plant coconut trees or build any buildings under the grid. However, this did not seem very serious. The demerits pointed out by the women's group were not related to electrification, but rather to the present system and management.

In addition, obstacles for electrification in this village were surveyed. The present situation is that ten houses (including a church building) have already been electrified, five (5) have had internal wiring completed, but have not yet been electrified. The rest, amounting to fifty (50) houses, are not yet electrified.

According to participants, firstly, the cost of around SB$6,000.00 is the biggest obstacle. Secondly, only permanent houses can be connected to the grid[15]. Though the cost will depend on the actual condition of each house, it is certain that a big amount of money is required to be connected with the grid initially[16]. Therefore, it will not be easy to make each house electrified quickly over the area electrified by the grid.

8.4.3 Electrification and rural development

Electrification will contribute to rural development. As mentioned above (8.4.1), the present state of infrastructure in rural areas is limited. In particular, lack or inadequacy of energy, transportation and communication is one of main obstacles for rural development. If reliable electricity is available, the present situation will be improved to some extent.

Malu'u Hydropower Station in Malaita Province gives a good example of the relationship between electricity and rural development.

The villages that Malu'u Hydropower Station is serving with electricity are located along the beach and would be common ones in Malaita Province. According to the SIEA staff at Malu'u Hydropower Station, it came into operation in 1981 and has served 202 customers in seven villages. Although there are still many people waiting for a connection to the grid line, the additional connections have not been approved due to limits on the power supply.

The total population in the villages where the power station is serving increased by 67% from 1986 to 1995 in spite of a lessor increase of 38% and 28% in the Solomon Islands and Malaita Province respectively during the same period[17]. Obviously the rate of population increase in the Malu'u area is quite high compared with general the trend.

The above example suggests the following; it is not realistic to assert that electrification directly causes rural development, but it would be possible to infer that electrification is an important driving force for rural development because it attracts people. From the viewpoint of rural development, electrification in rural areas can work as a catalyst, and therefore it is ideal to

[15] SIEA confirmed that this understanding is not true, however, it is not clear why rural people believe this.
[16] According to one electric shop which participated in wiring work in Honiara, the minimum material cost for internal wiring (two fluorescent lamps, two wall sockets and related wiring) is SB$1,373.10. Additionally, the cost of labor is SB$300.00-SB$400.00. Transportation costs and accommodation costs will be required, if necessary.
[17] Those numbers come from the "*Report on the Census of Population 1986 Report 2A:Basic Information*" and "*Village Resource Survey 1995/6*".

integrate several development resources (Constituency Development Assistance[18], Small Project Fund[19], Grassroots Assistance Program[20], etc.) with electrification projects for promoting rural development.

8.5 Sensitive Issue

There is always a high possibility of a dispute in relation to land ownership when any development project is executed in the Solomon Islands. The purpose of this study includes developing hydropower, thus such a dispute would be critical to implementing a hydropower project.

Eleven (11) potential sites for hydropower stations that had been screened based on the first field study were surveyed in detail from the social environmental point of view. For the time being, inevitable problems have not yet been found. If the following conditions are carefully observed, it will decrease the risk of the suspension of the project before completion.

8.5.1 Land Tenure System and Land Dispute

There are two (2) types of land tenure system in the Solomon Islands. Alienated land covers 13% of nation's land, and customary land covers 87%.

Alienated land is land that was exploited by colonial governments and foreign immigrants before such activities were banned in 1914. At present, most of the alienated land is utilized for the capital, provincial capitals and commercial farms. Boundary and ownership are fixed generally.

Customary land has been traditionally occupied by clans or land groups, and boundaries are defined by geographical features like rivers, valleys and mountain peaks. Therefore exact boundaries have not been fixed. Also some land has several kinds of owners who keep primary rights, secondary rights and, in some cases, tertiary rights[21]. Which right the claiming person or group has is the important issue.

The above explanation of customary land may give an impression of ambiguity in the traditional land tenure system. However, this was not a very big problem in the days when villages were dispersed in the forests of the Solomon Islands. The background of recent land disputes is that "*Development*", which has been introduced from the outside, has expanded across the Solomon Islands. The reason why "*Development*" incurs land disputes is because landowners are able to get cash from "*Development*". The most typical example is royalties from logging operated by foreign firms.

Meanwhile, the Solomon Islanders also realize that the land tenure systems, like the customary land system, impedes "*Development*" in the Solomon Islands. Activities to try to register

[18] The Solomon Islands operates this scheme to support rural development based on each parliament constituency.
[19] The New Zealand Government supports this scheme. The main target is small income generation in rural areas.
[20] The Japanese Government supports this scheme.
[21] The detail contents of each right is not uniform throughout the Solomon Islands. However, the land owner (owning group) who have first right is considered a final decision maker in the case of land acquisition or giving permission for land use.

customary land officially, and clarify unreliable situations, have been promoted. However, this has so far not produced much fruit.

8.3.2 Land acquisition

As a result of the detailed survey of eleven (11) potential sites for a hydropower station, three categories of land ownership have been identified. (As for details of each site, see Table 8-5-1)

The three groups are:

Type A: Customary land where land ownership has not yet been clarified officially

Type B: Customary land where land ownership has already been clarified officially

Type C: Alienated land where land ownership is already clear

The following are important points to be arranged by the Solomon Islands before deciding on project implementation according to each group's different conditions.

(1) Type A: Customary land where land ownership has not yet been clarified officially

For constructing a hydropower station, land acquisition will be required. If this is the case, then the first issue is identifying the just owner of the prospective land. Especially in the small areas, where several villages are located, this is expected to take a long time. This is due to the fact that there is no written record generally, and reliable evidence amounts to neighbor's memories and information that has been passed down from ancestors. Fig. 8-5-1 shows the procedure applied officially to acquire customary land, considering the above-mentioned situation.

If concerned people (groups) agree to obey the preliminary decision at Step 4 in Fig.8-5-1, land disputes will be easily and quickly concluded. If land disputes end up being taken to court (Step5-1 and Step6-1), it will take several years to reach a conclusion.

Actually, if a dispute is focused only on land ownership (and doesn't include implementing the project) the land dispute and the project can be processed separately. In the case of the construction for the Malu'u Hydropower Station in Malaita Province and the Buala Hydropower Station in Santa Isabel Province, the above separation of procedure was applied.

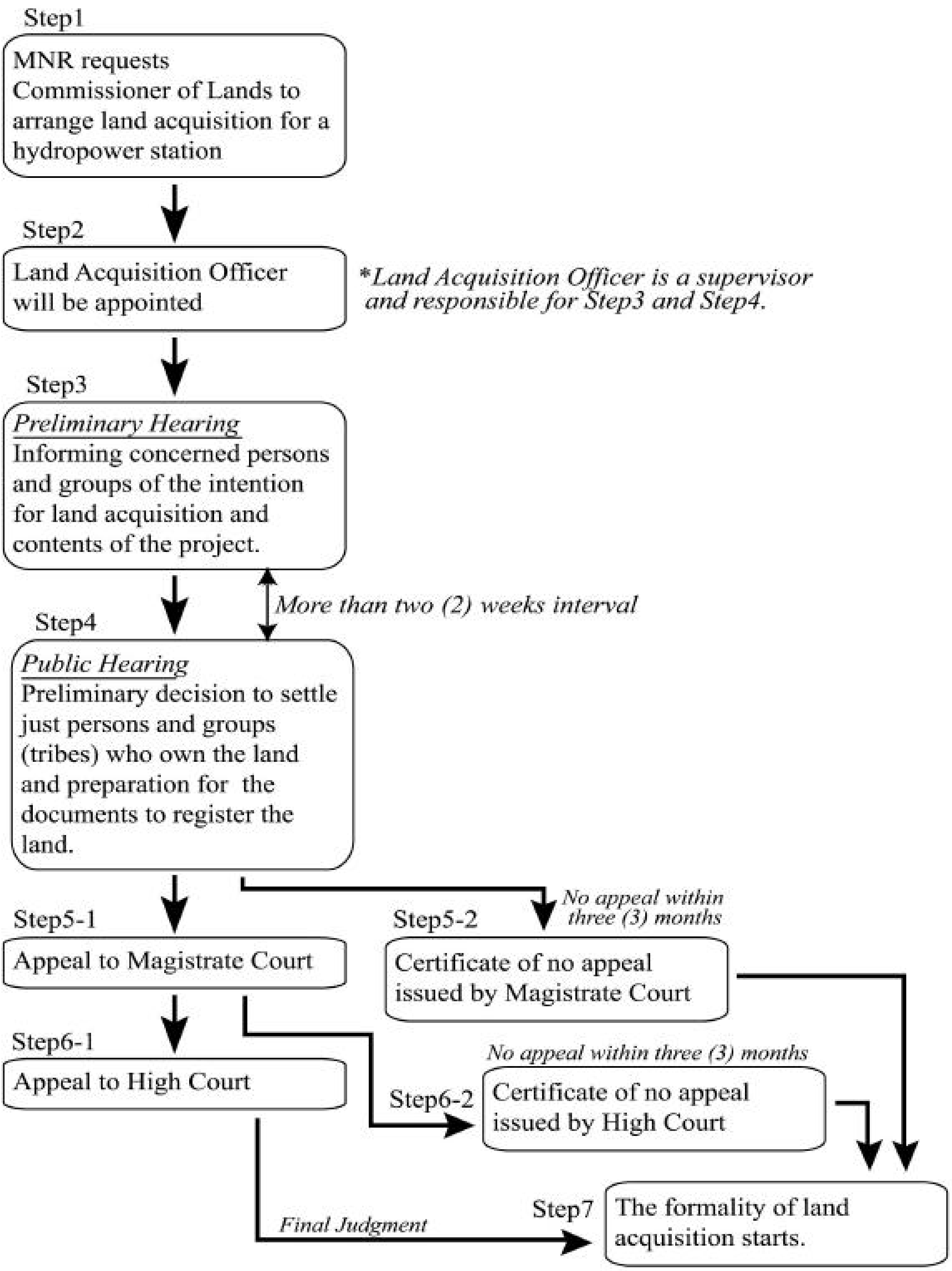
According to the procedure, when potential claiming persons and groups for land ownership become clear at Step5-1, those concerned persons and groups make an agreement that is legally binding and that separates the project from land dispute. The main contents of the agreement are as follows:

1)All concerned persons and groups agree to construct a hydropower station and will not disturb construction and operation of the station

2) All concerned persons and groups will respect the decision by the court, and the person or group who receives rent or compensation will be fixed based on the decision

After making such agreement, the risk of delay in the project due to land dispute is significantly decreased.

Fig. 8-5-1
Flow Chart for Land Acquisition
In case of constructing a hydropower station by Ministry of Natural Resources (MNR)



(2)Type B: Customary land where land ownership has already been clarified officially

(3)Type C: Alienated land where land ownership is already clear

In the case of the above two (2) types, the owners (owning groups) and rented persons (groups, firms) are assumed to be sure, thus the consent for constructing a hydropower station from those owners and rented persons should be obtained or confirmed.

8.5.3 *Tambu* Site

In this study, *Tambu* sites have not been added as potential areas for hydropower projects in the eleven (11) sites. As the result of the first field study, *Tambu* sites were found to be a critical obstacle to implementation of any project in the Solomon Islands.

There is not a general definition of *Tambu* sites, but these sites may be altars where human or animal sacrifices were conducted, burial grounds of ancestors and known chiefs or places where spiritual existence was important in some way before Christianity spread all over the nation. 96% of Solomon Islanders belong to the Christian religion, and Christianity has affected village life profoundly. Still *Tambu* sites are taboo for villagers and it is advisable not to ignore such feelings. Thus potential sites investigated (Ref.No.2 and Ref.No.3 in Table 8-5-1), have not included Tambu sites. However, these sites have been investigated in detail by a foreign mining company (Ross Mining N.L.) that has rented and occupied such areas. There is an agreement for damage compensation and the utilization of *Tambu* sites between the company and landowners. Thus, even if there are *Tambu* sites that are located in crucial places for the project, there is a precedent to proceed on.

8.5.4 Natural environment

From the point of view of the natural environment, the potential sites of Ref.No.6 and Ref.No.10 in Table 8-5-1 should be taken into certain consideration.

At the site of Ref.No.6, the plan includes constructing a dam as part of the facility. In this case, there are no residents in the affected area, thus migration or removal will not be required. The influence on the natural environment around the site will not be small, and it will be advisable to survey the site in more detail at the next stage, focusing on the natural environment.

On the downstream riverbank of site Ref.No.10, there are large reptiles (Crocodiles) that live in brackish water. The forest along the river has already been logged, and it is assumed that the natural conditions along the river have been seriously damaged. As this is the case, it will be safer to investigate in more detail from the ecological point of view before deciding on project implementation.

8.5.5 Water Rights

The law for utilizing river water has not yet been established.

It should be given enough consideration to minimize any bad influences in downstream areas caused by the construction of a hydropower station. In addition, it is strongly recommended any expected influences are explained clearly to downstream residents, and that consensus is reached to accept such influence among them in advance. In this study, any special income generating activities which have a close relationship to river water have not been observed along and in the river at each site, yet some rivers are the source of daily water. This is especially so in the dry season. If the volume of river water will be affected by the hydropower station, efforts to mitigate any inconvenience to affected rural residents should be discussed in advance.

In addition, a complex issue is how to treat such people who have land ownership for upstream areas, especially the water catchment area. The official stance of the government is that money will not be paid to the owners or owning groups of such areas. However, in the case of the Malu'u Hydropower Station, the provincial government paid a certain amount of money to the group who claimed compensation, because the river water for the Malu'u Hydropower Station came from their land.

The government of the Solomon Islands will be requested to coordinate avoiding such disputes, when owners of facilities' sites and upstream water catchment areas are different.

8.5.6 Others

Even when satisfying the above conditions, there still remains some risk of positive and passive interference from local residents without establishing consensus through involving them enough. As mentioned above (8.2 Villager Structure), local residents tend to follow the rules that are effective only within a small community like a village or land owning group. Such public facilities as hydropower stations for regions or the nation (beyond their community) may not be considered as facilities that they should pay a certain respect to. In other words, the rules for Solomon Islanders will not always make sense to local residents, and the government of doesn't have enough means (like a policing system or law system) to enforce them. Therefore, before starting the project, it is necessary to explain the project sufficiently -- not only to landowners (land owing groups) and residents along the river, but also to neighborhood residents who may not have any direct interests.

Table 8-6 List of Surveyed Village

Province	Detail Survey	Questionnaire Survey by Village assistant
Malaita	Maoro	Nggawale
	Silolo	Gkauna'ou
	Kwena	Iqwa
	Afufu	Tiuni
	Otekwana	Walo
		Mamalade
		Aisiko
Guadalcanal	Takamboru	Tuvu
		Naro
		Chuva
		Nunuha
Western	Kuzi	Pienuna
	Sageragi	Barakoma
		Vivie
Makira	Maipua	
	Kaonasugu	
	Kokana	
Santa Isabel	Kmagha	Huali
	Popoheo	Ligara
	Kubolata	Lelegia
	Guguha	Galatha
		Buma
		Kolotubi
Choiseul	Nukiki	
	Poroporo	
	Subesube	

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Ministry of National Planning and Development, 1998, Medium term Development Strategy 1999-2001 Volume-I Policy and Strategy (draft)

Table 8-5-1 Summary of Social and Environment Aspect for Potential Hydropower Sites

Ref.No.	1	2	3	4	5	6	7	8	9	10	11
Province	Guadalcanal	Guadalcanal	Guadalcanal	Malaita	Malaita	Malaita	Santa Isabel	Santa Isabel	San Cristbal	Choiseul	Santa Cruz
River Name	Sasa	Maotapukul	MaotapukulI	Rori	Silolo	Kwarea	Poporo	Kubolata	Waimapur	Sorave	Luembalele
Category	TypeA	TypeB	TypeB	TypeA	TypeA	TypeA	TypeA	TypeA	TypeA	TypeC	TypeA
Land Type	Customary Land Alienated Land	Customary Land	Customary Land	Customary Land	Customary Land	Customary Land	Customary Land	Customary Land	Customary Land	Alienated Land	Customary Land
Land Owners	Customary Land = Kakau Tribe, Lakuili Tribe (Both tribe chiefs live in Takamboru Village) Alienated Land = Catholic Church (The land ownership dispute for this alienated land were appealed to the court in 1965. The judgment is in favor of Takamboru villagers, however, a present land owner is Catholic Church. The villagers believe that the land should belong to them.	Customary Land = This area has already been acquired by Gold Ridge Mining (Ross Mining N.L.). The detail contents of contract, like lease period, is not clear.	Customary Land = This area has already been acquired by Gold Ridge Mining (Ross Mining N.L.). The detail contents of contract, like lease period, is not clear.	Customary Land = Limaabu Tribe, Birani Tribe, Takaniano Tribe, Fauwane Tribe (Those people live in Afufu, Mbuliako, Fainiampu and Laarancicle village.) There is high possibility that other land owner groups (tribes) will claim the land ownership for the part of expected facilities' area.	Customary Land = West part of the river: Robara Tribe, Aena'alinga Tribe, Abealo Tribe, Sunia Tribe/ East part of the river: Fasima Tribe, Fautharo Tribe (Above people scatter around Silolo river.)	Customary Land = West part of the river: Ilikata(Otekwana) Tribe / East part of the river: Olodaa Tribe (Ilikata Tribe chief lives in Otekwana Village. Olodae Tribe Chief lives in Goutaria Village.)	Customary Land = Nakmurufunei Tribe, Posamoga Tribe (Those people who are mainly concerned live in Niulahage Village and Kolomola Village.)	Customary Land = Posamogo Tribe, Thavia Tribe (Those people who are mainly concerned live in Kubolata Village.)	Customary Land = Atawa Tribe, Amoea Tribe (Atawa tribe may be main tribe and have primary right for customary land)	Alienated Land = Poroporo Association (Chief of association is Mr. Timoty Tukabon. Most of association members live in Poroporo Village.)	Not available
Tambu Sites	Not exist around expected facilities' area	The company has done detail survey about Tambu Sites and already made an agreement with land owners in case of using Tambu Sites. Therefore, Tambu Sites will not be an obstacle for constructing a hydro power station.	The company has done detail survey about Tambu Sites and already made an agreement with land owners in case of using Tambu Sites. Therefore, Tambu Sites will not be an obstacle for constructing a hydro power station.	Not exist around expected facilities' area.	Not exist around expected facilities' area.	Not exist around expected facilities' area.	There is a tambu site nearby the river, but it shall not be an obstacle to construct a new hydro power station.	The exact distance is not clear, but there is a tambu site nearby Kubolata spring (intake point).		Not exist around expected facilities' area.	Not exist
Usage of River	Fetching drinking water Washing Fishing	Because this area has been acquired and occupied by the company, there are no resident around this area. And it is not clear whether the company is using the water of this river.	Because this area has been acquired and occupied by the company, there are no resident around this area. And it is not clear whether the company is using the water of this river.	Fetching drinking water Washing Fishing	Source of water supply Swimming	No usage	Fetching drinking water Washing Fishing	Fetching drinking water Washing Swimming	Many people who lives nearby Waimapuru river depend on water supply facility operated by Waimapur Secondary School (Well). Small number of households may use this river for	Source of water supply for Choiseul Bay Secondary School Catching a crab in mangrove forest along the river	Fishing However, basically around the river no one live.
Source of information	Because of ethnic tension in Guadalcanal, The JICA Study Team could not conduct any survey around above mentioned area. The information was collected indirectly.	Above information was collected through an officer in charge of land acquisition in Gold Ridge Mining.	Above information is collected through an officer in charge of land acquisition in Gold Ridge Mining.	Through the interview with villagers who belong to the land owner groups (tribes).	Through the interview with villagers who belong to the land owner groups (tribes).	Through the interview with villagers who belong to the land owner groups (tribes).	Through the interview with villagers who belong to the land owner groups (tribes).	Through the interview with villagers who belong to the land owner groups (tribes).	Through the interview with villagers who belong to the land owner groups (tribes).	Through the interview with association members	Questionnaire survey fill out by Provincial Permanent Secretary
Remark	More detail inquiry will be required. In particular, the owner of alienated land should be clarified.	If the company agrees on using their leased area for constructing a hydro power station, the dispute in relation to land ownership will not arise.	If the company agrees on using their leased area for constructing a hydro power station, the dispute in relation to land ownership will not arise.	The villagers have started the preparation for the land registration, however, the dispute about the boundaries of their customary land has not yet fixed. In case of land acquisition, careful procedure will be required, because several land owner groups (tribes) will be concerned.	The villagers have already had a meeting for the preparation to construct a hydro power station. Their opinion for the station was positive, however, the detail discussion about the boundaries of their customary land has not yet done. Still it is questionable that all land owner groups surely agree to the construction.	Along Kwarea River, above two tribes own most of the area. Land ownership is rather simple and shall be easily clarified.	The condition of Land ownership is not so complex. Therefore, in the case of land acquisition, careful procedures shall enable avoidance further dispute. However, certain attention should be paid to the Posamoga Tribe.	Posamoga Tribe is one of the concerned parties in the land identified for the Buala Hydro Power Station. They were a little reluctant to construct a hydro power station on their land without promising certain benefit for their village.	This area belongs to two land groups (tribes), however the main groups live in the same village. Thus it will be easy to clarify the landowner.	If the association accepts land acquisition for a hydro power station, the dispute in relation to land ownership will not arise. However, according to villagers, crocodiles are found along this river, it will be necessary to consider the environment before starting the next stage.	There are private cattle farms along the river.

The Buildings in the Solomon Islands

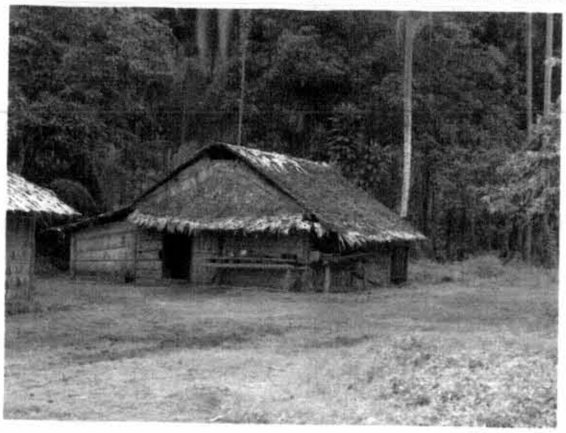

Photo8-1
Ordinary House (Bush House)

Photo8-2
Church (Bush House)

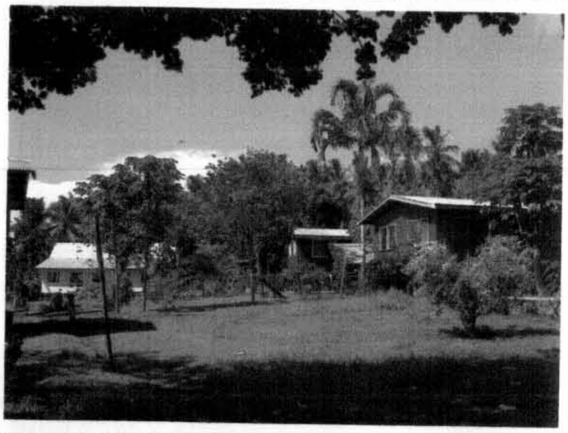

Photo8-3
Ordinary House (Permanent House)

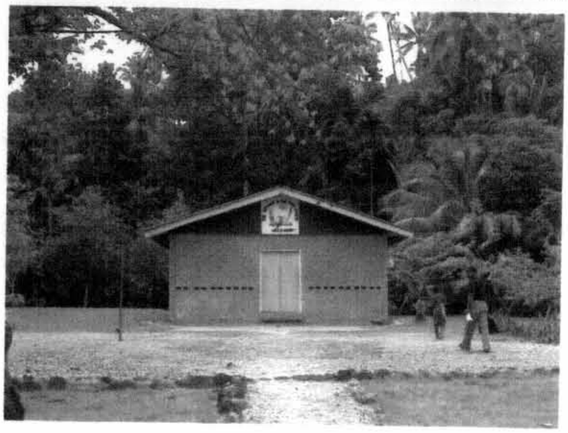

Photo8-4
Church (Permanent House)

Market Place in the Solomon Islands

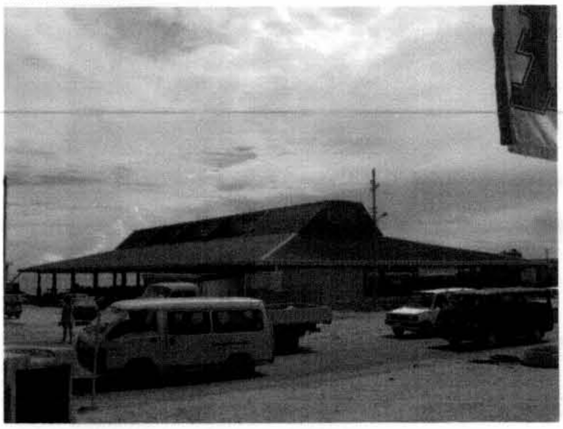

Photo8-5
Central Market in Honiara

Photo8-6
Inside of Central Market

Photo8-7
Market in Gizo (Provincial Capital)

Photo8-8
Market in Taro (Provincial Capital)

Products in Rural Area

Photo8-9
Copra

Photo8-10
Cocoa Fruit

Photo8-11
Canarium Nut

Photo8-12
Betel Nut

Photo8-13
Taro

Photo8-14
Yamu

Photo8-15
Other garden products

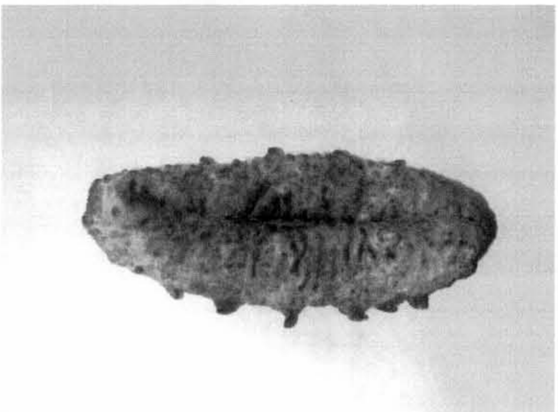

Photo8-16
Dried Beche de mer

CHAPTER 9

ENVIRONMENTAL CONSIDERATION

Chapter 9 Environmental Consideration

In this JICA M/P Study, the focal points in environmental consideration are to show important prospective conservation areas so that the potential sites for mini-hydro generation selected in the Study should not overlap them (see the clauses of 9.2 and 9.3). If the potential sites inevitably overlap the prospective conservation areas due to reasons for selecting them, it had better be confirmed whether the local concerned parts, local governments and acting local NGOs, would accept the possibility of prospective development. If these conditions are satisfied, it is proper that actual scoping of impacts and their mitigation planning will be carried out when respective projects are defined concretely, e.g., at the time of F/S, considering the projects schemes of mini-hydro power and solar power generation that have generally minor impacts. But it is to be noted that the process of forming consent for respective projects should follow the right procedure required with the customs of land ownership. With respect to solar power generation it is not conceivable that their environmental impacts depend heavily on site selection. The collection system for used-out batteries and other facilities of the solar system should be assessed for its economic feasibility and then included in the system at the design phase of respective projects.

In the above context this chapter showed the explanation for environmental legislation and guidelines of the Solomon Islands and the right procedure for environmental consideration after JICA M/P Study. The prospective conservation sites in the country are also indicated in the chapter to be the baseline information for the project's site selection in accord with the conservation scheme of the country. Further, general impacts to be considered in the project's scheme are discussed in the review of the scheme's existing cases and its conceptual analyses to be presented. Finally the baseline data are shown for the organizations now active in the conservation field of the country.

9.1 Environmental Legislature in the Solomon Islands

In 9.1.1 described are two basic laws of the Solomon government in the environmental sector, the Environment Bill, 1998, and the Wildlife Protection and Management Bill, 1998. Also described are the laws concerning water rights, River Waters Act (CAP.135), 1978, and Solomon Islands Water Authority Act (CAP.130), 1992, and provincial ordinances. In 9.1.2 and 9.1.3, of the Solomon government environmental sector, government organization and environmental assessment scheme and guideline are described.

9.1.1 National and provincial legislation

Toward the end of the year, 1998, two important bills in the environmental sector passed the parliament, which shall come into force shortly. Namely they are the Environment Act, 1998, and the Wildlife Protection and Management Act, 1998. These will be the basic legislation concerning environmental conservation and management of the Solomon Islands. With respect to water rights, two existing acts should be referred on the course of this master plan study (the

Study). They are River Waters Act (CAP.135), 1978, and Solomon Islands Water Authority Act (CAP.130), 1992.

(1) The Environment Bill 1998

The Act should work as basic law of the environmental sector. Included among the objects of the Act are the followings; to establish integrated systems of development control and environmental impact assessment, to reduce risks to human health and prevent the degradation of the environment by all practical means, e.g., promoting recycling, re-use and recovery of materials in an economically viable manner, and to comply and give effect to regional and international conventions and obligations relating with the environment.

The arrangement of clauses consists of five parts, of which the part II and III should be important to the Study;

(a) The part II is about the environmental administration which contains the mention of the Environmental Advisory Committee (see 9.1.2).

(b) The part III is titled 'Development Control, Environmental Impact Assessment, Review and Monitoring'. In this clause, it is emphasized that a developer should obtain consent and report to the Director of environment and conservation division before commencement of any development. The director may issue guidelines for assessment of reports and statements.

(2) The Wildlife Protection and Management Bill 1998

In the preliminary clause, the object of the Act is defined as 'to comply with obligations of Solomon Islands under the Convention or otherwise to further the protection and conservation of the wild flora and fauna of Solomon Islands••••…'. The Convention means the Convention on International Trade in Endangered Species of Wild Fauna and Flora signed at 3rd March 1973. Thus this act mainly regulates the export and import of the endangered or rare species of wildlife. So it does not closely relate to the Study though it should also be the basic law in the environmental conservation sector. But one object of this act should be noted; i.e., the management of flora and fauna to ensure sustainable uses of these resources for the benefit of Solomon Islands.

(3) River Waters Act (CAP.135) 1978

This act provides for the control of river waters, for their equitable and beneficial use and for the matters related to them. However, the Act only applies to areas that are specifically designated. Only five areas are now designated under the legislation (Mataniko and White Rivers, Mbalisuna, Ngalimbili, Lungga, and Mamara River).

Under the Act, a permit is required for a person : <u>to divert water from a river; to fell any tree so that it falls into a river or river bed; to obstruct or interfere with a river or river bed; to</u>

build any bridge, jetty or landing stage over or beside any river; to damage or interfere with the banks of any river. The grant of the permit is limited in the sense that regards have to be paid to the existing user of the river water, and that no legal authority is meant on the holder of the permit to enter other person's land or to do anything therein. See the clauses of 4, 5, 7, 12, 13, 15 and 16 of the Act. The Act safeguards the right of any person who used water or at least the right to appeal to the courts for the resulting damage. This should necessitate every reasonable step to avoid any inconvenience to the owners and the occupiers of the land entered.

(4) Solomon Islands Water Authority Act (CAP.130) 1992

This act provide for the proper management and development of urban water resources and services and sewerage services in the Solomon Islands and for the related matters. According to the clause of 18, a particular area from which urban water supply may be extracted, may be declared as a catchment area. In such area prohibited or restricted are activities without permission likely to result in pollution of, or interference with the proper use, flow or control of water. The clause 45 also prohibits any wrongful taking, using or diversion of water from such area.

The areas specified in the subsidiary legislation of the Act, Areas of Operation Order enacted on 10th February 1995, are as follows.

1. Guadalcanal	2. Munda/Noro	3. Lata	4. Buala	5. Tulagi
6. Kira Kira	7. Tinggoa	8. Auki	9. Gizo	10. Taro

The regulated activities in catchment areas are shown in Arrangement of Regulations of the Act enacted on 8th May 1995. In a controlled catchment area, for example, a person shall not damage or remove from the area plants growing therein (clause 6). Without authorization by a permit it is not allowed to, directly or indirectly, abstract water from a subterranean source in a Schedule area as above (clause 22).

(5) Provincial Ordinances

These are not well organized at the central government. Details should be checked at each province. Two offices, Attorney Generals Chambers and Department of Provincial Government and Rural Development, at the central government should be helpful for this matter. Examples of ordinances are as follows;

(a) Guadalcanal Province: Wildlife Management Area Ordinance 1990

(b) Isabel Province: Wildlife Sanctuary Ordinance 1995

Preservation of Culture Ordinance 1988

(c) Western Province: Environmental Management Ordinance 1991

Preservation of Culture Ordinance 1989

Public Nuisance Ordinance 1991

Simbo Megapode Management Area Ordinance 1990

(d) Makira Province: Preservation of Culture and Wildlife Ordinance 1984

(e) Temotu Province: Environmental Protection Ordinance 1989

Preservation of Culture Ordinance 1990

(6) Reference:

(a) Solomon Islands Environmental Legal Review (ELR), the South Pacific Regional Environment Programme (**SPREP**)

(b) Environmental Law in the South Pacific, Ch.6.Solomon Islands, Environmental Policy and Law Paper No.28, South Pacific Regional Environment Programme and IUCN Environment Law Center, IUCN- The World Conservation Union 1996

9.1.2 Government organization concerning environment

(1) The administration of environmental management, conservation and assessment of the Solomon Islands is defined at the part II of the Environment Bill, 1998, which is currently Solomon Islands Environment and Conservation Division (**SIECD**), Department of Forestry, Environment and Conservation, Ministry of Natural Resources.

For staff structure of the division, see **Fig.9-1-1** at the end of this clause.

(2) Environmental Advisory Committee is also defined at the part II of the Environment Bill, 1998. But it is not established yet at the time of February 1999. According to the director of SIECD, the committee is supposed to consist of the secretary, technical experts, NGO members and women. The director of SIECD will serve as the secretary. Technical experts will be served by either governmental or private sector's members. Experts may be from the field of pollution, bio-diversity, environmental planning, environmental engineering, environmental economy and environmental law.

9.1.3 Environmental assessment scheme and guideline

The part III of the Environment Act will also give the basis for environmental impact assessment, environmental report and statement, public information and monitoring procedure for environmental aspects of development. The director of SIECD may issue guidelines for the above. The currently effective ones are 'Solomon Islands Environmental Impact Assessment Guidelines, FOR PLANNERS AND DEVELOPERS, May 1996, SIECD'.

(1) EIA Guidelines, FOR PLANNERS AND DEVELOPERS, May 1996, SIECD

The guidelines refer, among general statements, to 'environmentally or ecologically sensitive elements'. Those range from wildlife habitats(undisturbed forests, mangroves, wetlands and swamps, coral reefs, sand and sea-grasses and so on), volcanic areas, places of great scenic beauty, archaeological sites, tambu sites, to catchment of rivers supplying drinking water and areas contributing to groundwater or groundwater lens recharge (mainly limestone areas) and sandy surfaces on low islands.

Archaeological sites are described as most difficult to recognize. Local people will be generally not aware that sites exist. Typical patterns in site occurrences are; sites behind beaches and headlands, on open areas near creeks, on ridges or saddles in hilly areas, in rock shelters, and at the sites of present, or former villages.

The responsibilities of any development proponent are, whether it is a government or a private body;

(a) to produce an adequate EIA as part of the development approval process,

(b) to undertake the mitigation and monitoring activities which may be necessary to minimize negative environmental impacts.

For the flow of public environmental report and environmental impact assessment process, see **Fig.9-1-2** at the end of the clause.

The guidelines have the following accompanying documents: Environmental Appraisal Summary, Solomon Islands EIA Guidelines; Checklists of Issues to Consider and Appraisal Form, Solomon Islands EIA Guidelines (one for forested areas: for construction, infrastructure, agricultural and mining projects in any environment: for coastal zone and marine environment).

(2) Reference:

A Guide to Environmental Impact Assessment in the Pacific, SPREP

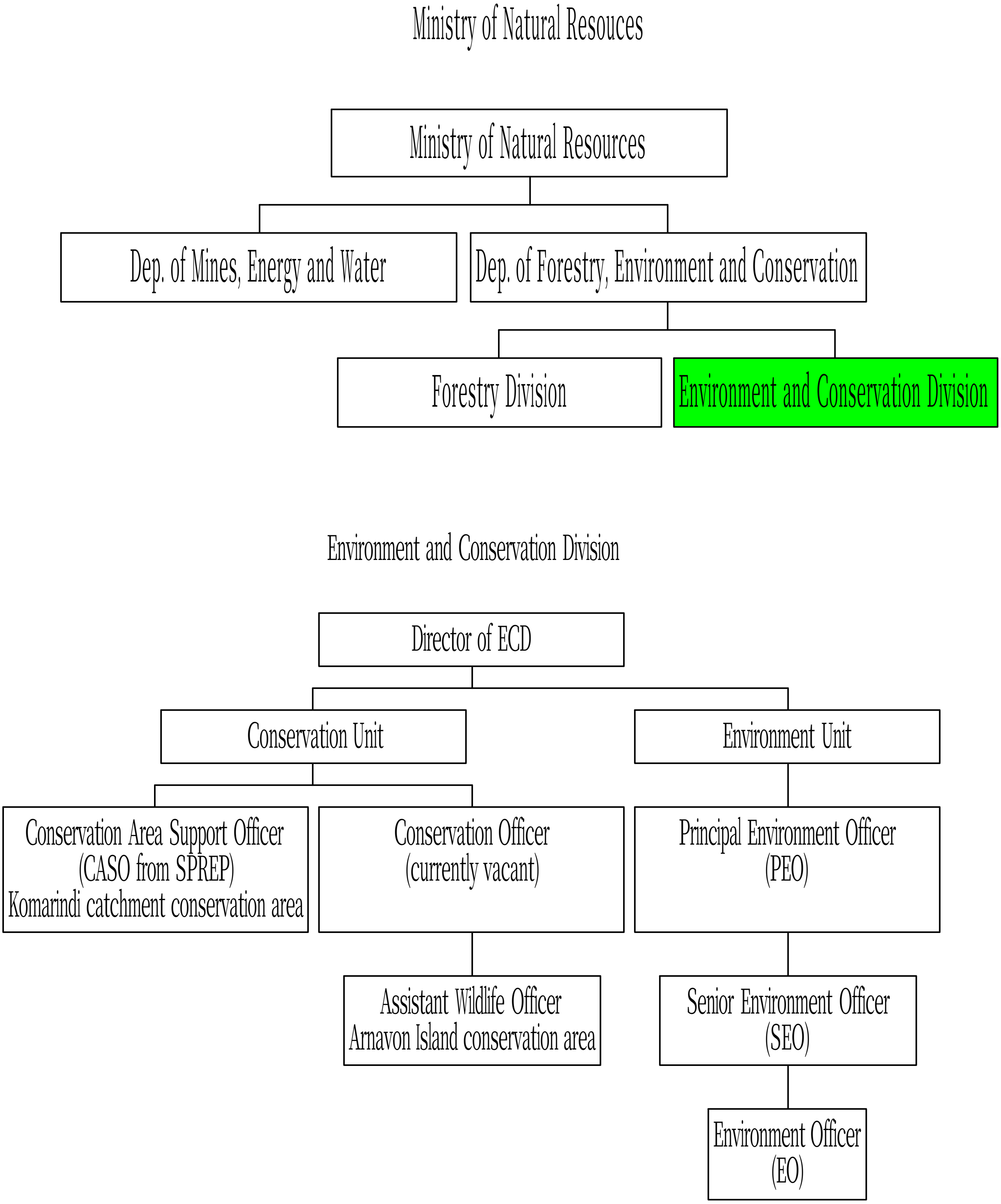

Fig. 9-1-1. Environmental Administration of the Solomon Government
(Effective from 14th December 1998)

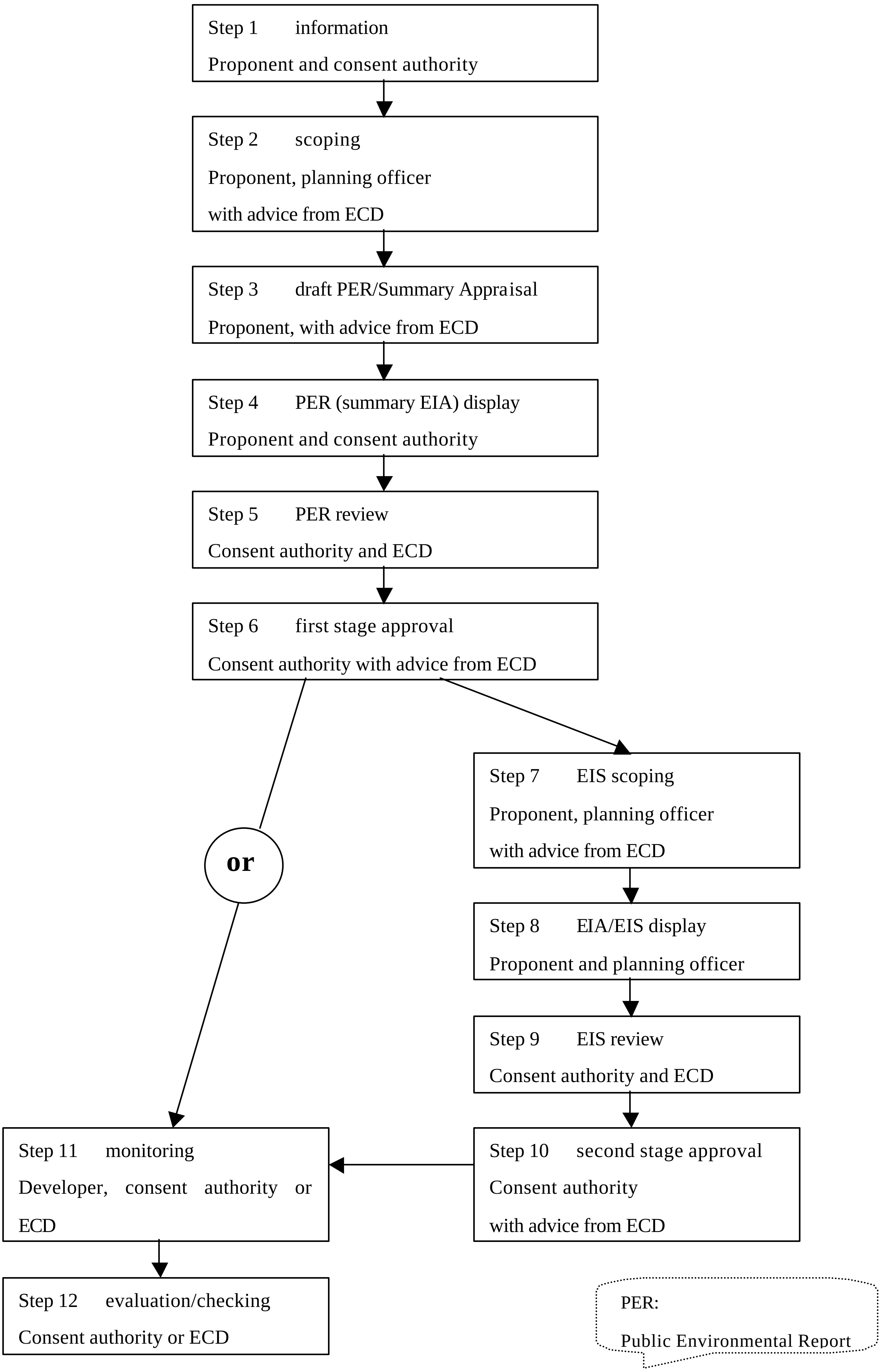

Fig.9-1-2 The steps in the recommended Solomon Islands PER/EIA

9.2 Current State of the Environment

This clause describes the current state of the environment over the Solomon Islands based on the two important documents. The first section explains the focal point of the environmental sector in 'Medium Term Development Strategy 1999-2001 (**MTDS**)', which discusses the serious threat to the bio-diversity, caused by commercial logging and other means of land use. The second section follows 'Maruia Society Report' that has been playing the important role in the conservation scheme in the country, and that has recommended prospective conservation areas some of which are currently under development.

(1) The Solomon Islands Government drafted 'Medium Term Development Strategy 1999-2001 (**MTDS**)' last year. The current situation of environment is summarized in it. While the economy of the Solomon Islands is heavily dependent on the natural resources, the exploitation of natural resources faces a serious threat to the very means of living. The main threat comes from excessive commercial timber harvesting, with contribution from increasing demand for land due to rapid extension of settlements and new farmland.

The loss of bio-diversity is a major concern to the country. There live 52 species of mammals and a diverse bird population, as well as several groups of flying foxes. Due to over exploitation and loss of habitat, the survival of 24 species of mammals is questionable. Although a number of protected areas have been established, the areas cover only about 2 percent of the land area. Plant and marine genetic resources would bring about immense income growth if developed properly. Coral reefs and mangroves have also come under increasing threat in recent years due to sedimentation from soil erosion, caused by deforestation and over-farming on the highlands.

(2) A Representative Protected Forests System for the Solomon Islands, Maruia Society, New Zealand, November 1990.

Maruia Society Report stated that approximately 80 percent of the Solomon Islands was believed to be covered in tropical rainforest. Forests continue to play an important role in the everyday lives of Solomon Islanders, supplying food, housing and canoe building materials, medicines, and many other useful items. They protect soil from erosion and by keeping streams and reefs free from excessive sedimentation protect them from damage. Thus forests in the Solomon Islands become important in cultural values. In addition to these values the forests have monetary value to village residents by way of logging, gardening and plantation. But increased pressure of such activities has necessitated the creation of protected forest system. The protected forests are necessary to balance land use and its management for cultural values and sustainable timber harvesting.

They are also important in biological values. Derived originally from several biological regions, the plants and animals of the Solomon Islands have been isolated over time. In this time some of the plants and animals of the Solomon Islands evolved unique (endemic). Of the 163 species of land birds that breed in the Solomon Islands, 72 species or 44% are found nowhere else in the world. 62 species or 38 % occur elsewhere but are represented in the Solomon by unique races or subspecies. 22 frogs, 27 lizards and 9 snakes are found only in the region. The level of endemism among the 4,500 species of plants in the Solomon is regarded as low, with certain groups exhibiting strong endemism. There is still much unknown by the scientific community about the biology of the Solomon Islands.

In the context above, several conservation areas, some of which enclose a whole catchment with buffer zones for land owners' sustainable use, are proposed to be set as reserves in Maruia Society Report as follows:

(a) Western Province

1.Marovo Lagoon 2.Mount Maetambe 3.South Choiseul 4.Kolombangara 5.Tetepare 6.Rendova 7.Others

(b) Isabel Province

1.North Western Isabel 2. Others

(c) Guadalcanal Province

1.Lauvi 2.Itina-Popomanaseu 3.Others

(d) Central Province

1.Rennell

(e) Makira Province

1.Central Makira, Bauro Highlands 2.Western Wetlands

(f) Malaita Province

1.Central Malaita Highlands 2.Are'Are, Maramasike

(g) Temotu Province

1.Protected areas for endemic or rare animals 2.Kauri reserve 3.Tinakula Island

(2) Reference:

Solomon Islands State of Environment report (SOE) , SPREP

'Loggers, Landowners, and Reformers in Solomon Islands', an article on Tok Blong Pasifik September 1998

9.3 Conservation Schemes in the Solomon Islands

The clause points out, in (1), three areas relevant to the Study among what the Solomon government identified to promote in environment policy during the MTDS period. Section (2) specifies the proposed conservation areas according to the government, and (3) indicates the strategic studies of the 'Solomon Islands National Forest Resources Inventory' prepared for the Forestry Division of the government.

(1) Areas relevant to the Study in environmental policy during MTDS period

As a signatory to the Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (the SPREP Convention), the Solomon Islands has an obligation to establish protected forests and other areas to ensure the preservation of its natural heritage. According to MTDS the government aim to promote community-managed conservation project. With assistance from SPREP, the government hopes to establish marine protected areas, too. Among 5 key areas the Solomon government identified to promote in environment policy during the MTDS period, 3 areas are supposed to be relevant to the Study.

①Enhancing community awareness and participation through community managed protected areas, campaigns and education programs, and involvement of NGOs

②Enforcement of EIA guidelines by requiring all new development projects to follow these guidelines

③Enforcement of the laws, regulations and guidelines established by respective sectoral agencies to protect the resources under their own responsibilities, such as standards and codes in forestry and fisheries.

(2) Declared and proposed conservation areas according to MTDS and the Director of SIECD

①Arnavon Island between Choiseul and Isabel Province; which is community-managed project, supported by the provincial government and by Nature Conservancy, an NGO. (a marine conservation area and the only protected area declared by the government)

②Queen Elizabeth II National Park, near Honiara, Guadalcanal (declared in 1965, but it exists today in name only)

③Kolombangara Forest Reserve, Western Province

④East Rennel World Heritage Candidate, Lake Te Nggano, Rennel, Central Province

⑤Oema, Dalakalau Bird Sanctuaries, Nggela, Florida Islands, Central Province

⑥The Komarindi catchment conservation area (currently being developed)

⑦Central Makira Bauro Highlands, Makira Province (SIDT programs)

⑧Marovo Lagoon World Heritage Candidate, New Geogia, Western Province

(3) Ecological and environmental aspects of the Solomon Islands forest

The titled aspects include water quality, the occurrence of rare and endangered species of flora and fauna, genetic diversity (and its need to be conserved) and ecological processes. Identified and described in 'Solomon Islands National Forest Resources Inventory' are: environmental domains (areas where the similar physical, environmental characteristics occur, e.g., climate, topography, land form, geology, soil) ; the botanical structure and floristics of the forests; major center of bio-diversity and of biological significance; areas that the governments should consider some form of protection; places in which there should be constraints on logging to protect local resources or downstream values such as swamps, reefs and fishing grounds. Each regional report of the Inventory includes a comprehensive report on ecological and environmental implications of forest resource utilization plus maps delineating areas of out-standing conservation value.

The Inventory notes that if a catchment (an area in which all water drains to a common exit point) supplies domestic water or a hydropower dam or includes an area worthy of conservation, the land upstream from those features may need protection. On the other hand, if mangrove areas, coral reefs, or near-shore fisheries are to be protected, land use in the whole catchment may need to be controlled. A list of areas of out-standing biological conservation value is given in the Inventory. See **Table 9-3-1** at the end of this clause. The total area of the proposed reserves is 610,650 hectares or 22 % of the land area of the Solomon Islands.

(4) Reference:

Solomon Islands National Forest Resources Inventory, National Overviews, Vol. I / Forest Resources Inventory, Guadalcanal / Forest Resources Inventory, Malaita / Forest Resources Inventory, Isabel / Forest Resources Inventory, New Georgia, Western Province / Forest Resources Inventory, Makira

Solomon Islands National Environmental Management Strategy (NEMS), SPREP, 1993.

Capacity 21: Workshop Proceedings: Community Resource Conservation Workshop, Tulaghi Central Province, Solomon Islands 17-19 July 1996, SPREP.

Project Preparation Documents (PPD's) for fourteen of the member countries from the South Pacific Biodiversity Programm (SPBCP), SPREP

Table 9-3-1 Areas that should be considered for conservation reserves in the Solomon Islands

province	Location	*Area(hectares)	Total for each province
Guadalcanal	Gallego	14000	
	Marau Sound	12000	
	Lauvi Lagoon		
	Aolo	18000	44000
Malaita	Central Highlands	35800	
	Maramasike	54900	90700
Choiseul	Mt. Maetambe	27600	
	SE Choiseul	54800	82400
Isabel	Western Islands	79000	
	Mt. Morescot	37200	
	San Jorge forests	22000	138200
Western Province	Western Vangunu	27800	
	Central Marovo	10000	
	Tetepare Island	11900	
	Hiriro Plateau	10600	
	Roviana karst & lagoon	19950	
	Mt. Veve	17850	
	NW Vella Volcanics	11950	
	Sth Simbo Pyroclastics	500	110550
Makira	Bauro Highlands	41700	
	Western Wetlands	24900	
	Star Harbour	7900	74500
Rennell	East Rennell	22400	
	West Rennell	32600	55000
Temotu	Tinakula Island	1050	
	LawrenceRiver, Nendo	11000	
	SW Vanikoro	3300	
	Southern Utupua	1000	15300
TOTAL			610650

*****Refers to the protection zone areas which are mainly over 30

(Source: Solomon Islands National Forest Resources Inventory, Vol. One, National Overview & Methods 1995, Ministry of Forest, Environment & Conservation)

9.4 General Environmental Impacts of Prospective Electrification

This clause describes the analyses of a F/S study report and the results of observations on existing operation-sites both for the mini-hydro power generation and for the solar home system (SHS), and summarizes conceivable general impacts by the proposed scheme. The reviewed existing sights, though the number is limited due to the constraint of the survey term, are supposed to represent well the general impacts and their aspects to be considered in the proposed scheme. So they are assumed to be the good cases of projects of the scheme as long as such basic hurdles are cleared as the very site of a proposed project does quite overlap a prospective conservation area. With respect to the SHS it is not conceivable that their environmental impacts depend heavily on site selection. Points of the SHS to be noted generally are considered, referring to two cases of existing villages among the still limited number, less than 10 yet, of the SHS sites. Especially pointed out is the necessity of the recollection system for used-out batteries and other facilities of the SHS.

9.4.1 Overviews of a couple of the past mini (or micro) hydropower generation projects

(1) the Buara Power Generation Plant

The F/S Report of the Mini Hydropower Scheme at Buara, Ysabel province (Project No. SIEA 17-C27) shows the analyses of its environmental impacts. The analyses are categorized in three phases; namely During Operation, During Construction and Global Environmental Impact.

(a) During operation

For this phase, possible adverse impacts studied are as follows:

＊**dry-up of the river bed** (provision of water legislation regarding the minimum amount of water to be left during dry periods; other water users downstream; hydrological or hydrographic conditions downstream of the proposed water intake during periods of low rainfall; water supply sources for the communities in the area; impact on the environment itself),

＊**migration of fish (**fish migration in the creek, water depth for habitation of a fish, comparison of the height of the proposed weir with that of natural drops),

＊**land use** (the stretches of land for the powerhouse, the forebay pond and the sand trap; the water conveyance structures-headrace and penstock pipes-buried in the ground; influence on agricultural production-food gardens-; land acquisition or a lease agreement in the case of customary land),

＊**aesthetics of the scheme** (blending with existing environment, any disruption of visual amenities).

(b) During construction

Possible adverse impacts studied are the below:

＊ **reshape of the environment** (any major earth moving or river diversion works),

* **scheme of construction (**a labor intensive approach, the use of heavy machinery and equipment, access roads, destabilization of the slopes, tender documents constraint prohibiting the use of track-mounted hydraulic excavators),
* **disturbance of surrounding societies** (an increased male population due to labor-intensive approach, construction period, characters of laborers recruited).

(c) Global environmental impact

In this category the comparisons are made for the amounts of carbon dioxide emission and required energy for compared schemes as follows:

* **the comparison of CO_2 gas emissions** between mini-hydropower (MHP) generation and diesel-based generation (CO_2 emissions per unit diesel fuel, electricity demand at the area over the project years, all diesel option, MHP system with diesel back-up option),
* **that of energy** required to produce the materials, such as cement, steel, etc., for the hydro and to build the scheme, such as transport, power tools, etc., (conversion of investment into equivalent energy using literature, comparison of energy the proposed mini-hydro generates with that required to implement it, which is positive)
* CO_2 gas emissions to generate all the required energy to implement the project, using the conversion factor of Australian coal-fired power plant as an example.

<u>In the report, all items mentioned above are described as positive (that means most are avoidable and so for the rests with appropriate mitigation measures), and possible adverse impacts are cleared logically.</u>

(2) the Malu'u Power Generation Plant

With site survey, it was observed that the environmental modification for the structure of topography and natural elements was very small in size. Namely the head of water conduction is 20 m high, the clearance of land is correspondingly minimal for a weir, water channel, pipes, generation station and power-transmission structures. The scheme of water intake mimics the natural structure to return surplus water of diversion to its original tributary, so any impacts due to water loss on downstream communities and the sea are unlikely. The influence on dry-spell is also unlikely because of small intake of water. The structure was observed to blend in natural landscape. Any occurrence of floods after implementation was not heard at the site.

But the influence on the wildlife was not known though it is unlikely because of the scale. The scale would not create obstacles of wildlife passage, the disturbance of estuary or the large change of underground water.

Note: Dispute on land went to court and local government paid compensation money to a group of tribe that appealed for the violated right of water utilization

9.4.2 Observation of a couple of villages where the SHS was installed

(1) Skiki Village and Makaluka Village

The villages are located on the southeast coast of Guadalcanal. SHS's are already introduced there. Hearing results say that in Makaluka 54 SHS's (household 47, school 6, church 1) are installed and more than 20 households are not yet done, and that in Skiki 49 systems (household 47, church 2) are installed and 3 households not.

Hearings say that use of fuel oils (kerosene) and dry batteries are as the table below:

	Dry batteries	Unit cost(DB)	Kerosene	Unit cost(Kr)
Makaluka	8-18 pieces/month	SB$ 3 / piece	1.5-2.2 lit/month	SB$ 5.4 / lit
Skiki	2-5 pieces/month	SB$ 2.5 / piece	4 -7 lit/month	SB$ 1.5 / lit

Note: Hearings are from the village chief at Makaluka, and from 4 middle-aged men at Skiki.

The installation of SHS has not necessarily reduced the consumption of dry batteries and kerosene, but it has extended the time under light 2 or 3 hours a day for readings of children, cooking of women and social gathering at church using electrical music instruments. They haven't faced with the problem how to dispose of batteries and used-out facilities for SHS since the first life cycle has not passed yet. The approach to the problem was not very clear by the users and GREA, an NGO that implemented the installation of SHS. Through observation the system did not seem to be disturbing the harmony with the surrounding landscape here. It was not observed that there are the poles for SHS facility fallen by cyclone or strong winds.

9.4.3 General conceivable impacts of electrification by mini-hydro power generation and solar home system

As for **the mini-hydro scheme**, conceivable impacts by the proposed method on the natural environment are: water shortage downstream of a water intake, especially during dry spell; water shortage or pollution of the potable water supply source if it is located downstream; adverse impacts on the downstream ecology if the scheme of implementation does not mimic the natural settings (for example, change of natural dry spell, access of large scale machinery and roads) ; disturbances of agroforestry production and landscape though unlikely with the proposed scheme; disturbance of migration of fish, which could be a food source to nearby communities.

The followings are unlikely with the proposed scheme, but still due to the sizes of their impacts it should be noted that they are carefully studied. Those to be studied are location of the structure in relation to the sites of conservation areas; impacts on endemic or rare species of wildlife; large scale reshaping of the slopes and rivers which could cause artificial or intensified landslides or floods.

See Chapter 8 on social aspects like land acquisition or lease agreement procedure, and laborer's inflow and disturbance of surrounding communities.

Supposing that the institution of **SHS** would give reduction to the usage of dry batteries, the amount of their disposal will be reduced. The reduction is a positive impact on the environment since dry batteries contain hazardous materials. Right now people throw away the used batteries without any appropriate scheme to collect them. On the other hand, batteries and equipment of SHS at the end of a lifecycle would be a nuisance, which requires proper recovery system. At present no organization actually provide with the economical collection system in the Solomon Islands. It is short of existing examples to judge if SHS reduces the consumption of kerosene in the Solomon Islands.

A matters of design is that harmony with the surrounding environment and safety in the cyclone and strong winds are assured with respect to transmission lines and SHS facilities.

9.5 Environmental Consideration to be noted

Listed here are the items of recommendable consideration for environment at this M/P study stage assuming the proposed scheme, mini-hydro power and solar power generation, and the proposed approach that be without resettlement of people and trans-boundary diversion of water. The descriptions of them were already made in the foregoing clauses or a chapter.

As for social consideration, recommended are the following.

＊ Land acquisition (see Chapter 8)
＊ Tabu (Tambu) sites (see Chapter 8)
＊ Water rights (see 9.1.1, (3) and (4))

As for natural environment, recommended are the following.

＊ Plants and wildlife

As for site selection, it should be confirmed at SIECD, provincial government, and acting local NGOs if a proposed site is in accord with any prospective conservation area (declared catchment areas, conservation areas for endemic or rare species, forest reserves, etc.). The occurrence of fish migration into a river should be screened on the study phase of respective projects, namely F/S study. Then necessary mitigation measures should be taken in the basic design if migration of important fish species is identified. (see 9.2 (1) and 9.3)

＊ Mimicry of the natural settings

The method should be employed on the basic design stage for respective projects.
(see 9.4.1 and 9.4.3)

* Securing and protection of intake of potable (drinking) water for the surrounding communities

  In case a proposed site might be inevitably selected upstream of drinking water source, the necessary measure should be taken to secure the amount of water intake and to protect the water quality on the basic design stage. (see 9.4.1 and 9.4.3)

* Influence on floods, landslides and soil erosion

  In the proposed scheme the serious impacts are unlikely on this aspect. However, this is a matter of technical design of the structural scheme, this aspect should be noted technically. (see 9.4.1 and 9.4.3)

* Battery disposal

  No proper disposal system for batteries seems to be actually working in the country. It is necessary that the collection system for used out batteries and facilities should be included in the design concept of SHS. It is recommendable that the economic feasibility be roughly evaluated in the JICA M/P Study for their prospective collection system. The collection system should be included on the basic design stage. (see 9.4.2 and 9.4.3)

* Harmony with the surrounding landscape and safety measures of power line and other facilities

  The proper consideration should be taken for the aspects on the design phase since the scheme does not contain a large size of facilities technically on the present stage. (see 9.4)

9.6 Activities of Organizations in Environment and Conservation concerning the Solomon Islands

This final clause shows the activities of governmental organizations, national NGOs, and international NGOs in the environment and conservation sector concerning the Solomon Islands. They are SPREP, SIDT, ISFMT, SWIFT, CI and WWF.

9.6.1 Governmental Organizations

(1) the South Pacific Regional Environment Programme (SPREP)

SPREP is an inter-governmental organization that comprises 22 south pacific countries (or territories) and Australia, France, New Zealand and United States of America. Its headquarters is located in Apia, Western Samoa. It aims to: facilitate the cooperative works on environmental problems among South Pacific Islands; assist a member to cope with the challenges to conserve and restore the environment that is shared among them; assist a member to attain sustainable development for present and future generations. Its activity is based on the five-year action plan from 1996 to 2000, four major fields of which are;

(a) the conservation of natural resources (conservation programs for bio-diversity and natural resources, coastal management),
(b) environmental management (climate change, **environmental impact assessment**, population problems and sustainable development, wastes management and pollution abatement),
(c) environmental education, information and cooperation (policy and strategy, legislature, education, information media), and
(d) data management and finance.

Reference:
In the Solomon Islands, SPREP has given consultation and support to prepare EIA for development-projects. Several reports and documents have been published on the environment of the Solomon Islands.

9.6.2 National NGOs

(1) Solomon Islands Development Trust (SIDT)

This trust is guided by the Conservation International, New Zealand-based international NGO for conservation of nature. The trust employs an approach to attain sustainable social development through community participation and nature conservation. It is based in Honiara, Guadalcanal, but has programs nationwide. Conservation in Development Department is their division having activities of conservation programs. Conservation unit of the department is now working on a pilot project of community conservation in Central Bauro region of Makira Province, which is a combination of sustainable harvesting, resource utilization (nut oil and bee-keeping) and eco-tourism. Eco-forestry unit of the department is working at conservation areas for sustainable forest management at 6 communities (including Marovo lagoon) in Western Province, 1 community (kemabona) in Central Province, 2 communities (longu, kaoka) in Guadalcanal Province and 1 community (tetere) in Makira Province.

(2) Isabel Sustainable Forestry Management Trust (ISFMT)

ISFMT has evolved from a project initiated by the Santa Isabel Provincial Government as part of natural resource management strategy. Funded by the European Union, the project began in 1995. The trust is now owned and controlled by village-dwelling communities in Santa Isabel. The office is located in Buala. ISFMT advocates a sustainable forestry management system, which includes land-use planning, bush conservation and water source protection. The trust also carries out research into bio-diversity of local flora with the view to protection and sustainable harvest. Tracking down the similar line of the concept to SIDT, the trust looks for the balance of conservation and their utilization of forest areas. They had some experiences in coordination between communities and development proponents, and environmental assessment.

(3) SWIFT

This trust is located at Munda United Church of Western Province. This trust is said to be working under the same line of concept as SIDT and ISFMT. But details are not known.

9.6.3 International NGOs

(1) Conservation International (CI)

Based in New Zealand, Conservation International partners with Solomon Islands Development Trust (SIDT). It has led the concept of 'conservation in development' for SIDT. Maruia Society Report 1990, so-called 'the green book', is a survey work by their members and is an important work for the conservation strategy for the Solomon Islands. The areas of high conservation potential in the country were recommended in the book, including detailed information on forest species.

(2) World Wide Fund for Nature (WWF)

WWF is a largest independent conservation group in the world. WWF Solomon Islands Program is based in Gizo of Western Province. WWF Pacific Regional Office is based at PMB Suba in Fiji. WWF's program in the Solomon Islands, Community Resource Conservation and Development (CRCD), is a model for supporting natural resource management based on participatory planning, for the purpose of community development and income generation alongside nature conservation, a concept similar to that of CI. The model may be applied to countries where customary resource tenure remains a key fact of life. CRCD program is working at present in the western half of the country, particularly in Marovo, Gizo, Simbo, Vella Lavella and Choiseul. Around thirty field staff are working in these areas, directly with local village communities, committees and tribal associations as well as with Area Councils, Provincial offices, church programs and other NGOs. WWF's Solomon program has received funding from Australia, the EC and the British Government.

CHAPTER 10

POWER SUPPLY PLANNING

Chapter 10 Power Supply Planning

10.1 Basic policy for power supply planning

The following basic policy for power supply planning is consistent with the "SOLOMON ISLANDS NATIONAL ENERGY POLICY AND GUIDELINES" formulated by the Solomon Government.

(1) Hydro power shall be developed as much as possible for supplying power to the area served by the existing grid power system such as Honiara-Lungga.

(2)-1 Hydro power shall also be developed as much as possible for supplying power to the provincial capital and large towns (station towns) such as Auki, Malu'u, Buala, Jejevo, Kirakira, Lata and Choiseul (Taro).

(2)-2 Hydropower or PV shall be developed for supplying power to large towns (station towns), such as Taro.

(3) PV shall be developed for rural electrification to the town/villages where there is no hydropower potential and no hydropower development plan.

(4) Existing diesel power shall be extended or up-graded for supplying power to the areas served by the existing diesel power system such as Noro, Munda and Tulagi, where there are no hydro potential sites or where to develop hydro power potential would take too long.

10.2 Existing power supply facilities

The existing power supply facilities were classified in June 2000 into two groups. One group is formed by government organizations (i.e. SIEA), and the other is formed by non- government organizations (NGO property, community property and private property).

10.2.1 SIEA owned facilities

SIEA has 30,730 kW of total capacity (de-rated capacity is 22,692 kW) as of June 2000, as shown in Table 10-2-1.

10.2.2 Non-SIEA owned facilities

Non-SIEA facilities had 280 kVA of total capacity by the end of 1989, as shown in Table 10-2-2. However, since churches and some people have their own diesel generators, the real situation is not clear.

10.3 The expansion plan of power development and rural electrification

When a power supply plan for an area is made in accordance with section "10.1 Basic policy for power supply planning", the area served by a power source is classified into three groups as:

A. Area served by grid power,

B. Area served by independent isolated power source (hydropower source or diesel power source), and

C. Area served by PV (Photovoltaic: Solar energy generation).

Even though an area belongs to group B or group C at an initial stage, it would be natural that it would become to be group A or group B as the power development progressed. It is desirable that the upgrading of this transition is promoted under the sound management of electric utilities.

The power supply plans for each province are shown below. The preparation of each power supply plan is based upon the power demand forecast for each province (demand center), as shown in Chapter 4. However, since the power demand could change by the current economic situation, the power demand forecast should be reviewed or rechecked at least once a year, and the power supply plans should also be reviewed to comply with changes of the demand forecasts.

Procedure for power supply planning

(1) Guadalcanal Province

The necessary power supply capacity is the sum of the peak load plus the largest generator capacity in the power system plus the next largest generator capacity in the power system.

(2) Other provinces

The necessary power supply capacity is the sum of the peak load plus the largest generator capacity in the power system.

The power supply development scheme should be implemented to meet the above mentioned necessary capacities. The schemes for each load center are shown in Appendix 10-3-11 to 10-3-91 (Appendix 10-3-81, and 10-3-82 Rennell and Bellona is only for reference).

10.3.1 Areas served by grid power

- Guadalcanal Province

This province has 49 hydro potential sites, which can be developed, as shown in Chapter 5, Table 5-4-3 to Table 5-4-4. The JICA Master Plan Study Team (JICA Team) investigated three sites and made comparisons of kW and construction costs for these sites, as shown in Table 10-3-1. Based upon these potential sites, four power supply plans were prepared as shown in Table 10-3-2, and were evaluated from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues, as shown in Table 10-4-1. According to this table, Plan-3 and Plan-4 score the same evaluation points. Since Plan-3 is considered to better meet the national energy policy and guidelines, it would be the most suitable plan for power supply. Plan-3 is selected as the optimum power supply plan for this demand center/area.

This province has large hydro potential sites such as Lungga. The negotiation between the

Solomon Island Government and SMEC, that is an independent power producer for the Lungga hydropower project, has suspended. According to an interview of staff belonging to the energy division of MNR, the Lungga hydropower project is assumed to be completed after the year 2010. The estimated capacity of Lungga hydro power will be 25,000 kW (5,000 kW, 5 units); three of these units will be used for the Gold Ridge and the other two units, to be available for power supply to SIEA grid, are considered in Plan-1 and Plan-2.

Araveu, Ruaniu, Ndoma, Aruliho and Kohimarama villages and the Technical College could be supplied power by extension of the existing transmission and distribution line from Mamara (end of the existing line), to Takomboro, according to the optimum power supply Plan-3. Also St. Martins and Tenaru Mission College could be supplied power by extension of the existing transmission and distribution line from Betukama (end of the existing line), to a point close to the Gold Ridge.

The future area served by grid power is shown in Appendix 10-3-1.

10.3.2 Areas served by independent power sources

(1) Malaita Province

This province has 23 hydro potential sites, which can be developed, as shown in Chapter 5, Table 5-4-5. The JICA Team investigated three sites and made comparisons of kW and construction costs as shown in Table 10-3-1. Six power supply plans were prepared based on these potential sites, as summarized in Table 10-3-3, and evaluated them from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues, as shown in Table 10-4-2. According to this table, Plan-3 is considered to be the optimum power supply plan for this demand center/area.

In this province there is a large project, the Bina Harbor Project, that is in progress to be completed in the year 2003. Although this project needs a large power supply source, there is no such power supply plan and this project should incorporate the necessary power supply source such as diesel power. Under these circumstances, the villages from Bina to Malu'u area in northern part of Malaita could be supplied power by extension of the existing transmission and distribution line according to the optimum power supply Plan-3.

The future area to be electrified is shown in Appendix 10-3-2.

(2) Isabel Province

This province has 6 hydro potential sites, which can be developed, as shown in Chapter 5, Table 5-4-6. The JICA Team investigated two sites and from a technical point of view judged that the Poporo potential site is very difficult to develop. Comparisons of kW and construction costs are as shown in Table 10-3-1. Based upon this table, two power supply plans were prepared, summarized in Table 10-3-4, and evaluated from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues. Results are presented in Table 10-4-3. According to this table, Plan- 1 is considered as the optimum power supply plan for this demand center/area.

This province has a coconut crushing mill at Ghojoruru and a community high school at Guguha. The villages, Buala and Jejevo, together with the factory and the school, could be supplied power by extension of the existing transmission and distribution line as proposed in the optimum power supply Plan-1.

The future area to be electrified is shown in Appendix 10-3-3.

(3) Makira Province

This province has 12 hydro potential sites, which can be developed, as shown in Chapter 5, Table 5-4-8. The JICA Team investigated one site and analyzed kW and construction costs, which are presented in Table 10-3-1. Based upon this cost analysis, two power supply plans were prepared, shown in Table 10-3-5, and evaluated from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues. Results are summarized in Table 10-4-4. According to these results, Plan-2 is considered to be the optimum power supply plan for this demand center/area.

The Waimapuru national secondary school, the Pamua vocational school and the Kaunasugu coconut crushing mill are located in this province. The villages, Kirakira township and Nukukaisi, and the above mentioned schools and factory could be supplied power by extension of the existing transmission and distribution line as recommended in the optimum power supply Plan-2.

The future area to be electrified is shown in Appendix 10-3-4.

(4) Temotu Province

This province has 2 hydro potential sites, which can be developed, as shown in Chapter 5, Table 5-4-10. The JICA Team investigated and checked one site, and prepared kW and construction costs, which are summarized in Table 10-3-1. Based upon this table, two power supply plans were prepared, as shown in Table 10-3-6, and evaluated from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues, as indicated in Table 10-4-5. According to this table, the Plan-2 is considered as the optimum power supply plan for this demand center/area.

In this province there are the Temotu coconut crushing mill and a fishery center. This factory and the center, together with the Lata township, could be supplied power by extension of the existing transmission and distribution line according to the optimum power supply Plan-2.

The future area to be electrified is shown in Appendix 10-3-5.

(5) Choiseul Province

This area has no power supply from SIEA at present. The province has 15 hydro potential sites, which can be developed, as shown in Chapter 5 Table 5-4-9. The JICA Team investigated one site and checked kW and construction costs as shown in Table 10-3-1. Based upon this table, two power supply plans were prepared as shown in Table 10-3-7, and evaluated from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues, as indicated in Table 10-4-6. According to this table, Plan-1 is considered as the optimum power supply plan for this demand center/area.

This provincial government has a development plan in which commercial and industrial areas will be developed adjacent to the provincial secondary school on the main island. These areas, together with surrounding villages to this new development could be supplied power by a newly constructed transmission and distribution line according to the optimum power supply Plan-1.

On the other hand, a new diesel power plant should be developed in Taro Island, because the interconnection line between the main island and Taro Island will be very difficult and not be economical due to the proximity of Choiseul Bay.

10.3.3 Area served by existing diesel power source

(1) Gizo area, Gizo Island, Western Province

This province has 23 hydro potential sites, which can be developed, as shown in Chapter 5 Table 5-4-7. There is no hydro potential in the Gizo area. Three power supply plans based on diesel power were prepared as indicated in Table 10-3-8, and evaluated from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues, as shown in Table 10-4-7. According to this table, Plan-2 is considered as the optimum power supply plan for this demand center/area.

Hotels, lodges and shops are located in this area. The extension and/or upgrade of the existing diesel power source are needed to meet the power demand from these consumers. The surrounding villages together with these consumers could be supplied power by extension of the existing transmission and distribution line as stated in the optimum power supply Plan-2.

The future area to be electrified is shown in Appendix 10-3-6.

(2) Noro-Munda area, New Georgia Island, Western Province

There are 23 hydro potential sites in this province and 8 sites in New Georgia Island, which can be developed, as shown in Chapter 5, Table 5-4-7. However, there is no suitable hydro potential site on New Georgia Island. Two power supply plans based on diesel power were prepared as shown in Table 10-3-9. Due to the fact that there are no hydro potential sites near to the demand centers, there are access problems for site surveys. The plans were evaluated from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues, as shown in Table 10-4-8. According to this table, Plan-2 is considered as the optimum power supply plan for this demand center/area. However, this power supply plan should be updated every year based on reviewed power demand forecasts.

The future area to be electrified is shown in Appendix 10-3-6.

(3) Tulagi area, Central Province

The JICA Team prepared the power supply plan shown in Table 10-3-10 based on diesel power source because maps for the hydro potential study could not be obtained. The plans were evaluated from several aspects such as cost, access, community capability, economic and financial analysis, environment, land and other issues, as shown in Table 10-4-9. According to this table, Plan-2 is considered as the optimum power supply plan for this demand center/area. This power supply plan, however, should be updated every year based on reviewed power demand forecasts.

10.3.4 Area electrified by Solar Energy Systems

It has been confirmed through a rural society survey and solar energy generation (PV) potential survey that the needs for electrification in every village are very high. However, it is found that there is a difference of income revenue among villages and that high-income villages tend to be located near to large towns or capitals. These high-income villages have capability to pay for PV systems.

The following scenario, which is the electrification plan for those areas which would not be electrified by grid extension or by power sources to be newly developed, is recommended as the rural electrification program until the year 2015.

Scenario for rural electrification

The scenario shall be classified into three stages in order to implement the rural electrification plan, which consists of the power supply to public facilities such as schools, churches and clinics and to individual houses in non-electrified villages.

(1) First stage: Preparation Stage

The following steps shall be carried out for solar power generation.

- Establishment of REAC and definition of its role
    - Awareness by villagers of information on PV
    - Establishment of a technical training center
    - Establishment of a revolving fund for SHS
    - Preparation of a management and technical training manual
- Establishment of a guideline to apply for PV systems
- Establishment of a workshop

(2) Second stage: Pilot Scheme

- In regard to the selection of a village for SHS installation, the average annual income of households should be investigated.
- Based upon the result of the average annual income survey, villages in Solomon Islands shall be classified into the next three categories. It is aimed to identify any difference that may rise from provinces and villages subject to this scheme.

In order to identify any difference between provinces or local conditions, the project is conformed to the following procedure, as explained below.

One to two villages would be selected from a total of eight provinces, but excluding Rennell and Bellona Province (36Wp, 55Wp, 75Wp system, 8 to 13 villages)

The pilot SHS plant would be installed at each selected village so that the monitoring of sustainability of the management organization could be made for three years.

The pilot scheme is described below.

Pilot Scheme (assumed starting year 2001) Unit: US$

No.	Provincial name	capital	Individual house			Public facility			Construction cost (US$)	Remarks
			Nos. of vil.		Nos. of set	Nos. of vil.		Nos. of set		
1	Guadalcanal	Honiara	1	36Wp	50	1	75Wp	3	64,950	
2	Malaita	Auki	1	36Wp	20	2	75Wp	3	33,900	
3	Isabel	Buala	1	36Wp	20	2	75Wp	3	33,900	
4	Makira	Kirakira	1	36Wp	20	2	75Wp	3	33,900	
5	Choiseul	Taro	1	36Wp	20	2	75Wp	3	33,900	
6	Western	Gizo	1	36Wp	50	1	75Wp	3	64,950	
7	Central	Tulagi	1	55Wp	50	1	75Wp	3	74,950	Vunuha vil.
8	Temotu	Lata	1	36Wp	20	2	75Wp	3	33,900	
9	Rennell & Bellona	Tinnggoa		-			-		0	
Total			8		250	13		39	374,350	

Note: Individual house 36Wp US$ 1,200 install at individual house
55Wp US$ 1,400 install at individual house
Public facility 75Wp US$ 1,650 install at school and/or church

The construction of PV SHS systems would be finished in the first year, and the monitoring should be carried out for three years to find whether or not a sustainable operation and maintenance organization is achieved, and to identify any deficiency. Results of this pilot scheme, together with results of the UNDP funded scheme to be implemented in Rennell and Bellona, should

(3) Third stage: Nationwide Scheme

The draft of the nationwide scheme would start at the second year after the pilot scheme finishes. A total of 270 sets of SHS for individual houses and 27 sets for public facilities in each village of 9 provinces would be installed every year. The nationwide scheme is described below.

Nationwide Scheme (assumed starting year: 2005) Unit: US$

No.	Provincial name	capital	Individual house			Public facility			Construction cost (US$)	Remarks
			Nos. of vil.		Nos. of set	Nos. of vil.		Nos. of set		
1	Guadalcanal	Honiara					75Wp			
2	Malaita	Auki					75Wp			
3	Isabel	Buala					75Wp			
4	Makira	Kirakira					75Wp			
5	Choiseul	Taro	9	36Wp	30	9	75Wp	3	368,550	
6	Western	Gizo					75Wp			
7	Central	Tulagi					75Wp			Vunuha vil.
8	Temotu	Lata					75Wp			
9	Rennell & Bellona	Tinnggoa					75Wp			
Total			9		270	9		27	368,550	

Note: Individual house 36Wp US$ 1,200 install at individual house
Public facility 75Wp US$ 1,650 install at school and/or church

The rural electrification plan including the pilot and the nationwide schemes are shown in Table 10-3-12.

Disposal of batteries used in SHS

According to the rural electrification plan based on the use of SHS, the lifetime of batteries would be seven (7) years. After batteries reach their life time and when some amount is stocked (approximately 500 batteries), they should be transported to Brisbane in Australia in order to dispose them for recycling, taking care that disposal should not affect the environment.

Reference: Solar power electrification plan in Rennell Island by UNDP

UNDP is going to implement a plan of rural electrification by solar power in Rennell Island under the co-financing between EU and Germany, as of May 2000. The results of this project could be expected to be a reference for our SHS rural electrification plan.

The JICA Team prepared a rural electrification draft plan by using solar and wind power for Rennell Island as shown in Table 10-3- 11 based upon the demand forecast described in Chapter 4 table 4-3-11. However, since the Team has not surveyed Rennell and Bellone Islands, this plan is for reference only.

10.4 Evaluation of power supply planning

The evaluation of power supply plans for each demand center has been carried out based on requirement conditions, which should be satisfied for each demand center. The plan that satisfies these conditions for each demand center is taken as the optimum power supply plan.

The power supply plans are also evaluated from the following aspects without any particular tendency, this being a reference evaluation only.

(1) Cost
- Unit cost per kW
- Unit cost per kWh
- Total construction cost

(2) Accessibility
- Survey
- Construction
- Operation and maintenance

(3) Receptivity
- Village community
- Compensation

(4) Economic and financial analysis

- EIRR
- FIRR
- LRMC (LRAIC)
- Electricity tariff

(5) Environmental issues

(6) Land ownership

(7) Others (Compatibility with the National Energy Policy and Guidelines)

The power supply plans, proposed for nine demand centers in eight provinces all over the Solomon Islands, are shown in Table 10-5-1.

10.5 Optimum power supply plan

From the above evaluation result, the optimum power supply plan for each demand center in each province is summarized in Table 10-5-1 and the rural electrification plan by SHS is shown in Table 10-3-12.

Table 10-2-1 Existing generators (Provincial wise/Islands wise)

As of Jun. 2000

Name of Province/Island	Name of P/S	Type of P/S	Unit No.	Name plate Rating (kVA)	Name plate Rating (kW)	De-Rated (kW)	Installed Year	Remarks
Guadalcanal P. /Guadalcanal				27,270	24,540	18,000		
	Lungga			19,390	18,040	14,000		
		Diesel	4	1,900	1,900	1,000	1971	Mirrless-Blachstone
			5	1,900	1,900	1,000	1971	Mirrless-Blachstone
			6	2,840	2,840	2,200	1998	Mirrless-Blachstone
			7	3,000	3,000	2,300	1987	W.H.Allen
			8	4,500	4,200	3,600	1993	Wartsila
			9	5,250	4,200	3,900	1999	Mitsubishi
	Honiara			7,880	6,500	4,000		
		Diesel	1	1,875	1,500	1,000	1997	Perkins
			2	1,875	1,500	1,000	1997	Perkins
			3	1,875	1,500	1,000	1997	Perkins
			5	1,128	1,000	500	1984	Mirrless-Blachstone
			6	1,128	1,000	500	1984	Mirrless-Blachstone
Malaita P. /Malaita				818	818	654		
	Auki			780	780	624		
		Diesel	1	260	260	208	1991	Perkins
			2	260	260	208	1991	Perkins
			3	260	260	208	1991	Perkins
	Malu'u			37.5	37.5	30		
		Hydro	1	37.5	37.5	30	1984	
Isabel P. /Santa Isabel				310	238	212		
	Buala			310	238	212		
		Diesel	1	110	88	62	1993	Perkins
		Hydro	1	200	150	150	1996	
Makira P. /San Cristobal				294	235	170		
	Kirakira			294	235	170		
		Diesel	1	100	80	60	1992	Catepillar
			2	114	91	50	1993	Perkins
			3	80	64	60	Out of service	Lister
Temotu P. /Nendo				330	264	160		
	Lata			330	264	160		
		Diesel	1	110	88	60	1993	Perkins
			2	110	88	40	1993	Perkins
			3	110	88	60	1995	Perkins
Western P. /New Georgia				5,333	4,277	3,252		
	Gizo			780	624	510		
		Diesel	1	260	208	170	1991	Perkins
			2	260	208	170	1991	Perkins
			3	260	208	170	1991	Perkins
	Noro			4,500	3,600	2,700		
		Diesel	1	1,500	1,200	900	1987	W.H.Allen
			2	1,500	1,200	900	1987	W.H.Allen
			3	1,500	1,200	900	1987	W.H.Allen
	Munda			53	53	42		Interconnected with Noro by 11kV
		Diesel	1	53	53	42	Out of service	
Central P. /Tulagi				400	320	244		
	Tulagi			400	320	244		
		Diesel	1	150	120	84	1999	Catepillar
			2	250	200	160	1999	Perkins
Choiseul P. /Choiseul								Not applicable

Source: The data provided by SIEA at the general meeting during third field survey (May 17-June 2, 2000)

Table 10-2-2 Existing generator owned by Non - SIEA

Province/Island	Owner	Type of power	Capacity (kVA)	Commissioning	Operation hour per	Numbers of Household	Remarks
Guadalcanal	Avuavu Provincial Secondary School	Diesel	10.5	1989	3	250/200	
Malaita	Su'u National Secondary School	Diesel	34.4	1983	3	360/305	#1
		"	20	1981	3		#2
Isabel							
	Allardyce Provincial Secondary School	Diesel	15	NA	3	240/210	
	Kamaosi Provincial Secondary School	Diesel	5	1988	3	250/190	
	Tasia Station /Tasia Training Center and Church of Melanesia Mission HQ	Diesel	6	1959	2.5	60/34	
Makira	Pawa Provincial Secondaryu Schoool	Diesel	15	1989	3	350/290	
	Pamua Rural Training Center	Diesel	NA	NA	3	NA	
	Waimapuru National Secondaryu Schoool	Diesel	60	NA	24	NA	#1, #2, #3
Western							
Vella Lavella	Vonunu rovincial Secondary School	Diesel	15	1983	3.5	280/210	
Kolombangara	Kukundu Station /Kukundu National Secondary School, Western Solomon Islands Mission of SDAC	Diesel	4	1979	7.5	440/300	#1
		"		1946	60		#2
	Vanga Point Rural Training Center	Diesel	2.5	NA	5	100/70	#1
		"			7		#2
		"			5.25		#3
Mbanga	Goldie College	Diesel	55	1987	6	350/290	
Choiseul	Choiseul Bay Provincial Secondary School	Diesel	17	1988	3	310/280	Stand by from 1998
			27	1998	3	NA	
Total			286.4				

Table 10-3-1 Cost comparison

As of 30 June, 2000

Guadalcanal province

No.	Project name	Completion year	Output kW	Output size	Gen. energy MWh	Construction cost 1000xSB$	Lower cost	Construction cost per kW 1000xSB$	Construction cost per kW 1000xUS$	Construction cost per kW 1000xJY	Unit cost per kW
1	Lungga diesel extension	1999	4,200	1		24,050 *4	1	5.726	1.534	190	1
2	Maotapuku 1		1,600	2	7,838	124,375 *3	3	77.734	15.547	1,632	2
3	Maotapuku 2		1,400	3	6,619	135,150 *3	4	96.536	19.307	2,027	3
4	Sasa		280	4	2,396	31,055 *3	2	110.911	22.182	2,329	4

Malaita province

No.	Project name	Completion year	Output kW	Output size	Gen. energy MWh	Construction cost 1000xSB$	Lower cost	Construction cost per kW 1000xSB$	Construction cost per kW 1000xUS$	Construction cost per kW 1000xJY	Unit cost per kW
1	Bina-Malu'u 33kV T/L *1	2000	-			5,920 *5	-	-	-	-	-
2	Bina harbor project *1	2003	4,500	1				-	-	-	
3	Malu'u (SIEA) *1	2000	30	10		1,501 *5	1	50.033	10.467	1,198.5	4
4	Auki diesel up-grading *1	2002	500	5			-	-	-	-	-
5	Manakwai *1		400	6		5,583 *5	3	13.958	2.920	334	1
6	Fiu (SIEA) *1	2008	560	4		27,998 *5	4	49.996	10.460	1,197.6	3
7	Ruala'e (SIEA) *1	2007	200	7		4,163 *5	2	20.815	4.355	499	2
8	Rori		300	8	2,526	29,950 *3	5	99.833	19.967	2,097	6
9	Silolo (JICA)		2,100	2	10,495	141,320 *3	7	67.295	13.459	1,413	5
10	Kware'a		600	3	2,541	90,925 *3	6	151.542	30.308	3,182	7

Isabel province

No.	Project name	Completion year	Output kW	Output size	Gen. energy MWh	Construction cost 1000xSB$	Lower cost	Construction cost per kW 1000xSB$	Construction cost per kW 1000xUS$	Construction cost per kW 1000xJY	Lower cost per kW
1	Kubolata		80		563	8,250 *3		103.125	20.625	2,063	
2	Poporo	Technically very difficult									

Makira province

No.	Project name	Completion year	Output kW	Output size	Gen. energy MWh	Construction cost 1000xSB$	Lower cost	Construction cost per kW 1000xSB$	Construction cost per kW 1000xUS$	Construction cost per kW 1000xJY	Unit cost per kW
1	Kirakira diesel extension *1		192	1		1,895 *5	1	9.870	2.065	236	1
2	Huro *1		120	2		7,155 *5	3	59.625	12.474	1,428	2
3	Waimapuru		20	3	181	4,555 *3	2	227.750	45.550	4,783	3

Temotu province

No.	Project name	Completion year	Output kW	Output size	Gen. energy MWh	Construction cost 1000xSB$	Lower cost	Construction cost per kW 1000xSB$	Construction cost per kW 1000xUS$	Construction cost per kW 1000xJY	Unit cost per kW
1	Lata diesel up-grading *1		192	1		2,117 *5	1	11.026	2.307	264	1
2	Luembalele		50	2	432	20,590 *3	2	411.800	82.360	8,236	2

Choiseul province

No.	Project name	Completion year	Output kW	Output size	Gen. energy MWh	Construction cost 1000xSB$	Lower cost	Construction cost per kW 1000xSB$	Construction cost per kW 1000xUS$	Construction cost per kW 1000xJY	Unit cost per kW
1	Diesel in Taro Is. *1		60	2		1,484 *5	1	24.733	5.174	592	1
2	Sorave		70	1	592	9,295 *3	2	132.786	26.557	2,656	2

Source:
*1 Rural Electrification 2000 and beyond Project Document, June 1999 SIEA
*2 Draft Malaita Generation Augmentation 2000-2010, September 1999, SIEA
*3 JICA Master Plan Study Team Estimation. US$1 = JY 105. US$1 = SB$5.00
*4 US$1 = JY 124. US$1 = SB$ 3.733
*5 US$1 = JY 114.5. US$1 = SB$ 4.78

Note: [shaded box] denotes the site where JICA Master Plan Study Team Investigated.

Table 10-3-2 Power supply development scheme in Guadalcanal province, Honiara-Lungga

Year \ Plan No.	1	2	3	4
1998	-	-	-	-
1999	Lungga diesel No.9 (3900kW) installed	Lungga diesel No.9 (3900kW) installed	Lungga diesel No.9 (3900kW) installed	Lungga diesel No.9 (3900kW) installed
2000	Lungga diesel No.10 (4200kW) install, Lungga diesel No.4 & No. 5 (1000kW*2) and Honiara diesel No. 5 & No. 6 (500kW*2) retire	Lungga diesel No.10 (4200kW) install, Lungga diesel No.4 & No. 5 (1000kW*2) and Honiara diesel No. 5 & No. 6 (500kW*2) retire	Lungga diesel No.10 (4200kW) install, Lungga diesel No.4 & No. 5 (1000kW*2) and Honiara diesel No. 5 & No. 6 (500kW*2) retire	Lungga diesel No.10 (4200kW) install, Lungga diesel No.4 & No. 5 (1000kW*2) and Honiara diesel No. 5 & No. 6 (500kW*2) retire
2001	-	-	-	-
2002	-	-	-	-
2003	Lungga hydro No.1 & No. 2 (5000*2) develop	Lungga hydro No.1 (5000*1) develop	Lungga diesel No.11 (5000kW) develop	Lungga diesel No.11 (5000kW) develop
2004	Lungga diesel No.7 (2300kW) retire	Lungga hydro No.2 (5000*1) develop, Lungga diesel No.7 (2300kW) retire	Lungga diesel No.12 (5000kW) develop, Lungga diesel No.7 (2300kW) retire	Lungga diesel No.12 (5000kW) develop, Lungga diesel No.7 (2300kW) retire
2005	-	-	-	-
2006	-	-	-	-
2007	Lungga diesel No.11 (5000kW) install	Lungga diesel No.11 (5000kW) install	Lungga diesel No.13 (5000kW) install	Lungga diesel No.13 (5000kW) install
2008	Lungga diesel No.8 (3600kW) retire	Lungga diesel No.8 (3600kW) retire	Lungga diesel No.8 (3600kW) retire	Lungga diesel No.8 (3600kW) retire
2009	-	-	-	Lungga diesel No.14 (5000kW) install
2010	-	Maotapuku 1 & 2 (1600kW, 1400kW) develop	Maotapuku 1 & 2 (1600kW, 1400kW) develop	-
2011	Lungga diesel No.12 (5000kW) install	-	-	-
2012	-	Lungga diesel No.12 (5000kW) install	Lungga diesel No.14 (5000kW) install	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	Lungga diesel No.15 (5000kW) install
2016	Lungga diesel No.13 (2000kW) install	-	Lungga diesel No.15 (2000kW) install	-
2017	-	Lungga diesel No.13 (2000kW) install	-	-
2018	-	-	-	-

The table and figure mentioned above are shown in Table A4-1-1 to Table A4-1-4.

Table 10-3-3 Power supply development scheme in Malaita province, Auki - Malu'u

Year \ Plan No.	1	2	3	4	5	6
1998	-	-	-	-	-	-
1999	-	-	-	-	-	-
2000	Auki diesel 2 units (200kW*2) replace, Malu'u diesel 1 unit (83kW) install	Auki diesel 2 units (200kW*2) replace, Malu'u diesel 1 unit (83kW) install	Auki diesel 2 units (200kW*2) replace, Malu'u diesel 1 unit (83kW) install	Auki diesel 2 units (200kW*2) replace, Malu'u diesel 1 unit (83kW) install	Auki diesel 2 units (200kW*2) replace, Malu'u diesel 1 unit (83kW) install	Auki diesel 2 units (200kW*2) replace, Malu'u diesel 1 unit (83kW) install
2001	Bina diesel No.1 unit (1500kW) develop, existing diesel 1 unit (208kW) retire	Bina diesel No.1 unit (1500kW) develop, existing diesel 1 unit (208kW) retire	Bina diesel No.1 unit (1500kW) develop, existing diesel 1 unit (208kW) retire	Bina diesel No.1 unit (1500kW) develop, existing diesel 1 unit (208kW) retire	Bina diesel No.1 unit (1500kW) develop, existing diesel 1 unit (208kW) retire	Bina diesel No.1 unit (1500kW) develop, existing diesel 1 unit (208kW) retire
2002	Bina diesel No.2 unit (1500kW) install	Bina diesel No.2 unit (1500kW) install	Bina diesel No.2 unit (1500kW) install	Bina diesel No.2 unit (1500kW) install	Bina diesel No.2 unit (1500kW) install	Bina diesel No.2 unit (1500kW) install
2003	Bina diesel No.3 unit (1500kW) install, Rori hydro (300kW) develop	Bina diesel No.3 unit (1500kW) install, Manakwai hydro (400kW) develop	Bina diesel No.3 unit (1500kW) install, Rori hydro (300kW) develop	Bina diesel No.3 unit (1500kW) install, Ruala'e hydro (200kW) develop	Bina diesel No.3 unit (1500kW) install, Manakwai hydro (400kW) develop	Bina diesel No.3 unit (1500kW) install, Ruala'e hydro (200kW) develop
2004	-	-	-	-	-	-
2005	-	-	-	-	-	-
2006	-	-	-	-	-	-
2007	-	-	-	Manakwai hydro (400kW) develop	-	Rori hydro (300kW) develop
2008	-	-	-	-	-	-
2009	Manakwai hydro (400kW) develop	-	Ruala'e hydro (200kW) develop	-	-	-
2010	-	-	-	-	-	-
2011	-	Ruala'e hydro (200kW) develop	-	-	Rori hydro (300kW) develop	-
2012	-	-	-	-	-	-
2013	-	-	Silolo hydro (2100kW) develop	-	-	Silolo hydro (2100kW) develop
2014	Silolo hydro (2100kW) develop	Silolo hydro (2100kW) develop	-	Silolo hydro (2100kW) develop	Silolo hydro (2100kW) develop	-
2015	-	-	-	-	-	-
2016	-	-	-	-	-	-
2017	-	-	-	-	-	-
2018	-	-	-	-	-	-

The table and figure mentioned above are shown in Table A4-2-1 to Table A4-2-6.

Table 10-3-4 Power supply development scheme in Isabel province, Buala

Year \ Plan No.	1	2
1998	-	-
1999	-	-
2000	-	
2001	-	New diesel No.2 (110kW) install
2002	-	-
2003	-	-
2004	-	-
2005	New diesel No.2 (160kW) install	-
2006	-	-
2007	-	-
2008	-	-
2009	Kubolata hydro (80kW) develop	New diesel No.3 (110kW) install
2010	-	-
2011	-	-
2012	New diesel No.3 (160kW) install	New diesel No.4 (110kW) install
2013	Existing old diesel (62kW) retire	Existing old diesel (62kW) retire
2014	-	-
2015	-	-
2016	-	-
2017	-	-
2018	-	-

The table and figure mentioned above are shown in Table A4-3-1 to Table A4-3-2.

Table 10-3-5 Power supply development scheme in Makira province, Kirakira

Year \ Plan No.	1	2	3
1998	-	-	-
1999	-	-	-
2000			
2001	New diesel No.4 (200kW) install	New diesel No.4 (200kW) install	New diesel No.4 (200kW) install
2002	-	-	-
2003	-	-	-
2004	Huro hydro (120kW) develop	Huro hydro (120kW) develop	New diesel No.5 (170kW) install
2005	-	-	-
2006	-	-	-
2007	-	-	-
2008	-	-	-
2009	-	-	-
2010	-	-	-
2011	Waimapuru hydro (20kW) develop	New diesel No.5 (240kW) install	New diesel No.6 (170kW) install
2012	New diesel No.5 (300kW) install Existing old diesel No.1 (60kW) retire	Existing old diesel No.1 (60kW) retire	Existing old diesel No.1 (60kW) retire
2013	Existing old diesel No.2 (50kW) retire	Existing old diesel No.2 (50kW) retire	Existing old diesel No.2 (50kW) retire
2014	-	-	-
2015	-	-	-
2016	-	-	-
2017	-	-	-
2018	-	-	-

The table and figure mentioned above are shown in Table A4-4-1 to Table A4-4-3.

Table 10-3-6 Power supply development scheme in Temotu province, Lata

Year \ Plan No.	1	2
1998	-	-
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	New diesel No.4 (200kW) install	New diesel No.4 (200kW) install
2006	-	-
2007	-	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	Luembalele hydro (50kW) develop	New diesel No.5 (200kW) install
2013	New diesel No.5 (150kW) install Existing old diesel No.1 (60kW) retire	Existing old diesel No.1 (60kW) retire
2014	Existing old diesel No.2 (40kW) retire	Existing old diesel No.2 (40kW) retire
2015	Existing old diesel No.3 (60kW) retire	Existing old diesel No.3 (60kW) retire
2016	-	-
2017	-	-
2018	-	-

The table and figure mentioned above are shown in Table A4-5-1 to Table A4-5-2.

Table 10-3-7 Power supply development scheme in Choiseul province, Taro & Choiseul

Year \ Plan No.	1	2
1998	-	-
1999	-	-
2000	New diesel No.1 & 2 (20kW*2) develop in Taro Is.	New diesel No.1 & 2 (20kW*2) develop in Taro Is.
2001	-	-
2002	-	-
2003	Sorave hydro (70kW) develop in Main island	New diesel No.1 & 2 (60kW*2) develop in Main island.
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
2014	-	-
2015	-	-
2016	-	-
2017	-	-
2018	-	-

The table and figure mentioned above are shown in Table A4-6-1 to Table A4-6-2.

Table 10-3-8 Power supply development scheme in Western province, Gizo

Year \ Plan No.	1	2	3
1998	-	-	-
1999	-	-	-
2000	Gizo diesel 2 units (200kW*2) replace	Gizo diesel 2 units (200kW*2) replace	Gizo diesel 2 units (200kW*2) replace
2001	-	-	New diesel No.4 (400kW*1) install
2002	New diesel No.4 & No.5 (600kW*2) install	New diesel No.4 & No.5 (300kW*2) install	-
2003	Existing old diesel No.3 (170kW) retire	Existing old diesel No.3 (170kW) retire	New diesel No.5 (400kW*1) install, existing old diesel No.3 (170kW) retire
2004	-	-	-
2005	-	-	-
2006	-	New diesel No.6 (300kW*1) install	-
2007	-	-	-
2008	-	-	-
2009	-	-	New diesel No.6 (400kW*1) install
2010	-	-	-
2011	-	-	-
2012	-	-	-
2013	-	-	-
2014	-	-	-
2015	New diesel No.6 (600kW*1) install	New diesel No.7 (300kW*1) install	-
2016	-	-	-
2017	-	-	-
2018	-	-	-

The table and figure mentioned above are shown in Table A4-7-1 to Table A4-7-3.

Table 10-3-9 Power supply development scheme in Western province, Noro-Munda

Year \ Plan No.	1	2
1998	-	-
1999	-	-
2000	-	-
2001	Noro new diesel No.4 & No.5 (2000kW*2) extend	Noro new diesel No.4 & No.5 (2000kW*2) extend
2002	-	-
2003	-	-
2004	-	-
2005	New diesel No.6 (4200kW*1) extend	New diesel No.6 & No.7 (2000kW*2) extend
2006	Exsiting old diesel No.1 (900kW) retire	Exsiting old diesel No.1 (900kW) retire
2007	New diesel No.7 (4200kW*1) extend, exsiting old diesel No.2 (900kW) retire	Exsiting old diesel No.2 (900kW) retire
2008	Exsiting old diesel No.3 (900kW) retire	Exsiting old diesel No.3 (900kW) retire
2009	-	-
2010	-	New diesel No.8 & No.9 (2000kW*2) extend
2011	-	-
2012	-	-
2013	New diesel No.8 (4200kW*1) extend	-
2014	-	-
2015	-	-
2016	-	New diesel No.10 (2000kW*1) extend
2017	-	-
2018	-	-

The table and figure mentioned above are shown in Table A4-8-1 to Table A4-8-2.

Table 10-3-10 Power supply development scheme in Central province, Tulagi

Year \ Plan No.	1	2
1998	-	-
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	New diesel No.3 (83kW*1) extend	New diesel No.3 (60kW*1) extend
2006	-	-
2007	-	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
2014	-	-
2015	-	-
2016	-	-
2017	-	-
2018	-	-

The table and figure mentioned above are shown in Table A4-9-1 to Table A4-9-2.

Table 10-3-11 Power supply development scheme in Rennell and Bellona province, Rennell

Year \ Plan No.	1	2
1998	-	-
1999	-	-
2000	-	-
2001	-	-
2002	Solar PV (30kW*2) develop	Solar PV (20kW*3) develop
2003	-	-
2004	-	-
2005	Wind power (20kW*1) develop	Wind power (20kW*1) develop
2006	-	-
2007	-	-
2008	Solar PV (30kW*1) extend	Solar PV (15kW*2) extend
2009	-	-
2010	-	-
2011	Wind power (20kW*1) extend	Wind power (20kW*1) extend
2012	-	-
2013	-	-
2014	Solar PV (30kW*1) extend	Solar PV (15kW*2) extend
2015	-	-
2016	-	-
2017	-	-
2018	-	-

The table and figure mentioned above are shown in Table A4-10-1 to Table A4-10-2.
This plan is only for reference.

Table 10-3-12 Electrification plan by PV (SHS) in remote rural area

Plan No. / Year	Project name	Contents
1998	-	-
1999	-	-
2000	-	-
2001	Pilot scheme (1st year)	36Wp SHS 200 sets, 55Wp SHS 50 sets, 75Wp SHS 39sets
2002	Pilot scheme (2st year)	
2003	Pilot scheme (3st year)	
2004	-	-
2005	Nationwide scheme (1st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2006	Nationwide scheme (2st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2007	Nationwide scheme (3st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2008	Nationwide scheme (4st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2009	Nationwide scheme (5st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2010	Nationwide scheme (6st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2011	Nationwide scheme (7st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2012	Nationwide scheme (8st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2013	Nationwide scheme (9st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2014	Nationwide scheme (10st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2015	Nationwide scheme (11st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2016	Nationwide scheme (12st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2017	Nationwide scheme (13st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets
2018	Nationwide scheme (14st year)	36Wp SHS 270 sets, 75Wp SHS 27 sets

10.4.1 Evaluation of power supply plan for Honiara-Lungga in Guadalcanal Province

Points to be considered in regard to the power supply plan are as follows:

1. It is desirable that a run-of-river type hydro with capacity of less than 4,000kW be developed as a base load power source. Consequently, operation hours of diesel generators could be reduced.
2. To develop a hydro potential site which should be, as much as possible, close to the demand center and compatible with the National Energy Policy.

Taking into consideration the above points, three power supply plans were prepared including Lungga hydro IPP, Maotapuku 1 and Maotapuku 2. Concerning the Lungga hydro IPP, tax negotiations have been discussed between the Solomon Government and Lungga hydro IPP but since negotiations have not yet concluded, the possibility of construction would be low. Plan-3 is the best plan to meet the National Energy Policy and guidelines and has similar development costs compared to other plans. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-1 Evaluation result on power supply plan for Honiara-Lungga in Guadalcanal province

Aspect \ Plan No.	1	2	3	4
Cost	3	3	4	5
kW cost (US$/kW)	4,761	4,761	2,731	1,353
kWh cost (US$/kWh)	0.050	0.050	0.081	0.091
Total cost (Mil. US$)	157.6	157.6	90.4	44.8
Accessibility	3	3	5	5
Survey	Possible	Possible	Possible	Possible
Construction	Geological investigation is needed before construction, the space should be kept for extension of diesel generator in Lungga Diesel powerstation.	Geological investigation is needed before construction, the space should be kept for extension of diesel generator in Lungga Diesel powerstation.	Hydropower development can be executed, the space should be kept for extension of diesel generator in Lungga Diesel powerstation.	Space should be kept for extension of diesel generator in Lungga Diesel powerstation.
O & M	Possible	1	Possible	Possible
Acceptability	3	3	5	5
Community	The agreement for construction of Lungga and Maotapuku hydro power is needed between the community and the Government.	The agreement for construction of Lungga and Maotapuku hydro power is needed between the community and the Government.	The agreement for construction of Maotapuku hydro power is needed between the community and the Government.	No agreement is needed.
Compensation	Same as above	Same as above	Same as above	Same as above
Economic and Financial	4	4	4	5
EIRR (%)	13.69	14.58	14.44	28.92
FIRR (%)	12.34	13.07	12.26	25.72
LRMC(US$/kWh)	0.2083	0.2027	0.1622	0.1364
Power tariff (US$/kWh)	0.2345	0.2316	0.1803	0.1476
Environment problem	3	3	4	3
	The environment study should be carried out, but air pollution would be lower than Plan-3 and Plan-4.	The environment study should be carried out, but air pollution would be lower than Plan-3 and Plan-4.	The environment study should be carried out, and air pollution would be higher than Plan-1 and Plan-2.	Air pollution would be higher than Plan-1 and Plan-2.
Land acquisition	3	3	4	5
	There is not much problem.	There is not much problem.	There is not much problem, and lower than Plan-1 and Plan-2.	There is no problem.
Remarks	4	4	5	3
	The agreement for construction of Lungga hydro is needed between the IPP and the Government, and it will take much time.	The agreement for construction of Lungga hydro is needed between the IPP and the Government, and it will take much time.	This plan has no problem such as Plan-1 and Plan-2, and is not economical compare to Plan-1 and Plan-2. This plan is coordinated with the national energy policy and guidelines.	This plan is not coordinated with the national energy policy and guidelines.
Total point	23	23	31	31
Priority	3	3	1	1

10.4.2 Evaluation of power supply plan for Auki-Malu'u-Bina in Malaita Province

Points to be considered in regard to the power supply plan are as follows:

1. Since the land ownership is an important issue in the area compared with other areas, a plan that does not solve these issues would have a low possibility of realization.
2. The Bina Harbor project requires a large capacity power source, which should be developed in the near future.
3. It is necessary to develop possible hydro potential sites based on the National Energy Policy and guidelines.
4. The generated power from Rori, Silolo, Manakwai, Tamba and Aero sites, which are located close to provincial roads, could be supplied to Auki-Malu'u system through the main transmission line which would be constructed in the near future. Operation hours of the diesel generator could be reduced as a consequence.

Six power supply plans were prepared taking into consideration above points. Although Bina project requires a large amount of power soon, the only alternative could be to purchase their own diesel generator requires a within a private project since there is no plan to attend to such large demand. The Plan-3 is the best plan to meet the national energy policy and guidelines having a similar level of development costs compared to other plans. The hydro potential sites, having easy construction conditions, should be included from the demand point of view, because the present situation between demand and supply is very tight and new power sources should be developed immediately. Since Rori hydropower potential is a suitable site from the above conditions, Plan-1 and Plan-3, which include the Rori site, are better plans. Plan-3 is judged to be the best plan against Plan-1 which includes the closing of the existing Malu'u hydro site when Manakwai hydro is developed. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-2 Evaluation result on power supply plan for Malaita province, Auki-Malu'u

Aspect \ Plan No.	1	2	3	4	5	6
Cost	4	5	4	5	4	4
kW cost (US$/kW)	5,758	5,158	5,879	5,158	5,758	5,879
kWh cost (US$/kWh)	0.038	0.037	0.041	0.037	0.038	0.041
Total cost (Mil. US$)	42.51	37.56	42.23	37.56	42.51	42.23
Accessibility	4	4	5	4	4	4
Survey	Easy	Easy	Easy	Easy	Easy	Easy
Construction	Easy	Easy	Easier	Easy	Easy	Easier
O & M	Easy	Easy	Easy	Easy	Easy	Easy
Acceptability	4	4	4	4	4	4
Community	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.
Compensation	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.	The agreement is needed for hydro power construction.
Economic and Financial	4	5	4	5	5	4
EIRR (%)	7.21	9.26	6.39	9.04	8.18	6.80
FIRR (%)	6.55	8.39	5.78	8.22	7.38	6.12
LRMC(US$/kWh)	0.1408	0.1262	0.1420	0.1264	0.1345	0.1355
Power tariff (US$/kWh)	0.2268	0.1979	0.2313	0.1988	0.2137	0.2191
Environment problem	4	4	4	4	4	4
	Environment study is needed in detail, but it seems there is no problem.	Environment study is needed in detail, but it seems there is no problem.	Environment study is needed in detail, but it seems there is no problem.	Environment study is needed in detail, but it seems there is no problem.	Environment study is needed in detail, but it seems there is no problem.	Environment study is needed in detail, but it seems there is no problem.
Land acquisition	3	3	3	3	3	3
	The ageement is needed among related village/community	The ageement is needed among related village/community	The ageement is needed among related village/community	The ageement is needed among related village/community	The ageement is needed among related village/community	The ageement is needed among related village/community
Remarks	3	3	5	3	3	5
	Malu'u hydro will be closed after Manakwai hydro is constructed.	Malu'u hydro will be closed after Manakwai hydro is constructed.	Nothing particular	Malu'u hydro will be closed after Manakwai hydro is constructed.	Malu'u hydro will be closed after Manakwai hydro is constructed.	Nothing particular
Total point	26	28	29	28	27	28
Priority	6	2	1	2	5	2

10.4.3 Evaluation of power supply plan for Buala in Isabel Province

A point to be considered in regard to the power supply plan is the necessity to develop possible hydro potential sites based on the National Energy Policy and guidelines.

Two power supply plans were prepared taking into consideration this requirement. Although the team investigated two hydro potential sites, one of these two sites was judged from technical aspects to be not feasible. Since one of these plans considers only diesel power source, Plan-1, which includes hydropower, is the best plan to meet the National Energy Policy and guidelines, and also is a better plan from economic aspects compared to Plan-2. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-3 Evaluation result on power supply plan for Isabel province, Buala

Aspect \ Plan No.	1	2
Cost	3	5
kW cost (US$/kW)	5,828	2,300
kWh cost (US$/kWh)	0.066	0.091
Total cost (Mil. US$)	2.33	0.76
Accessibility	4	4
Survey	Easy	Easy
Construction	Possible	Possible
O & M	Easy	Easy
Acceptability	4	5
Community	The agreement for construction of hydro power is needed between the community and the Government.	No agreement is needed.
Compensation	The agreement for construction of hydro power is needed between the community and the Government.	No agreement is needed.
Economic and Financial	4	3
EIRR (%)	4.26	2.70
FIRR (%)	3.66	1.82
LRMC(US$/kWh)	0.1763	0.1329
Power tariff (US$/kWh)	0.2955	0.1893
Environment problem	5	3
	The environment study is needed in detail, but it seems not to be problem.	Air pollution would be higher than Plan-1.
Land acquisition	4	5
	The ageement is needed among related village/community.	There is no problem.
Remarks	5	3
	This plan is not economical compare to Plan-2. This plan is coordinated with the national energy policy and guidelines.	—
Total point	29	28
Priority	1	2

10.4.4 Evaluation of power supply plan for Kirakira in Makira Province

A point to be considered in regard to the power supply plan is the necessity to develop possible hydro potential sites based on the National Energy Policy and guidelines.

Two power supply plans, which include two hydro potential sites, were prepared taking into consideration this requirement. Waimapuru hydropower has not good profitability and has lower profitability than diesel power source. When Plan-2, which include another hydro potential, and Plan-3, which is only for diesel power source, are evaluated, Plan-2 is the best plan from operation cost and profitability points of view. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-4 Evaluation result on power supply plan for Makira province, Kirakira

Aspect \ Plan No.	1	2	3
Cost	3	5	4
kW cost (US$/kW)	5,255	4,208	2,065
kWh cost (US$/kWh)	0.054	0.046	0.091
Total cost (Mil. US$)	3.36	2.36	1.12
Accessibility	4	4	5
Survey	Easy	Easy	Easy
Construction	Possible	Possible	Easy
O & M	Possible	Possible	Easy
Acceptability	4	4	5
Community	The agreement for construction of hydro power is needed between the community and the Government.	The agreement for construction of hydro power is needed between the community and the Government.	No agreement is needed.
Compensation	The agreement for construction of hydro power is needed between the community and the Government.	The agreement for construction of hydro power is needed between the community and the Government.	No agreement is needed.
Economic and Financial	4	5	3
EIRR (%)	7.53	9.67	3.93
FIRR (%)	6.79	8.92	3.01
LRMC(US$/kWh)	0.2713	0.2256	0.1653
Power tariff (US$/kWh)	0.2901	0.2528	0.1798
Environment problem	5	5	4
	Environment study is needed in detail, but it seems there is no problem.	Environment study is needed in detail, but it seems there is no problem.	Air pollution would be higher than Plan-1 and Plan-2.
Land acquisition	4	4	5
	The ageement is needed among related village/community.	The ageement is needed among related village/community.	There is no problem.
Remarks	3	5	3
	This plan is not economical compared to Plan-2. This plan is coordinated with the national energy policy and guidelines.	This plan is coordinated with the national energy policy and guidelines.	—
Total point	27	32	29
Priority	3	1	2

10.4.5 Evaluation of power supply plan for Lata in Temotu Province

A point to be considered in regard to the power supply plan is the necessity to develop possible hydro potential sites based on the National Energy Policy and guidelines.

Taking into consideration this condition, two power supply plans, hydro potential development plan (Plan-1) and diesel-only power source plan (Plan-2) were prepared. Plan-2, which is not compatible with the National Energy Policy and guidelines, is advantageous against Plan-1 from the economical point of view. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-5 Evaluation result on power supply plan for Temotu province, Lata

Aspect \ Plan No.	1	2
Cost	2	5
kW cost (US$/kW)	11,976	2,307
kWh cost (US$/kWh)	0.106	0.091
Total cost (Mil. US$)	4.79	0.92
Accessibility	5	5
Survey	Easy	Easy
Construction	Possible	Possible
O & M	Easy	Easy
Acceptability	4	5
Community	The agreement for construction of hydro power is needed between the community and the Government.	No agreement is needed.
Compensation	The agreement for construction of hydro power is needed between the community and the Government.	No agreement is needed.
Economic and Financial	1	4
EIRR (%)	-1.87	2.67
FIRR (%)	-2.13	2.53
LRMC(US$/kWh)	0.5092	0.1974
Power tariff (US$/kWh)	0.4714	0.1896
Environment problem	5	4
	The environment study is needed in detail, but it seems not to be problem.	Air pollution would be higher than Plan-1.
Land acquisition	4	5
	The ageement is needed among related village/community.	There is no problem.
Remarks	5	3
	This plan is not economical compare to Plan-2. This plan is coordinated with the national energy policy and guidelines.	—
Total point	26	31
Priority	2	1

10.4.6 Evaluation of power supply plan for Taro and main islands in Choiseul Province

Points to be considered in regard to the power supply plan are as follows:

1. To secure power supply capability for Choiseul main island
2. To secure power supply capability for Taro main island
3. It is necessary to develop possible hydro potential sites based on the National Energy Policy and guidelines.

Taking into consideration above conditions, Plan-1, which includes Sorave hydro potential easily accessible in the main island, and Plan-2, which considers only diesel power source, were prepared and evaluated. Plan-1 is much better than Plan-2, because it is compatible with the National Energy Policy and guidelines and has advantageous operating cost and profitability. Results of evaluation from several aspects are shown below only for reference.

Table 10-4-6 Evaluation result on power supply plan for Choiseul province, Taro & Main Is.

Aspect \ Plan No.	1	2
Cost	3	5
kW cost (US$/kW)	18,231	5,174
kWh cost (US$/kWh)	0.051	0.091
Total cost (Mil. US$)	2.0	0.8
Accessibility	5	4
Survey	Easy	Easy
Construction	Easy	Possible
O & M	Easy	Easy
Acceptability	4	5
Community	The agreement for construction of hydro power is needed between the community and the Government.	No agreement is needed.
Compensation	The agreement for construction of hydro power is needed between the community and the Government.	No agreement is needed.
Economic and Financial	1	3
EIRR (%)	3.66	-5.02
FIRR (%)	3.14	-5.68
LRMC(US$/kWh)	0.5199	0.3270
Power tariff (US$/kWh)	0.6499	0.3063
Environment problem	5	3
	The environment study is needed in detail, but it seems not to be problem.	Air pollution would be higher than Plan-1.
Land acquisition	4	4
	The ageement is needed among related village/community.	The ageement is needed among related village/community.
Remarks	5	3
	This plan is not economical compare to Plan-2. This plan is coordinated with the national energy policy and guidelines.	–
Total point	27	27
Priority	1	2

10.4.7 Evaluation of power supply plan for Gizo area in Western Province

Points to be considered in regard to the power supply plan are as follows:

1. It is necessary to develop possible hydro potential sites based on the National Energy Policy and guidelines.
2. Gizo is the second largest city in Solomon Islands.
3. There is no hydro potential in Gizo Island.

Taking into consideration above points, three plans, which are only for diesel power source, were prepared. Since conditions are the same for the three plans, selection of the best plan is carried out by economical evaluation. Plan-2 is selected as the best option. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-7 Evaluation result on power supply plan for Western province, Gizo

Aspect \ Plan No.	1	2	3
Cost	4	5	5
kW cost (US$/kW)	2,000	2,000	2,000
kWh cost (US$/kWh)	0.091	0.091	0.091
Total cost (Mil. US$)	4.4	3.2	3.2
Accessibility	5	5	5
Survey	Easy	Easy	Easy
Construction	Possible	Possible	Possible
O & M	Easy	Easy	Easy
Acceptability	5	5	5
Community	No agreement is needed.	No agreement is needed.	No agreement is needed.
Compensation	No agreement is needed.	No agreement is needed.	No agreement is needed.
Economic and Financial	4	5	4
EIRR (%)	4.31	4.31	4.31
FIRR (%)	3.37	3.37	3.37
LRMC(US$/kWh)	0.1600	0.1488	0.1532
Power tariff (US$/kWh)	0.1771	0.1771	0.1771
Environment problem	4	4	4
	The environment study is needed in detail, but it seems not to be problem.	The environment study is needed in detail, but it seems not to be problem.	The environment study is needed in detail, but it seems not to be problem.
Land acquisition	5	5	5
	There is no problem.	There is no problem.	There is no problem.
Remarks	3	3	3
	This plan is not coordinated with the national nenrgy policy and guidelines, but there no hydro power potential in the area.	This plan is not coordinated with the national nenrgy policy and guidelines, but there no hydro power potential in the area.	This plan is not coordinated with the national nenrgy policy and guidelines, but there no hydro power potential in the area.
Total point	30	32	31
Priority	3	1	2

10.4.8 Evaluation of power supply plan for Noro-Munda system area in Western Province

Points to be considered in regard to the power supply plan are as follows:

1. It is necessary to develop possible hydro potential sites based on the National Energy Policy and guidelines.
2. It is the third largest city in Solomon Islands
3. There is no hydro potential near Munda or Noro

Taking into consideration above points, two plans, which are only for diesel power source, were prepared. Since conditions are the same for both plans, selection of the best plan is carried out by economical evaluation. Plan-2 is selected as the best option. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-8 Evaluation result on power supply plan for Western province, Noro-Munda

Aspect \ Plan No.	1	2
Cost	4	5
kW cost (US$/kW)	1,800	1,800
kWh cost (US$/kWh)	0.091	0.091
Total cost (Mil. US$)	29.88	25.20
Accessibility	5	5
Survey	Easy	Easy
Construction	Possible	Possible
O & M	Easy	Easy
Acceptability	5	5
Community	No agreement is needed.	No agreement is needed.
Compensation	No agreement is needed.	No agreement is needed.
Economic and Financial	4	5
EIRR (%)	5.60	5.60
FIRR (%)	4.61	4.61
LRMC(US$/kWh)	0.1470	0.1380
Power tariff (US$/kWh)	0.1690	0.1690
Environment problem	4	4
	The environment study is needed in detail, but it seems not to be problem.	The environment study is needed in detail, but it seems not to be problem.
Land acquisition	5	5
	There is no problem.	There is no problem.
Remarks	4	4
	This plan is not coordinated with the national nenrgy policy and guidelines, but there no good hydro power potential in the area.	This plan is not coordinated with the national nenrgy policy and guidelines, but there no good hydro power potential in the area.
Total point	31	33
Priority	2	1

10.4.9 Evaluation of power supply plan for Tulagi area in Central Province

Points to be considered in regard to the power supply plan are as follows:

1. It is necessary to develop possible hydro potential sites based on the National Energy Policy and guidelines.
2. There are no maps to study this area

Taking into consideration above points, two plans, which are only for diesel power source, were prepared. Since conditions are the same for both plans, selection of the best plan is carried out by economical evaluation. Plan-2 is selected as the best option. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-8 Evaluation result on power supply plan for Western province, Noro-Munda

Aspect \ Plan No.	1	2
Cost	4	5
kW cost (US$/kW)	1,800	1,800
kWh cost (US$/kWh)	0.091	0.091
Total cost (Mil. US$)	29.88	25.20
Accessibility	5	5
Survey	Easy	Easy
Construction	Possible	Possible
O & M	Easy	Easy
Acceptability	5	5
Community	No agreement is needed.	No agreement is needed.
Compensation	No agreement is needed.	No agreement is needed.
Economic and Financial	4	5
EIRR (%)	5.60	5.60
FIRR (%)	4.61	4.61
LRMC(US$/kWh)	0.1470	0.1380
Power tariff (US$/kWh)	0.1690	0.1690
Environment problem	4	4
	The environment study is needed in detail, but it seems not to be problem.	The environment study is needed in detail, but it seems not to be problem.
Land acquisition	5	5
	There is no problem.	There is no problem.
Remarks	4	4
	This plan is not coordinated with the national nenrgy policy and guidelines, but there no good hydro power potential in the area.	This plan is not coordinated with the national nenrgy policy and guidelines, but there no good hydro power potential in the area.
Total point	31	33
Priority	2	1

10.4.10 Evaluation of power supply plan for Rennell area in Rennell and Bellona Province

Points to be considered in regard to the power supply plan are as follows:

1. It is necessary to develop possible hydro potential sites based on the National Energy Policy and guidelines.
2. There is a low possibility to construct a diesel power plant because a wharf could not be constructed.
3. There is no hydro potential judging from geographical features.

Taking into consideration above mentioned points, two plans, based on the use of solar energy, were prepared. However, since the team has not investigated the site and no statistical wind data has been available, both plans are only for reference. Since conditions are the same for both plans, selection of the best plan is carried out by economical evaluation. Plan-2 is selected as the best option. Results of evaluation from several aspects are shown below for reference only.

Table 10-4-10 Evaluation result on power supply plan for Rennell & Bellona province, Rennell

Aspect \ Plan No.	1	2
Cost	5	5
kW cost (US$/kW)	25,000	25,000
kWh cost (US$/kWh)	0.000	0.000
Total cost (Mil. US$)	4.00	4.00
Accessibility	5	5
Survey	Possible	Possible
Construction	Possible	Possible
O & M	Possible	Possible
Acceptability	5	5
Community	No agreement is needed.	No agreement is needed.
Compensation	No agreement is needed.	No agreement is needed.
Economic and Financial	5	4
EIRR (%)	1.70	1.70
FIRR (%)	4.68	4.68
LRMC(US$/kWh)	4.6539	4.7935
Power tariff (US$/kWh)	3.2273	3.2273
Environment problem	4	4
	Environment study is needed in detail, but it seems there is no problem.	Environment study is needed in detail, but it seems there is no problem.
Land acquisition	5	5
	There is no problem.	There is no problem.
Remarks	4	4
	This plan is coordinated with the national energy policy and guidelines, but the plan has a high cost.	This plan is coordinated with the national energy policy and guidelines, but the plan has a high cost.
Total point	33	32
Priority	1	2

Table 10-5-1 Optimum power supply development scheme in Solomon Islands

Province	Guadalcanal	Malaita	Isabel	Makira	Temotu	Choiseul	Western		Central	Rural electrification by SHS
Island	Guadalcanal	Malaita	Santa Isabel	San Cristbal	Santa Cruz	Choiseul	Gizo	New georgia	Tulagi	Solomon Islands 9 provinces
Demand center	Honiara-Lungga	Auki-Malu'u	Buala	Kirakira	Lata	Taro & Choiseul	Gizo	Noro-Munda	Tualgi	Solomon Islands 9 provinces
Plan No. / Fiscal Year	3	3	2	2	2	1	2	2	2	-
1998	-	-	-	-	-	-	-	-	-	-
1999	Lungga diesel No.9 (3900kW) installed	-	-	-	-	-	-	-	-	-
2000	Lungga diesel No.10 (4200kW) install, Lungga diesel No.4 & No. 5 (1000kW*2) and Honiara diesel No. 5 & No. 6 (500kW*2) retire	Auki diesel 2 units (200kW*2) replace, Malu'u diesel 1 unit (83kW) install			-	New diesel No.1 & 2 (20kW*2) develop in Taro Is.	Gizo diesel 2 units (200kW*2) replace	-	-	-
2001	-	Bina diesel No.1 unit (1500kW) develop, existing diesel 1 unit (208kW) retire	-	New diesel No.4 (200kW) install	-	-	-	Noro new diesel No.4 & No.5 (2000kW*2) extend	-	Pilot scheme First year 36Wp SHS 200 sets, 55Wp SHS 50 sets, 75Wp SHS 39sets
2002	-	Bina diesel No.2 unit (1500kW) install	-	-	-	-	New diesel No.4 & No.5 (300kW*2) install	-	-	Pilot scheme Second year Monitoring
2003	Lungga diesel No.11 (5000kW) develop	Bina diesel No.3 unit (1500kW) install, Rori hydro (300kW) develop	-	-	-	Sorave hydro (70kW) develop in Main island	Existing old diesel No.3 (170kW) retire	-	-	Pilot scheme Third year Monitoring
2004	Lungga diesel No.12 (5000kW) develop, Lungga diesel No.7 (2300kW) retire	-	-	New diesel No.5 (170kW) install	-	-	-	-	-	-
2005	-	-	New diesel No.2 (160kW) install	-	New diesel No.4 (200kW) install	-	-	New diesel No.6 & No.7 (2000kW*2) extend	New diesel No.3 (60kW*1) extend	Nationwide scheme first year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2006	-	-	-	-	-	-	New diesel No.6 (300kW*1) install	Existing old diesel No.1 (900kW) retire	-	Nationwide scheme second year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2007	Lungga diesel No.13 (5000kW) install	-	-	-	-	-	-	Existing old diesel No.2 (900kW) retire	-	Nationwide scheme third year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2008	Lungga diesel No.8 (3600kW) retire	-	-	-	-	-	-	Existing old diesel No.3 (900kW) retire	-	Nationwide scheme 4th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2009	-	Ruala'e hydro (200kW) develop	Kubolata hydro (80kW) develop	-	-	-	-	-	-	Nationwide scheme 5th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2010	Maotapuku 1 & 2 (1600kW, 1400kW) develop	-	-	-	-	-	-	New diesel No.8 & No.9 (2000kW*2) extend	-	Nationwide scheme 6th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2011	-	-	-	New diesel No.6 (170kW) install	-	-	-	-	-	Nationwide scheme 7th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2012	Lungga diesel No.14 (5000kW) install	-	New diesel No.3 (160kW) install	Existing old diesel No.1 (60kW) retire	New diesel No.5 (200kW) install	-	-	-	-	Nationwide scheme 8th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2013	-	Silolo hydro (2100kW) develop	Existing old diesel (62kW) retire	Existing old diesel No.2 (50kW) retire	Existing old diesel No.1 (60kW) retire	-	-	-	-	Nationwide scheme 9th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2014	-	-	-	-	Existing old diesel No.2 (40kW) retire	-	-	-	-	Nationwide scheme 10th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2015	-	-	-	-	Existing old diesel No.3 (60kW) retire	-	New diesel No.7 (300kW*1) install	-	-	Nationwide scheme 11th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2016	Lungga diesel No.15 (2000kW) install	-	-	-	-	-	-	New diesel No.10 (2000kW*1) extend	-	Nationwide scheme 12th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2017	-	-	-	-	-	-	-	-	-	Nationwide scheme 13th year 36Wp SHS 270 sets, 75Wp SHS 27 sets
2018	-	-	-	-	-	-	-	-	-	Nationwide scheme 14th year 36Wp SHS 270 sets, 75Wp SHS 27 sets

CHAPTER 11

INSTITUTIONAL BUILDING IN ELECTRICITY SECTOR

Chapter 11 Institutional Building in the Electricity Sector

Institutional building is a key factor for planning, implementation and management of any type of project. This chapter provides the data, information, and analysis used to plan an effective institutional framework for promoting rural electrification. It also presents the framework based on this analysis. First of all, information on the current institutional setting for electricity service is provided. Secondly, the chapter analyzes the planning issues for structuring an institutional framework. Lastly, it presents an institutional framework for rural electrification.

11.1 Overview of Stakeholders in Electricity Sector

Fig. 11-1-1 identifies the stakeholders in the electricity sector and the relationships between them. In choosing a desirable institutional framework, it is important to carefully scrutinize characteristics of the existing and potential stakeholders, as well as the related policy and legal framework.

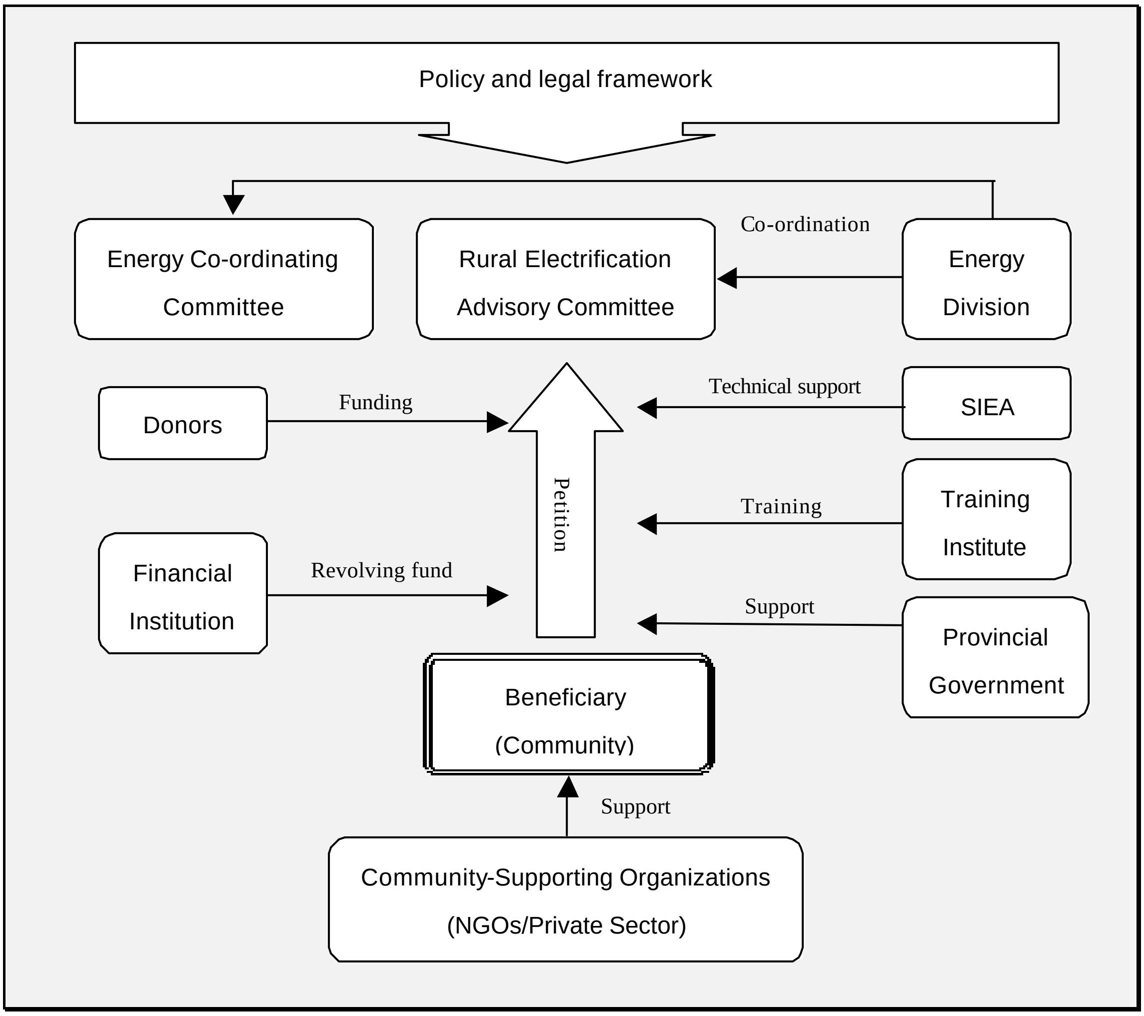

Fig. 11-1-1 Institutional framework for rural electrification

11.1.1 National Energy Policy Statement & National Energy Policy and Guidelines

The National Energy Policy Statement (the Statement) was made and approved by the government in December 1998. It defines national policy for the energy sector for the next 10-15 years and provides the framework within which stakeholders make decisions on issues such as operation planning and management and long-term investment.

The National Energy Policy and Guidelines (the Guidelines), on the other hand, expand upon the Statement by setting out guidelines that are the energy sector's blueprint for formulating working plans. The Guidelines define the roles of the National Coordinating Committee and Rural Electrification Advisory Committee, both of which are to be established this year. They also define the roles of existing institutions such as the Energy Division and NGOs. The Guidelines states the goals to be realized through the promotion of rural electrification as follows:

- To contribute to the health and well-being of the entire rural population;
- To promote the efficiency and productivity of the rural economy;
- To directly and indirectly generate employment and income in the rural areas; and
- To ensure that the quality and sustainability of the rural environment is maintained.

11.1.2 Electricity Act

The Electricity Act of 1968 is the law that authorizes the establishment of SIEA as a statutory authority for promoting the generation and distribution of electricity, contributing to the social and economic development of the country. The Act also regulates issues such as licensing for electrical work, as well as the institutional, financial, and operational matters of SIEA.

11.1.3 Energy Coordinating Committee/Rural Electrification Advisory Committee

The Energy Coordinating Committee (ECC) is held when issues influencing the national energy interest have arisen. Its members are from the ministries concerned, including the Ministry of Natural Resources (MNR), the Solomon Islands Electricity Authority (SIEA), and major energy suppliers and users. The meeting was convened in 1997 when fuel stocks for electricity generation declined to a reserve of only three weeks. Any serious energy issue will lead to the assembly of the ECC.

The Rural Electrification Advisory Committee (REAC) has not yet started. REAC assumes a primary responsibility for coordinating and promoting rural electrification programs. A lack of communication and coordination on energy issues was observed in the past between concerned ministries, such as Health & Medical Services, Education, and Natural Resources. REAC expects to begin operation once the Energy Division of the MNR has recruited staff to fill vacant positions, reshaped its organizational structure to effectively conduct its tasks, and secured funding for rural electrification projects. Members include ministries concerned with electrification, SIEA, the private sector, donors and the Energy Division. NGOs are expected to participate in REAC on a rotational basis.

11.1.4 Energy Division, Ministry of Natural Resources

Energy Division currently has nine professional positions, though four positions are vacant. The recruitment of new staff has been delayed, as the position of Chief Administrator (and recruiting director) of the MNR had been vacant. The Division also plans to restructure once all vacant positions are filled. Two officers are planned for assignment to the Deputy Director. One will be responsible for the management of the Division as a whole and the other responsible for rural electrification projects. The Division has its own budget for training for solar power systems, while the budget is also allocated to other projects such as the construction of a national fuel depot and the study of the Komarindi/Lunga hydroelectric power project.[1] Table 11-1-1 shows the list of energy related projects expected to be implemented in 2000.

Table11-1-1: Development budget for electricity affairs and services in 2000 (Unit: SB$)

Project title	Source of funds	Loan or grant	Cash	Non-cash
Provincial Centers Electrification	ADB	Loan	3,000,000	0
Bina Harbour-Malu's Transmission Line	ADB	Loan	3,000,000	0
Komarindi/Lungga Power Plant	Government	Grant	500,000	0
Wartsila Diesel Generator Installation	World Bank	Loan	1,600,000	0
National Fuel Farm	ADB	Loan	1,000,000	0

Source: Solomon Islands Government 2000 Draft Development Estimates

11.1.5 Solomon Islands Electricity Authority

Solomon Islands Electricity Authority (SIEA) was established according to the provisions of the Electricity Act of 1968. SIEA is a statutory authority responsible for electricity generation and distribution meant to contribute to the national development of the Solomon Islands.

This chapter examines the operation of SIEA from five critical perspectives relating to the operation of an organization: (1) financial status; (2) internal business process; (3) human resources; (4) customer relations, and (5) mission.

(1) Financial status

(a) Tariff

The electricity tariff was raised in August 1999, following a previous raise in September 1998. Its proposal had been already submitted to the government for approval by March 1999. The delay was caused by the replacement of the Permanent Secretary of the MNR. The government agreed that it would compensate for the loss of revenue that would have otherwise accrued from this increase between March and August. They will apply a 50% reduction of duty on imported fuel and capital goods.

In addition, SIEA has been strengthening inspections of current electricity users. This has succeeded in identifying illegal wiring, leading to increased revenue. One hotel in Honiara was found to have used electricity illegally, accumulating an outstanding bill of 600,000 SB$. Only 280,000 SB$ of the outstanding amount has so far been collected by SIEA.

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[1] *Solomon Star*, November 26, 1999

Ethnic tension in Guadalcanal Island had a negative affect on the operational and financial condition of SIEA. For safety reasons, SIEA stopped sending staff to collect tariffs in the affected area. Some people illegally occupied the houses of others and used their electricity, partially offsetting the increased revenue. SIEA then decided to stop electricity transmission to those areas, but plans to transmit electricity to those genuine users who are ready and willing to pay the tariff.

SIEA is still delaying the repayment of a loan from the Asian Development Bank and the National Provident Fund that was used for the purchase of generators. They are currently four to five months behind schedule on the loan. The situations described above have had both positive and negative effects on the financial position of SIEA. The outcome has yet to be seen.[2]

(b) Cash Power 2000[3]

Cash Power 2000 has been running since March 1999. It is currently being installed at the rate of 40 units per month. As it costs as much as 100 US$ per unit, SIEA is planning to purchase in bulk jointly with the electricity authority of Papua New Guinea. This is expected to significantly reduce the unit price. Equipment costs are recovered through users' prepayment. 10% of prepayment is allocated for payment of the equipment and installation cost.

The installation of Cash Power 2000 is targeted particularly at users with delinquent payment records, government agencies, as well as new subscribing users.

(2) Internal business process

The internal business process within SIEA and in its relations with the supervising ministries has been lengthy and inefficient. SIEA has two supervisory ministries at present, the Ministry of Finance (MF) and the MNR.

Although MF and MNR are still supervising SIEA, the internal business process has changed to some extent. SIEA used to report financial matters to MF and operational matters to MNR. However, it is now reporting both to the latter. MNR now handles matters with MF.

Recently, SIEA requested permission from MNR to release equipment from storage as costs were increasing. MNR's action made it possible, which in turn improved the maintenance operation of SIEA, as well as reduced the storage cost.

(3) Human resources

In keeping with the movement toward more efficient operation, SIEA has taken several steps to improve the performance of the staff. Firstly, SIEA has introduced a system of fixed-term contracts for the management team. The team is employed by SIEA on a three-year contract basis and the board

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[2] See Chapter 12 for the detailed analysis of the financial position of SIEA.

[3] Cash Power 2000 is the equipment that records and displays the amount of electricity available to users. Before users remaining electricity reaches zero, they are required to pay a specified sum of money in order to obtain a password , which authorizes them to use a specified amount of electricity.

of directors decides whether to renew the contract, based on their performance. Secondly, an evaluation system for senior and junior staff has been introduced to ensure a high standard of work. Furthermore, SIEA has recently enacted redundancy measures. Fifteen line and administrative staff were made redundant in 1998. In 1999, compulsory retirement of those over 50 years old was enforced and redundancy measures are still being carried out. As a result, the number of SIEA staff, including the management team, decreased to nearly 200.

(4) Customer relations

Presently, SIEA is not regularly monitoring customer feedback and factoring it into the operation. However, SIEA has taken several measures on an ad hoc basis to raise awareness among users. For example, SIEA's image-building and awareness-raising campaign was expected to start early this year. It will be implemented primarily through posters.

(5) Mission

The management team is discussing "SIEA Corporate Plan 2000-2010" with Board members. It is likely to be finalized in December 1999 and is expected to be implemented in January 2000 pending Board approval. On the other hand, the MF reviewed and analyzed the operation of SIEA this year. It plans to tender a one-year management contract to an independent third party with an optional one-year extension. This is intended to strengthen SIEA's organizational and managerial ability. Privatization is considered by the Ministry of Finance to be a long-term objective. Thus, the future of SIEA has not yet been decided. Whatever measures are taken, they should achieve the following objectives.

1. Improvement of collection rate of electricity tariff
- Promotion of ongoing "Cash Power 2000" installation
- Expansion of compulsory electricity disconnection to default users (especially to statutory organizations)

2. Efficiency of generation and distribution of electricity
- Introduction of wireless monitoring for outstations' operation[4]
- Improvement of maintenance work for generating and distributing facilities

3. Strengthening of management capability
- Contract out of management the Ministry of Finance is currently planning for tender
- Formulation of Corporate plan

4. Increase of electricity tariff
- Increase of electricity tariff up to the level enough to produce operational profit

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[4] SIEA referred to an idea of installing wireless monitoring systems to outstations to monitor generating and distributing operation, though the possibility of implementation is not clear.

11.1.6 Non-governmental organization

There are more than 50 non-governmental organizations (NGOs) in the Solomon Islands. The majority of them are under the Development Services Exchange, the NGOs umbrella organization. While the interests and activities of those NGOs are diverse, there are two NGOs that concentrate on rural electrification: the Guadalcanal Rural Electrification Agency (GREA) operates solar home systems (SHS) projects; and Appropriate Technology for Community and Environment (APACE) implements micro-hydropower projects.

(1) GREA

GREA implemented three SHS projects at the community level so far.[5] The Sukiki village project was seriously damaged by the conflict with the Guadalcanal Revolutionary Army (GRA).[6] In the battle with the GRA, seven solar panels were broken and twelve houses were burned down. Although Sukiki village reached a peace agreement with the GRA, who promised to compensate them for the damage and loss of property, no compensation had been paid at the time of this survey.

Payments of users in Sukiki village are expected to end in April 2001. After that, users will take complete responsibility for the operation and maintenance of the project, including the replacement of used batteries. However, as all users are not yet ready to pay for new batteries (which will occur in the next few years), the sustainability of the project is still uncertain.

(2) APACE

APACE recently visited potential sites for micro-hydropower generation in Makira, Choiseul, Isabel and Malaita provinces. APACE plans to implement one micro-hydropower project this year as the Activities Implemented Jointly (AIJ) Project funded by Australia.

Table 11-1-2 Current status of APACE micro-hydropower projects in Kolombangara

Village	Monthly tariff	Status
Iriri	10 SB$ per household	Operating
Vavanga	2SB$ for kitchen, 4 SB$ for house	Not operating
Ghatere	N/A	Not operating[7]

Source: APACE Honiara office

[5] See Table 7-2-1 for a list of SHS projects already implemented and being planned by GREA.

[6] The conflict started in August 1999 when the GRA demanded that the Sukiki village comply with traditional ways of living. The village refused the demand.

[7] APACE plans to fund the replacement of a turbine.

Table 11-1-3 Source of Fund

Village	Source of fund
Iriri	UNIDO
Vavanga	AusAID
Ghatere	Adventist Development Relief Agency
Manawai	EZF (German church)
Buelavata	Catholic Relief Fund

Source: APACE Honiara office

11.1.7 Training institutes

There are several potential organizations that could become training institutes for rural electrification. Firstly, Solomon Islands College of Higher Education (SICHE) has a School of Industrial Development and a program of electrical study. Students study theory for two years and complete practical work for the final two years in the program. Graduates of the program can apply for a grade 'A' electrician's license from SIEA after having practiced for six months in the field and passed the exam. Secondly, rural training centers (RTCs) target young dropouts and offer practical courses such as mechanics, agriculture and others.[8] Lastly, Willies Electrical Skills Center (WESC) was started by a former lecturer at SICHE and specializes in courses that assist secondary school dropouts and produce skilled electricians. In November 1999, five students holding grade 'A' licenses and twelve students with basic-level certificates completed the first course at WESC.[9] While SICHE and WESC could offer the training courses for SHS and micro-hydropower, RTCs could effectively provide the training venues for the course with the appropriate assistance of external or domestic experts.

11.1.8 Community organizations

All villages surveyed showed relatively democratic decision-making. Decisions affecting villages are based on the consensus of the villagers, though the village committee discusses issues first and does make a preliminary decision. Chapter 8 identifies the types of village organizations that were commonly observed in the villages survey by the JICA Study Team.

11.1.9 Donors

Donors have been steadily increasing the assistance to the Solomon Islands. Although it is in the draft stage, the government has produced an estimated development budget. This budget projects external assistance of 196 million SB$ in 2000, approximately 93% increase from 1999. In particular, ADB is expected to increase its loan from 2.6 million SB$ in 1999 to 24 million SB$ in 2000, while the World Bank will increase from 8 million SB$ in 1999 to 23.5 million SB$ in 2000.[10]

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[8] See the case of Tasia RTC in Appendix.

[9] *Solomon Star*, November 19, 1999

[10] Actual disbursement of the donors' fund is likely to be affected by current ethnic tension.

Table 11-1-4 Estimated development budget

	1998 Estimates	1999 Estimates	2000 Estimates	Difference
Overseas loan	27,243,723	26,600,000	60,366,000	33,766,000
Domestic grant	19,500,000	30,000,000	30,000,000	0
Overseas grant	61,579,656	59,198,000	105,856,000	46,658,000
Total	**108,323,379**	**115,798,000**	**196,222,000**	**80,424,000**

Source: Solomon Islands Government 2000 Draft Development Estimates

Note: Figures exclude non-cash contributions.

11.1.10 Financial institutions

(1) Development Bank of the Solomon Islands

The Development Bank of the Solomon Islands (DBSI) engages mainly in savings and loans operations nationwide. It offers loans to the agricultural, service and commercial sectors, though working capital is not eligible for loans. In lending, DBSI limits the amount of the loan to no more than 65% of the total cost and requires the applicants to provide collateral of the following type:

1. Registered land (customary land is not accepted as collateral);
2. Assets (to be purchased by the loan); and
3. Guarantees (to be provided by the organizations such as the Ministry of Commerce, Central Bank or National Provident Fund).

The Rural Development Constituency Fund, which started in 2000 and is administered by DBSI, is assisted by Taiwanese aid. Part of this money, the Equity Trust, totalling 50,000 SB$, will be initiated to support the equity that is not met by loans, but must be financed by the borrowers. The rest of the money (i.e. 250,000 SB$) is offered to rural communities through the members of Parliament to be used for welfare-oriented activities. This portion is offered at a preferential interest rate of 10%, compared to the 14% rate for lending to the agricultural sector and 16% to other sectors.

(2) Credit unions

There are 163 registered credit unions with a membership reaching up to 16,000, with women holding a 40 percent share. While 34 credit unions are located in urban areas, the rest are in rural areas. The volume of lending as of the end of 1998 reached 21 million dollars. Credit unions operate under the Credit Union Act and belong to the Solomon Islands Credit Union League.

Maximum amounts of loans vary depending on the sum of the equity contribution of members of credit unions.[11] If a member has equity of $100, he or she can borrow up to 100 SB$. The union does not require collateral and a guarantor, but the equity is regarded as collateral. If a borrower defaults, the union will take the equivalent amount of equity. The union is flexible in deciding what amount

[11] See the case of Gomania Credit Union in the Appendix for a brief description of the credit union's operation.

borrowers must repay, depending on their disposable income.

11.2 Analysis of Planning Issues

Based on the findings, planning issues are presented and analyzed here in order to aid the creation of an action plan for effective institution building. The analysis focuses on electrification through SHS and micro-hydropower generation and targets communities in rural areas. The issues to be reviewed here are shown in Fig. 11-2-1.

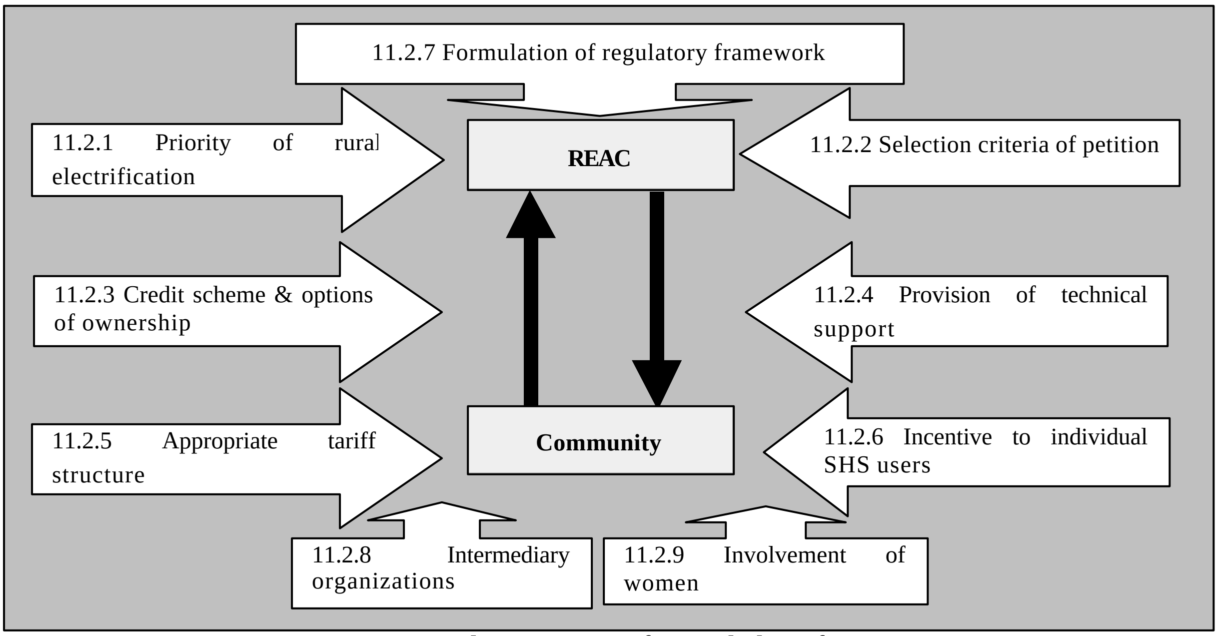

Fig. 11-2-1 Planning issues for rural electrification

11.2.1 Priority of rural electrification

The issue of targeting is critical, because limited resources are likely to deter organizations concerned from promoting nationwide rural electrification. In this section, the possibility of targeting public facilities such as clinics and schools is discussed. This is followed by an analysis of the selection of particular geographical areas and particular social groups.

Table 11-2-1 Comparison of priority targets for rural electrification

Target	Positive impact	Cost recovery	Remarks
Schools	AAA	AAA	Consensus of parents is required.
Clinics	AAA	A	Users willingness to pay is unknown.
Churches	AA	AAA	Use of church buildings is generally limited to religious purposes.
Targeting based on geographical location	?	?	Positive impact and cost recovery depend on project area selection. Selection of particular islands/areas is politically difficult.
Social strata group (poor)	AAA	A	Cost recovery period is long.

Note: AAA; possibility is high, AA; medium, A; low

(1) School

Primary schools need electricity for lighting for night study. In particular, students in standard 5 and 6 need to prepare for national examinations.[12] The provision and installation of SHS in classrooms for lighting could be beneficial, especially in the non-electrified areas where students are forced to study under the dim light of kerosene lamps. Secondary schools with boarding facilities need access to electricity for night lighting for students. Electricity can be also used to power electric appliances for mechanics and agriculture classes.

The Ministry of Education is responsible for paying the salaries of teachers and providing textbooks. However, the maintenance of school facilities is the responsibility of each community. The financing of SHS and micro-hydropower equipment seems more feasible, because schools have channels for raising money from parents through increased school fees or other fundraising activities. For example, Gizo Community School charges a primary school fee of 150 SB$ and 400 SB$ for a secondary school fee. Jejebo Community School charges 50 SB$ for the former and 400 SB$ for the latter.

(2) Clinic

Potential uses of electricity at rural clinics lie mainly in medical equipment, refrigerators for storing vaccines, wireless telephones for communicating patients' referrals, and lighting for medical examination and delivery at night. The greatest needs of provincial hospitals and health centers having inpatients facilities are in the operating room. There is also a need for fans and air conditioning, in addition to the needs mentioned above. Hospitals that have access to electricity through a grid extension may be able to use SHS as a standby to be used, for example, for limited lighting.

A barrier to the electrification of clinics in rural areas is insufficient cost recovery. In principle, public clinics do not charge patients for medical treatment and prescriptions. Operational costs rely almost entirely upon the funding of the Ministry of Health and Medical Services and the provincial governments, though there are some exceptions. Last year, for example, Buala Hospital raised money from the communities through fund raising activities. Taro Health Center charges a small medical treatment fee (0.2 SB$ or local food) to outpatients. Auki Area Health Center charges a 0.1 SB$ treatment fee. These examples indicate that rural clinics may have alternative channels for raising money, in addition to government grants.

(3) Church[13]

The need for electrification of churches is in lighting for night gatherings. The majority of villages surveyed regularly hold night gatherings at churches with lighting powered by diesel generators or kerosene lamps. Christ the King Cathedral in Malaita province is a case in point. The church has been

[12] Primary schools in the Solomon Islands have students from standard 1 to 6.

[13] The JICA survey team observed that some villages have meeting halls that are used for public purposes. Meeting halls are identified as public facilities in this report.

using solar panels and fluorescent lights for night gatherings since 1988.[14] The church holds a one-hour gathering every evening between 6 and 7 p.m. It should be noted, however, that churches are normally only used for religious purposes, not for other public gatherings.

One advantage in targeting churches is the relative ease of raising funds. The Study Team found that the communities in this country are generally active in fund raising for construction and improvement of church buildings and facilities.

(4) Targeting based on geographical location

Another issue in question is whether specific islands or areas should be selected as target sites for the rural electrification project. Geographical selection can be justified by the limited resources and capacity of the implementing organizations. This method is also practical in a country where a large number of small rural villages are widely dispersed. This dispersion creates difficulty in transportation, communication and logistics resulting in increased costs for nationwide rural electrification projects.

The areas having nearby SIEA outstations with technical staff could be potential target areas. Their operation and maintenance would be relatively easy and less costly. Selection of one or more islands is another option, however, a political decision by the government will be required, rather than one based strictly on economic analysis. This method could result in the efficient allocation of resources by concentrating them in a limited geographical area. However, this decision is unlikely, given current biases and the constant pressures of interest groups.

(5) Social strata groups

Though the Statement states that rural electrification should contribute to the improvement of welfare, it does not necessarily argue that it should target poorer areas in order to realize its objective. If the rural electrification project puts a priority on welfare, that is, improving the livelihood of the poor, the monthly tariff should be set at a level low enough for them to pay.

However, affordable tariff levels targeted at the poor may increase the number of petitions and result in the application of a strict assessment of the ability to pay as a selection criterion. There is a possibility that the project may fail to reach the target groups. REAC may select only those groups that have the ability to pay, in order to avoid defaults and make the project sustainable. If it is to set the tariff affordable to the poor, REAC should allocate a certain percentage of the budget to this group in order to avoid the aforementioned situation.

Full cost recovery is considered an important condition for guaranteeing the financial sustainability of the project. However, it does not mean that those who do not have the ability to pay should be neglected. As an alternative measure, REAC may target the poor by electrifying public facilities; where cost recovery is easier. The installation of SHS to individual houses is targeted mainly at wealthier groups with the financial means to pay.

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[14] The panels, batteries and lights were donated by an Australian family whose son died in this village. Operation and maintenance costs of the church are borne by the family via the Church of Melanesia.

11.2.2 Selection criteria of petition

Whichever areas and groups are targeted, the criteria for selecting petitions are critically important and should be strictly applied to the selection process, since it is likely that REAC receives more petitions than it can fund. The Guidelines define five criteria for this purpose. These criteria are discussed based on the findings of the survey.

Criteria for selection of petitions

1. Proven ability of beneficiaries to contribute to the project
2. Established development plan for the area and/or the community
3. Resource owners (land, water) agree with the project
4. The proposed technology option is the least-cost option (lowest life-cycle costs)
5. Rural electrification project supports other rural development activities in the area

(1) Ability to pay

The JICA village survey found that different villages have different sources of income, which are influenced by factors such as access to markets, availability of wage-work opportunities, and so on.[15] Though it is next to impossible to prove income levels in the Solomon Islands through any sort of official documents, the petition should, at least, identify income sources and approximate levels of income. This will enable REAC to assess and compare the ability to pay among the communities.

The survey also revealed that an income gap exists between villagers in the same village. Wealth and income gaps make it difficult to achieve agreement among all members of a particular community for submitting a petition. This is especially evident when discussing an application for a rural electrification project and the issue of who pays and what cost, regardless of wealth and income level.[16]

To avoid tariff default caused by an inability to pay, REAC may need to allow communities to submit the petition without the consensus of all community households. This means that poorer households unable to pay may be voluntarily or compulsorily excluded from the petition. During the workshop, which will be explained later, communities may accept a self-screening process. Down payments could be used as an indicator of the ability to pay. If potential users have made large cash investments in advance for the equipment, they are less likely to default.

Although communities assume an obligation for collecting tariffs, “Cash Power 2000” could be an alternative measure. The justification for the installation of a “Cash Power 2000” prepayment scheme is its effectiveness in preventing default payments. It reduces the likelihood that payment regularity will be influenced by a household’s financial situation (especially income fluctuations). Those who do

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[15] See Chapter 8 for the analysis of income in rural areas.

[16] In the case of Sukiki village most of the villagers participated in the SHS project in the beginning, but a few withdrew from the project due to their inability to pay the tariff.

not pay simply cannot use the system. This is especially effective for micro-hydropower projects.

(2) Needs assessment

Communities can identify and prioritize their needs by using a ranking method.[17] The survey revealed that the priority of needs felt by communities varies depending on social, economic and geographical characteristics. Although needs can be assessed in the workshop, the communities should identify their prioritized needs in their petition. With the assistance of the concerned organization, efforts should be also made to produce a development plan for a community, as in the project funded by UNDP.[18] In the case of micro-hydropower projects, the potential for initiating income-generating activities needs to be considered as an important criterion in selecting villages.

(3) Agreement of resource owners

According to the Guidelines, an agreement by resource owners on the project site is one of the requirements to be included in a petition. However, a written agreement by resource owners may not necessarily be enough, particularly when they do not benefit from the project. It could lead to intentional subversive actions and delay of construction.[19] To avoid this, measures ensuring benefit to resource owners may need to be taken in consideration.

(4) Establishment of electricity committee

An absence of the committee in charge of a project does not necessarily mean a community is negligent. However, to make their responsibility clear, the establishment of an electricity committee and the assignment of the community members to that committee should be a requirement of a petition.

A community normally has several committees based on functions, as explained in Chapter 8. Despite the varying degree of activities, the request to establish a new committee is unlikely to impose an intolerable burden on the community side, as they have experience in establishing and running a committee.

(5) Informed decision making

REAC should disseminate relevant information through workshops to the communities planning to submit the petitions and assist them in making informed decisions.[20] Although the villages surveyed by the JICA Study Team knew what SHS and micro-hydropower generation were like, it does not

[17] See Chapter 8 for the issue of needs assessment in detail.

[18] In cooperation with the Department of Provincial Government and Rural Development, UNDP is currently implementing "Solomon Islands Development Administration and Participatory Planning Program (SIDAPP). It is assisting selected constituencies in producing socio-economic profiles, formulating development plans and identifying potential projects.

[19] See the case of Fulikaomae village in Appendix for this issue.

[20] Possible contents of workshop are explained in 11.3.2 (2).

guarantee that they all recognize the costs and benefits and other aspects.

11.2.3 Credit scheme and options of ownership

The majority of the villagers interviewed did not have any experience in borrowing money from a formal financial institution.[21] The areas serviced by bank branches are limited to the capital and provincial centers. Although this chapter originally viewed financial institutions as potential credit providers, facts suggest that payments should be collected as electricity tariffs, rather than loan payments. This would reduce the costs involved in processing individual loan applications and producing loan contracts. REAC should establish its own revolving fund to finance rural electrification projects and prepare the operational procedure, instead of structuring special credit schemes for individuals.

Options of ownership are another important issue, especially in the case of SHS. The case of the Sukiki village project provides insight on this issue. When asked about maintenance, villagers recognized their own responsibility for covering the cost of replacing used batteries. This would be coming in the next few years and would be expensive, but they were not prepared to save enough money yet. Although it is difficult to decide whether ownership should be transferred to users or retained and serviced by the implementing organization, the case of Sukiki suggests that REAC should provide electricity to users for the lifetime of the SHS project. This would circumvent SHS operation stoppages resulting from the failure to replace used batteries. REAC would also retain ownership of the equipment. It also suggests that the tariff should be calculated based on capital and operational costs, as well as the cost for batteries. Users should have to pay a tariff for 20 years, which is the assumed lifetime of an SHS project.

11.2.4 Provision of technical support

Those involved in the rural electrification project need appropriate training. A lack of training in operation and maintenance can easily lead to fatal technical failure, as observed in the case of the Taro Health Center.[22]

However, the Energy Division and SIEA have limited technical capabilities in SHS and micro-hydropower. To reach the target groups without placing a heavy burden on REAC and to reinforce the capability of the Division and SIEA, it may be necessary to organize and train licensed electricians and provincial government engineers to assist in operation and maintenance as advanced technical experts.[23] It could also extend the geographical coverage of rural electrification projects beyond what the Division and SIEA alone can cover.

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[21] There was a case in which one village borrowed money from the DBSI for their plantation project.

[22] See this case in Appendix.

[23] The number of electricians holding A grade licenses is said to reach approximately 100 in the country.

11.2.5 Appropriate tariff structure

SIEA currently applies a unitary tariff schedule to users based on user categories. This warrants further study to see if a similar unitary tariff schedule should be applied to the communities with rural electrification projects. The SHS projects in Sukiki and Makaruka village apply different tariff levels, which are seen in the different costs of the equipment imported at different times. Micro-hydropower projects implemented by APACE also have different levels of tariffs.

A tariff schedule should be chosen cooperatively by communities, based on seasonal fluctuations in their income levels, if any exist. However, the total sum of the tariffs collected must at least meet the cost-recovery payment level determined by REAC. The communities need to be informed of their potential costs for maintaining the system before they decide on a tariff level.

REAC should allow users to pay tariffs more quickly when they earn casual income. The advantage here is that REAC's revolving fund cash flow would be improved. If users complete payments in less than 20 years, they maintain the right to receive the service for 20 years, including battery replacement costs. It is worth noting, however, that users are prohibited from the resale of SHS, even when they have completed payments. REAC maintains ownership. Moreover, battery replacement should be limited to a total of two during the lifetime of the SHS in order to limit REAC's costs and to provide incentive to users to utilize the system properly.

11.2.6 Incentive to individual SHS users

Considering the limited financial resources available to implementing organizations, much effort is needed to promote the installation of SHS for individual users by private dealers. However, the high import duty still remains a disincentive for private users.

It will become necessary to reduce the import duty to make the cost of SHS more affordable to individual users. An example of this, the Rural Water Supply and Sanitation project (RWSS project) funded by Australia, is the sale of materials such as pipes and cement with reduced import duties. A similar measure could be applied in this case, but it must first be explained to, and then approved by, the Customs Department, the Ministry of Finance.

11.2.7 Formulation of a regulatory framework to assure the quality of electricity service

Regulation and specification of both SHS and micro-hydropower equipment is essential, though the current Electricity Act does not specifically refer to these areas. If this is not clearly defined and enforced, low quality equipment may be installed resulting in extra costs for repair and replacement of equipment and ultimately, disappointed users. Even if the Act does not need revision, regulations should be formulated to cover these issues. REAC should be responsible for inspecting and checking installed equipment.

11.2.8 Intermediary organizations

The Guidelines assume that NGOs and/or the private sector will work as supporting organizations to the communities requesting SHS/micro-hydropower projects. Unfortunately, NGOs and a significant private sector are not found in the Solomon Islands, especially in rural areas. Of course, there are exceptions, but they may not have the capacity to assist all of the communities. Provincial governments may function as alternative intermediary organizations, linking beneficiary communities with REAC in Honiara. The RWSS project uses provincial environmental health officers as intermediaries. They receive and process applications, conduct preliminary site surveys and disseminate relevant information through workshops. However, in the case of the rural electrification project a problem exists. The provinces do not have provincial energy officers.

Provincial physical planners in the Department of Land and Housing may assume the responsibility of an intermediary organization for receiving, processing and sending community rural electrification project applications to REAC. Provincial government engineers (e.g. the Department of Works, fisheries centers) could take over technical repairs of project equipment, which is beyond the ability of community technicians, even if they are properly trained.

In areas where SIEA outstations are located, staff should assume this role even though it increases their workload considerably. It should be noted, however, that SIEA is under pressure to improve its performance and faces the possibility of their top management function being contracted out. This may act as a disincentive to further involvement in rural electrification projects, as they are not so profitable.

Furthermore, churches act as supporting organizations, facilitating the process of planning, implementation and operation of the project. The JICA village survey found that several villages had mothers' unions that had been initiated and supported by the churches. Some NGOs may take on this responsibility. Solomon Islands Development Trust (SIDT) is one of the largest NGOs in the country. SIDT has approximately 160 village field staff working closely with rural villages. Indeed, SIDT has experience working with the government on rural development projects. The possibility of cooperation with those identified above is worth exploring before the project begins.

If these options do not work well, as an alternative measure, REAC may regularly dispatch technicians (e.g. once or twice a year) to check and repair the project equipment.

11.2.9 Involvement of women in the project

The involvement of women in the process is essential. Women are generally not well represented in community organizations, as the majority of the committee members are men. Indeed, only one of the villages surveyed by the JICA Team has a female member on the village committee. To reflect women's needs relating to electricity, an effort should be made to involve women in the process.

11.3 Institutional Framework for Rural Electrification

This section is intended to present a preliminary institutional framework for rural electrification that is adapted to the context of the Solomon Islands, based on the survey results. The principles underling the institutional framework is described below. The framework is composed of (1) functions of REAC, (2) process of petitions, and (3) contents of workshop.

<u>Principles of an institutional framework for rural electrification</u>

(1) Need-based approach

Rural electrification projects will be implemented based on the processing and selection of petitions submitted by potential users, instead of selections by REAC. This is because projects require large capital investments. REAC is unable to meet every request in a reasonably short time due to its limited financial and technical capability. In addition, rural communities have a variety of needs and should apply for a project after a due-diligence process has identified electricity as a priority.

(2) Achievement of financial and operational sustainability

While a project targets those users who want to use electricity and desires to meet their demands, it also aims to achieve sound financial conditions and an efficient and effective operational system. This makes project expansion possible in the future.

(3) Provision of satisfactory electricity service for users

Those applying for rural electrification projects do not want to own SHS or micro-hydropower equipment, but want to receive high quality electricity service. Great effort should be made to maximize user satisfaction, which will in turn guarantee timely tariff payments and further requests from communities for projects.

(4) Correction of infrastructure imbalance in rural areas

By making the tariff affordable to the poor, the scheme attempts to correct the infrastructure gap between rural and urban areas.

11.3.1 Time framework for rural electrification projects

The implementation of the project can be set up as follows.

1. Preparation stage (1 year)

REAC will be established under the Ministry of Natural Resources pending Cabinet approval. It will become the major coordinating body for the implementation of rural electrification projects, with the Energy Division assigned as Secretariat. Members include the ministries of Education, Health, Finance, SIEA, NGOs, and donors, as well as the Energy Division.

Preconditions for initiating REAC are (1) discussion with relevant organizations and securing their cooperation, (2) dissemination of rural electrification scheme information to other members, and (3) increasing the staff of the Energy Division. Functions and responsibilities of REAC are described in 11.3.2.

2. Pilot project stage (3 years)

Prior to project implementation, REAC should secure funding from donors as well as a government grant. At this stage, the assistance of donors for strengthening the technical and organizational ability of REAC and relevant organizations is critically important to the sustainability and future expansion of the project.

Pilot projects will be implemented in selected sites. The predetermined institutional framework and procedure specified in the following section will be tested and modified based on the outcome of the operation. At this stage, REAC should focus on: (1) guaranteeing satisfactory project performance for users rather than expanding geographical coverage of the project and, (2) strengthening institutional and organizational ability for sustainable operation. The former draws the attention of potential users to the project, while the latter increases donors' interest in funding the project.

3. Expansion stage

Projects will be expanded by securing new donor funding and utilizing funds collected from ongoing projects. If REAC succeeds in operating projects efficiently and effectively, it will be more likely to receive new funding. In cases where donors offer to provide loans to potential users for the purchase of SHS, DBSI would be best equipped to manage the credit scheme. They have the necessary experience and expertise. Coordination would be required between REAC and DBSI.

11.3.2 Functions of REAC

REAC shall be established as the primary organization responsible for the rural electrification program. Their main tasks are as follows.

1. Dissemination of information
2. Establishment of a technical center
3. Establishment of Rural Electrification Fund
4. Production of training manuals
5. Legislation and revision of a regulatory framework
6. Selection of petitions
7. Procurement and Installation
8. Provision of after care service
9. Monitoring and evaluation

1. Dissemination of information

Dissemination of relevant information via posters, radio programs, provincial governments, and other available means should be promoted. Information provided should include the requirements of petitions, expected costs, benefits and limitations of the scheme, the beneficiary community's responsibility for its operation and maintenance, etc. This activity is critical since misunderstanding of the scheme can easily lead to failure of the project and disappointment.

2. Establishment of a technical center

A technical center should be established within REAC, but with the assistance of SIEA, licensed electricians and the private sector. Overseas experts may possibly assist in the initial stage. The center assumes the role of overseeing the quality of imported equipment, preparing training manuals, providing training to villagers at project sites, and offering repair services for technical failures that are beyond the ability of community technicians. In addition, the center should manage the disposal of used batteries for SHS, as it is likely to be unprofitable, which is disincentive to the private sector. One SHS dealer in Honiara considered an option of consigning it to a Filipino company before, but abandoned the plan due to high transportation cost. The center should be the primary organization for disposing batteries in bulk, which could contain the cost involved and prevent environmental destruction.

3. Establishment of Rural Electrification Fund

A revolving fund account should be established to: (1) manage the grant funds from both the government or donors, the tariff collected, and transfer of SIEA's increased tariff[24] and (2) fund rural electrification projects. It will be initiated with both domestic and overseas funding.

Neither the Energy Division nor SIEA have enough expertise and experience in managing a revolving fund. Instead, the DBSI or Credit Union League should participate as fund manager. The fund should be kept as a special account to protect it from misuse or misdirected spending. Indeed, the DBSI is managing the "Rural Constituency Development Fund", which is intended to provide: (1) grants to community-based projects and, (2) loans to individuals. If the DBSI assumes this responsibility, a contract should be made between the REAC and the DBSI. It should be noted that the REAC might bear additional operating costs for fund administration, resulting in increased project costs.

At the same time, REAC should contact donors to secure new project funds. Tariffs will be collected from project sites over a specified period of time, which means reinvestment in new projects will take a considerable amount of time without securing new funding.

4. Production of training manuals

A standardized operation and maintenance manual, similar to the RWSS project manual should be produced. The RWSS project "Community Resource Manual" provided those involved with information regarding: (1) water and sanitation issues and, (2) an approach for communities on how they can remedy these problems and, of course, the project information. REAC should prepare two types of technical training programs. One should be for village technicians responsible for daily operation and maintenance and another for more advanced technicians to enable them to check and repair the equipment.

The training manual should also include a section on strengthening the organizational capacity of the electricity committee, which plays a major role in operation and maintenance at the community level. It must clarify the role and responsibilities of the committee, such as tariff payments to REAC and the salaries of village technicians.

[24] See 12.4.3 for the argument regarding this issue.

5. Legislation and revision of a regulatory framework

As already mentioned, no comprehensive regulation exists for SHS and micro-hydropower systems. New regulations should provide standard specifications for SHS and micro-hydropower systems, safety and efficient electricity use. REAC or contracted engineers should inspect imported and installed equipment in accordance with these regulations.

As discussed in Chapter 12, it is expected that SIEA's increased tariff will be transferred to the Rural Electrification Fund. As the implementing organizations for grid and SHS electrification are different, the Energy Division should make necessary revision of relevant regulations, which make it possible to transfer the tariff.

6. Selection of petitions

REAC is the primary organization responsible for selecting petitions. The process is explained below. After having selected communities as projects sites, REAC engages in project implementation in cooperation with communities and the organizations concerned.

7. Procurement and installation

Approved petitions move to the next stage of equipment procurement and installation. Installation can be done by the newly established technical centre or can be contracted out to the private sector. In the case of contracting out, REAC should advise the technical centre to verify that installed equipment complies with regulations.

8. Provision of after care service

Communities with generating facilities are responsible for their daily operation and maintenance. When technical failures occur that are beyond the knowledge and skill of communities, REAC needs to provide repair service. A reputation for quick and efficient service can provide incentive to potential users, who may apply for a project. To ensure good service, REAC must also store spare parts in locations that allow for rapid delivery when requested.

Disposal of used batteries should be included in after care service, as communities do not have the capacity to dispose of them. REAC should take responsibility for contracting an overseas disposal facility. The cost should be covered by the tariff.

9. Monitoring and evaluation

At the pilot project stage, REAC should monitor and evaluate project operation. It should also learn from them and revise the institutional framework and project procedures if necessary.

11.3.3 Process of petitions

The procedure for processing petitions should be transparent and based on clear rules to avoid the interference of outsiders. In reality, pressure from communities or politicians seems unavoidable, as was observed in the RWSS project.[25] Indeed, it is impossible to implement projects for all the competing villages in a relatively short time and satisfy them all. However, transparent and rule-based procedures for processing petitions could alleviate frustration among villages.

This section details information to be included in the petition and the content of the workshops to be held in the villages.

(1) Information required for applications

1. Name of village/ward/province
2. Purpose/target of electrification
3. Number of households
4. Expenditure for kerosene and dry batteries
5. Agreement of resource owners
6. Income sources and level
7. Responsible organization/person
8. Agreement of users of public facilities

1. Name of village/ward/province

The names of the village, ward and province should be clarified in the application, possibly with a map showing the location of the village and the water source (if relevant).

2. Purpose/target of electrification

The petition should clarify (1) the purpose of rural electrification (e.g. lighting, income generating activity, individual house or public facilities) and (2) the type of electrification method (SHS or micro-hydropower). If a community has a plan to start income generating activities by utilizing electricity generated, they may need to receive assistance from the organization concerned to assess its feasibility.[26] In such a case, REAC should try to help a community receive assistance from the relevant organization.

3. Number of households

Any petition should clarify the number of households in the village so that REAC can estimate the approximate cost for the project and calculate the average cost for each villager. In the case of public facility electrification, the number of users should be estimated.

[25] In the RWSS project in Malaita province, the officer in charge meets with villagers and politicians every day to discuss requests for water supply. Approximately 100 villages are on the waiting list for funding.

[26] The Department of Commerce, Employment and Tourism is implementing two projects called "Employment Generation and Sustainable Livelihood in Rural Areas" and "Small Scale Industry Development in Provinces" with the funding and technical assistance of UNDP and UNIDO. Assistance for schemes like this should be sought for where possible.

4. Expenditure for kerosene and dry batteries

Although average expenses for kerosene and dry batteries vary among villagers, the village should identify these expenses so that REAC can assess their ability to pay.

5. Agreement of resource owners

An agreement of resource owners in writing should be attached to the petition. Even in the case of SHS, agreement letters may be necessary, such as when the installation of SHS results in the cutting down of trees.

6. Income sources and level

Types of income sources and average income levels should be identified and estimated in the petition so that REAC can again estimate the ability to pay.

7. Responsible organization/person

Although an electricity committee is a requirement in principle, the responsible village organization (e.g. village committee) can be identified in a petition as an alternative responsible committee. In either case, a committee in charge should assign villagers to the positions of Chairman, Vice Chairman and Treasurer. They represent the village and engage in discussion and negotiation with the organizations concerned. The petition also needs to identify candidates with the appropriate educational background to become village technicians.

8. Agreement of users of public facilities

In the case of electrification of public facilities, users are supposed to share the cost. Persons and organizations responsible should explain the project and have the approval of cost sharing in advance, if possible.

(2) Content of workshop

The workshop should be held at an appropriate time during the planning and implementation stage of the project, which includes the following:

1. Information dissemination
2. Socio-economic profiling
3. Needs assessment
4. Environmental impact assessment
5. Survey of water source
6. Technical transfer of operation and maintenance knowledge
7. Agreement of contribution for project implementation
8. Agreement of resource owners
9. Contract signing
10. Tariff collection

1. Information dissemination

Information regarding the following issues needs to be disseminated to those villages that are likely to apply for rural electrification projects. In addition, fluorescent lighting should be demonstrated in the villages during the workshop so that villagers can assess the benefits of electricity.

- Project procedures
- Cost estimates
- Benefits and limitations
- Responsibility of the village for operation and maintenance
- Safe and efficient use of electricity

2. Socio-economic profiling

Applications submitted by villages are supposed to identify sources and levels of income for estimating their ability to pay. They should also identify kerosene and dry battery expenses. The workshop should ask questions and verify if these figures are correct as well as activities of village organizations.

3. Needs assessment

Needs assessment should be a part of the workshops to determine whether electricity supply is a prioritized need for a community. For example, one may doubt whether electricity is indeed a priority in a village that does not have access to water, which forces them to spend considerable time fetching water. Therefore, needs assessment should be involved in the process of the workshop. If a development plan is available, it should be also examined to see if an electrification method proposed best achieves the goal identified in the plan.

If the community has assessed and prioritized their needs based on sufficient information on rural electrification projects, unreal expectations among villagers will be avoided, increasing the possibility of success considerably (satisfactory tariff payment, maintenance work, etc.).

4. Environmental impact assessment

The construction of a micro-hydropower facility may have negative impact on the environment. In addition, the project site may involve the *tambu* locations, which can be identified through site surveys.[27] They should be identified in advance to avoid trouble during and after the implementation of the project.

5. Survey of water source

[27] See Chapter 8 for the explanation of *Tambu* places.

Unlike SHS, the potential of micro-hydropower generation is influenced largely by distance between water source and a community, head drop, and rate of discharge. The officer in charge needs to check the location of the water source and its flow to analyze its technical and economic feasibility. Seasonal fluctuations should be also checked with villagers.

6. Technical transfer of operation and maintenance knowledge

Training should be provided to selected village technicians at an appropriate time after they are selected. They will be responsible for routine maintenance work.

7. Agreement of contribution for project implementation

Agreement needs to be reached on the contribution of the community, such as accommodation and food for workers, cash contributions for initial capital costs and donation of local materials for construction.

8. Agreement of resource owners

When the project uses the land and/or water source, the project staff should confirm that the resource owner recognizes the effect the project would have on that resource.

9. Contract signing

After the relevant information gets disseminated to the community, primary issues should be clarified. These include issues such as the agreement of the resource owners, the approval of contributions to the project and tariff collection. The contract between REAC and the community can be signed at an appropriate time.

10. Tariff collection

Tariffs should be collected by the electricity committee representative and transferred to REAC. Bank branches or the Provincial Treasurer can accept payments and transfers of tariffs. Surpluses could be saved in a bank account if a bank branch is nearby, or kept by the treasurer of the electricity committee. Surpluses should be applied to operation and maintenance expenses. If the surplus outweighs maintenance costs, the community can spend it elsewhere, such as for the establishment of emergency fund.

Appendix

Taro Area Health Center, Choiseul province

The Taro Area Health Center has eight staff and receives an average of 20 outpatients per day. The center has one diesel generator and one gas generator. They are used only in circumstances such as for treating patients in serious condition. This is due to the limited budget for fuel. Kerosene lamps are used for inpatients.

A solar powered refrigerator was obtained from a nurse-training center that was abandoned in 1999 after the suspension of its UK funding. It experienced a technical failure that stopped its operation in several months. The center also used a kerosene-powered refrigerator, but it has stopped operating due to a kerosene leak. With no working refrigerator available, the center has to go to Sasamugga Rural Health Center twice a month to pick up vaccines. This costs as much as 120 SB$ for round trip transportation.

In Choiseul province, solar-powered wireless telephones were provided to clinics by the Canadian government four years ago. This center's telephone is still functioning.

The needs of clinics identified by staff are:

1. Refrigerator
2. Cold chain facility
3. Lighting
4. Operating room
5. Air conditioners

Taro Primary School, Choiseul province

Taro Primary School was established 11 years ago and has two teachers (there should be six teachers), a Principal and 165 pupils. The need for electricity is to assist night study for standard five and six students' preparing for the national exam. Indeed, this school has an extra hour of study for these students. The school carried out fundraising activities and a video show in 1999 to collect money for maintenance (repair of desks and chairs, for example).

Tasia Rural Training center, Isabel province

Tasia Rural Training center was established in 1983 after being converted from a girl's school and offers two-year courses ranging from mechanics, home economics, carpentry and agriculture as major courses, to English, mathematics and business as minor courses for young dropouts. It currently has 34 students who all board at the center. It can accommodate up to 60 students.

Isabel province and the Anglican Church are responsible for the operation of the center. The center receives 15,000 SB$ from the Ministry of Education, 56,000 SB$ from the province and 20,000 SB$ from the church.

The RTC has a diesel generator to supply electricity for lighting the classrooms, dormitories and machines uses for teaching. The generator consumes four gallons a week, which costs approximately 40 SB$ and eight liters of oil per month. Teachers and students of the mechanics course are involved in its daily operation and maintenance. When minor repairs are necessary that are beyond their capacity the staff of SIEA Buala outstation are called in. A service fee then must be paid. Last year, the generator's wiring burned out and the rubber was also worn out. The RTC had to ask the supplier in Honiara to come and repair it, which cost as much as 8,500 SB$.

The center is planning to move to the new site next year courtesy of a grant from the Canadian government for the construction of the center's buildings. The present diesel generator will continue to be used.

Gomania Credit Union, Makira province

The credit union has 75 members and covers three villages with 20,191 SB$ in equity and 11,519 SB$ in loans. It was established in 1996 with one full-time officer and a committee consisting of a chairman, vice-chairman, treasurer, and two ordinary members. It offers members savings (share contribution) and loan facilities. Savings are the equity contribution to the credit union and are paid no interest. Loans are made to members at an interest rate of 1%. The basis of the loans is the shareholder's equity, as well as grants from the Credit Union League.

Maximum loan amounts of depend on the equity contribution of the applicant. If a member has equity of $100, he or she can borrow up to 100 SB$. The union does not have any collateral and guarantor requirements because their equity is regarded as a collateral. If a borrower defaults the union will take the equivalent amount of equity. The union allows borrowers to repay at reasonable terms, depending on their disposable income.

The loan amount in most cases is less than 500 SB$. Loans are granted for urgent needs such as school fees, rather than capital investment. Although there is the need for loans of more than 500 SB$, the union cannot meet the need due to limited funds.

Fulikaomae village (RWSS project), Malaita province

A water tank and pipes were installed in June 1998. The water source is on tribal land and the village tribe has customary rights. The village has disputed the ownership of the land where the water source is located. The decision of the court was favorable, however those who live near the water source sometimes break the water pipes (six times last year) and Fulikaomae villagers must go and repair them.

Before the village submitted the petition to the provincial government, the villagers had reached consensus in favor of the project. The village previously carried water from the stream a ten-minute walk away downhill. They have experienced serious droughts twice in the past. The village contributed 5,000 SB$ (a quarter of the total cost) in cash, local material, labor, etc. to the implementation of the project. The village collected money by fundraising from villagers, MPs and others.

The village does not have a water supply committee. Instead, the village committee is responsible for the operation and maintenance of the system. No monthly tariff is collected for water use.

The problem facing the village is over-use of water resulting from a significant population increase, caused by those previously living in Honiara returning to Malaita province to avoid ethnic tension (the population almost doubled). Its over-use resulted in a shortage of water and villagers are advised to save water.

CHAPTER 12

ECONOMIC AND FINANCIAL ANALYSIS

Chapter 12 Economic and Financial Analysis

In this Study, candidate sites for small hydropower plants and SHS installations have been surveyed, and the optimum power supply and rural electrification plans were compiled based on these surveys (see Chapter 10). In this chapter, analysis and examination shall be carried out on the above plans in the following order:

12.1 Calculation of LRMC and recommendation of the tariff
12.2 Economic and financial analysis of the optimum power supply plans
12.3 Economic and financial analysis of the rural electrification plans
12.4 Funding and repayment plans
12.5 Analysis of financial conditions in SIEA

12.1 Calculation of LRMC and examination of the tariff

In this section, LRMC (Long Run Marginal Cost) is calculated for each power supply district and the overall optimum power supply plan, and the power tariff is examined based on this calculation.

12.1.1 Calculation of LRMC

The LRMC expresses the average cost with respect to a single unit increase in power demand (increase per 1 kWh) in the long run power expansion program. In terms of economic price theory, limited resources are distributed in the optimum manner and the maximum economic effect is generated by setting the power tariff at the LRMC. The purpose of calculating the LRMC is to obtain basic figures for examining the power tariff. The World Bank and other international institutions recommend compilation of power tariffs based on the LRMC, and this has been estimated in many countries.

The optimum power supply plan compiled in this Study is an overall collection of all the optimum plans selected in each power supply district (10 districts). Here, LRMC shall be calculated separately for each power supply district, and then the LRMC for the whole country shall be sought. The optimum power supply plan mainly consists of power supply plans based on small hydropower and diesel power generation. Since the power supply plan for Rennell district is the only one that is based on solar and wind power, this was excluded from calculations of the LRMC.

The optimum plan selected in each power supply district is as follows.

Honiara - Lungga grid	Plan-3	Choiseul district	Plan-1
Auki – Malu'u – Bina grid	Plan-3	Gizo district	Plan-2
Buala grid	Plan-1	Noro – Munda grid	Plan-2
Kirakira grid	Plan-2	Tulagi grid	Plan-2
Lata district	Plan-2	Rennell district	—

The process for calculation of LRMC is as follows.

1) Preparation of the expected long run demand and power supply plan
2) Estimation of construction costs of all power plants included in the supply plan
3) Estimation of all fuel and maintenance costs included in the supply plan
4) Calculation of the kWh cost based on the estimated construction cost, fuel cost and O&M cost

Two kinds of LRMC are used depending on the method of calculation, and the merits and demerits of each are as follows:

Long run average increase in cost (LRAIC)

Features:	Marginal cost calculation is based on increases in facilities capacity.
Merits:	Cost based on demand forecast can be calculated.
Demerits:	In cases of facilities plans which are in excess of the demand forecast, the calculation can not reflect its effect.

Long run marginal cost (LRMC)

Features:	Marginal cost calculation is based on increases in power demand.
Merits:	Cost based on demand forecast can be calculated.
Demerits:	Calculation results are affected by differences in the demand forecast.

These two figures should be close by moving the LRMC plant factor closer to 100%, however, these two figures can be very different occasionally. Therefore, LRAIC and LRMC shall be used separately hereafter.

In this section, both LRMC and LRAIC are calculated. For the basic value of the power tariff, the LRAIC shall be adopted. Since the recent economic growth in the country is not stable and there are many uncertain factors regarding the demand forecast, LRAIC, which is not affected by differences in the demand forecast, shall be used better than LRMC.

The process of LRMC and LRAIC calculation in Honiara-Lungga grid Plan-3 is as described below.

Table 12-1-1-1 Calculation process of the LRMC
(Example of the Honiara-Lungga grid Plan-3)

Honiara-Lungga grid Plan 3

Year	Peak Demand (kW)	Incremental Demand (kW)	Plan-3 New (kW)	Total Cost (US$)
1998	10,450	0	0	0
1999	10,604	154	3,900	0
2000	11,144	540	4,200	6,442,800
2001	11,711	567	0	0
2002	12,477	766	0	0
2003	13,298	821	5,000	7,670,000
2004	14,168	870	5,000	7,670,000
2005	14,953	785	0	0
2006	15,785	832	0	9,037,292
2007	16,667	882	5,000	20,221,795
2008	17,602	935	0	21,589,087
2009	18,727	1,125	0	7,029,005
2010	19,632	905	3,000	0
2011	20,525	893	0	0
2012	21,495	970	5,000	7,670,000
2013	22,511	1,016	0	0
2014	23,237	726	0	0
2015	24,221	984	0	0
2016	25,247	1,026	2,000	3,068,000
2017	26,317	1,070	0	0
2018	27,434	1,117	0	0
Total =		16,984 ①	33,100 ③	90,397,980 ⑤
NPV =		6,991 ②	18,205 ④	43,490,075 ⑥
Discount Rate		8.00% (= r)		

	AIC (capacity)	US$/kW	2,389	⑦= ⑥/④
	AIC (demand)	US$/kW	6,221	⑧= ⑥/②
	*AIC = Average Incremental Cost			
Power balance	Hydro	kW	3,000	9.06% (= h)
in 2018	Thermal	kW	30,100	90.94% (= t)

Power value			
Weighted average life time	year	22.72	n = 50*h+20*t
CRF		0.0969	CRF = r/(1-(1+r)^(-n))
Annualized Power value	US$/kW/year	231.39	⑨=⑦*CRF
Average Plant factor	%	34.3%	⑩
Average total loss	%	9.9%	⑪
Fixed O&M cost	%	3.45%	⑫
Power value per kWh	US$/kWh	0.0884	⑬=⑨/(8760*⑩)/(1-⑪)*(1+⑫)
Energy value			
Fuel Cost	US$/kWh	0.0841	
Energy loss		5.00%	
Variable O&M		3.45%	
Energy value	US$/kWh	0.0916	(= e)
Weight average Energy value	US$/kWh	0.0833	⑭=e * t
LRAIC =	US$/kWh	0.1717	⑮=⑬+⑭
	SB$/kWh	0.8585	
LRMC =	US$/kWh	0.1622	⑯=⑧*CRF/8760/(1-⑪)*(1+⑫)+⑭
	SB$/kWh	0.8112	

The LRAIC and LRMC for each power supply district and the country overall are indicated below.

Table 12-1-1-2 LRAIC and LRMC for each power supply district

			US$/kWh	SB$/kWh
Honiara-Lungga	Plan-3	LRAIC =	0.1717	0.8585
		LRMC =	0.1622	0.8112
Auki-Malu'u-Bina	Plan-3	LRAIC =	0.2203	1.1013
		LRMC =	0.1420	0.7100
Buala	Plan-1	LRAIC =	0.2814	1.4071
		LRMC =	0.1763	0.8815
Kirakira	Plan-2	LRAIC =	0.2407	1.2037
		LRMC =	0.2256	1.1278
Lata	Plan-2	LRAIC =	0.1806	0.9030
		LRMC =	0.1974	0.9868
Choiseul	Plan-1	LRAIC =	0.6190	3.0949
		LRMC =	0.5199	2.5997
Gizo	Plan-2	LRAIC =	0.1687	0.8435
		LRMC =	0.1488	0.7442
Noro-Munda	Plan-2	LRAIC =	0.1610	0.8048
		LRMC =	0.1380	0.6902
Tulagi	Plan-2	LRAIC =	0.2849	1.4247
		LRMC =	0.1404	0.7020
Total		LRAIC =	0.1791	0.8956
		LRMC =	0.1922	0.9609

As can be seen from the above results, both LRAIC and LRMC fluctuate a lot between each power supply district. As an overall trend, LRAIC is exceeds US$0.20/kWh in the districts of Auki-Malu'u-Bina, Buala, Kirakira, Choiseul and Tuagi, while it is comparatively low in the other districts. LRAIC in Choiseul district ended up being extremely high due to the high construction cost of Sorave small hydropower.

The LRAIC for the optimum power supply plan was calculated to US $ 0.1791. The calculation process of it is shown in the following page.

Table 12-1-1-3 LRMC for optimum power supply plan

Year	Peak Demand (kW)	Incremental Demand (kW)	Retire (kW)	New Capacity (kW)	H-3 (US$)	A-3 (US$)	B-1 (US$)	K-2 (US$)	L-2 (US$)	C-1 (US$)	G-2 (US$)	N-2 (US$)	T-2 (US$)
1998	12,983	0	0	0	0	0	0	0	0	0	0	0	0
1999	13,573	591	3000	3,900	0	0	0	0	0	0	0	0	0
2000	14,400	827	0	4,723	6,442,800	149,400	0	0	0	206,960	800,000	0	0
2001	15,277	877	416	5,700	0	7,277,254	0	413,000	0	0	0	7,200,000	0
2002	16,207	930	208	2,100	0	3,916,738	0	1,144,017	0	1,798,469	1,200,000	0	0
2003	17,194	987	510	6,870	7,670,000	2,700,000	0	304,106	0	0	0	0	0
2004	18,065	871	2300	5,120	7,670,000	0	0	0	0	0	0	0	0
2005	19,165	1,100	0	4,420	0	0	368,000	0	461,400	0	0	7,200,000	300,000
2006	20,332	1,167	900	300	9,037,292	0	0	0	0	0	600,000	0	0
2007	21,569	1,238	900	5,000	20,221,795	0	0	0	0	0	0	0	0
2008	22,882	1,313	4500	0	21,589,087	665,624	1,595,307	0	0	0	0	0	0
2009	23,811	929	0	80	7,029,005	176,938	0	0	0	0	0	0	0
2010	25,016	1,205	0	7,200	0	4,921,343	0	0	0	0	0	7,200,000	0
2011	26,282	1,266	0	240	0	6,835,198	0	495,600	0	0	0	0	0
2012	27,612	1,330	60	5,360	7,670,000	11,756,541	368,000	0	461,400	0	0	0	0
2013	29,009	1,397	172	0	0	3,827,711	0	0	0	0	0	0	0
2014	29,896	887	40	2,100	0	0	0	0	0	0	0	0	0
2015	31,103	1,207	60	300	0	0	0	0	0	0	600,000	0	0
2016	32,358	1,256	0	4,000	3,068,000	0	0	0	0	0	0	3,600,000	0
2017	33,665	1,306	0	0	0	0	0	0	0	0	0	0	0
2018	35,024	1,359	0	0	0	0	0	0	0	0	0	0	0
Total =		22,041 ①	13,066	57,413 ③	90,397,980	42,226,747	2,331,307	2,356,723	922,800	2,005,429	3,200,000	25,200,000	300,000
NPV =		9,338 ②		30,903 ④	43,490,075	19,150,571	999,028	1,442,537	394,733	1,388,299	1,902,064	12,663,739	162,081
Discount Rate		8.00% (= r)											

	AIC (capacity)	US$/kW	2,640	⑦= ⑥/④
	AIC (demand)	US$/kW	8,738	⑧= ⑥/②
Power balance	Hydro	kW	5,870	10.18% (= h)
	Thermal	kW	51,787	89.82% (= t)

Power value

Weighted average life time	year	23.05	n = 50*h+20*t
CRF		0.0963	CRF = r/(1-(1+r)^(-n))
Annualized Power value	US$/kW/year	254.37	⑨=⑦*CRF
Average Plant factor	%	34.3%	⑩
Average total loss	%	9.9%	⑪
Fixed O&M cost	%	3.24%	⑫
Power value per kWh	US$/kWh	0.0970	⑬=⑨/(8760*⑩)/(1-⑪)*(1+⑫)
Energy value (weighted)	US$/kWh	0.0821	⑭ = e * t
LRAIC =	US$/kWh	0.1791	⑮=⑬+⑭
	SB$/kWh	0.8956	
LRMC =	US$/kWh	0.1922	⑯=⑧*CRF/8760/(1-⑪)*(1+⑫)+⑭
	SB$/kWh	0.9609	

Energy value (kWh value)

Fuel Cost	0.0841	US$/kWh	
Energy loss	5.00%		
Variable O&M	3.24%		
Energy value	0.0914	US$/kWh	(= e)

12.1.2 Examination concerning the tariff

Based on the LRAIC calculated above, examination of the future power tariff in the Solomon Islands is carried out. The present tariff and the record of tariff increase are as indicated below.

Table 12-1-2-1 Record of the tariff increase

(SB Cents/kWh)

Date	Residential	Commercial/ Industrial	High Voltage	Service Charge	AFPA*
1989	33.5	42.5	38.25	4.00	
1990	33.5	42.5	38.25	4.00	4.00
1991	33.5	42.5	38.25	4.00	
1992	33.5	42.5	38.25	4.00	
Nov-93	**37.5**	**55.5**	**50.5**	**4.50**	
1994	37.5	55.5	50.5	4.50	
1995	37.5	55.5	50.5	4.50	
1996	37.5	55.5	50.5	4.50	
1997	37.5	55.5	50.5	4.50	
1998	37.5	55.5	50.5	4.50	
Oct-98	**41.30**	**61.00**	**55.50**	**5.00**	
Aug-99	**46.46**	**68.75**	**61.80**	**5.00**	**11.00**
Nov-99	46.46	68.75	61.80	5.00	**16.00**

Source: SIEA

The current tariff is SB$0.4646/kWh for residential use and SB$0.6875/kWh for commercial and industrial use, and the AFPA (automatic fuel price adjustment, currently SB$0.16) is added to this. Moreover, since the ratio of power supply between residential use and commercial and industrial use is approximately 25% to 75%, the weighted average value works out to be SB$0.7918/kWh.

	Base	AFPA	SB$/kWh	
Residents	0.4646	0.16	0.6246	25%
Commercial & Industr	0.6875	0.16	0.8475	75%
			0.7918	

Concerning the current tariff system, the above power rates are multiplied by the used amount of power (kWh), then a service charge and AFPA are added to this. For example, assuming that a typical residential user consumes 100 kWh in one month, the tariff payment will be as follows:

100kWh * SB$0.4646 + SB$5.00 + 100kWh * SB$0.16 = SB$67.46

Service charge: equivalent to the basic rate in Japan

A flat rate SB$5.00 is paid when monthly power usage is less than 22kWh, while the charge is added on top of the tariff when monthly power usage is more than 23 kWh.

AFPA (automatic fuel price adjustment)

This was introduced from April 1990 to enable immediate response to increases in fuel price. It is revised every three years.

The recommended tariff for the optimum power supply plan shall be based on the LRAIC calculated above. If the tariff is set at the level of the computed LRAIC, on the price theory of small economics, the benefit shall be maximized to both consumer and producer and the optimum efficiency in the national economy shall be achieved. However, when the future expansion of work at SIEA is considered, it is necessary to set the tariff by adding a further uniform margin to the LRAIC. However, if part of the construction cost in the plan can be obtained from grant aid, that portion shall be the extra margin of the SIEA. The estimated tariff for each power supply district and the country overall in the plan shall be set as follows.

Table 12-1-2-2 Estimated tariff in each power supply district

		LRAIC +		US$/kWh
		0.0%	5.0%	10.0%
Honiara-Lungga	Plan-3	0.1717	0.1803	0.1889
Auki-Malu'u-Bina	Plan-3	0.2203	0.2313	0.2423
Buala	Plan-1	0.2814	0.2955	0.3096
Kirakira	Plan-2	0.2407	0.2528	0.2648
Lata	Plan-2	0.1806	0.1896	0.1987
Choiseul	Plan-1	0.6190	0.6499	0.6809
Gizo	Plan-2	0.1687	0.1771	0.1856
Noro-Munda	Plan-2	0.1610	0.1690	0.1771
Tulagi	Plan-2	0.2849	0.2992	0.3134
Total		0.1791	0.1881	0.1970

Since the LRAIC in each power supply district differs, the tariff will also naturally be different. However, since the Solomon Islands has adopted a single power tariff system until now, the optimum power supply plan will also adopt a national uniform rate of tariff. The LRAIC for the overall plan shall be adopted as the standard for tariff setting. In the above calculation, the LRAIC for the overall plan is US$0.1791, and the values obtained by adding a 5% and 10% margins are US$0.1881 and US$0.1970, respectively.

The tariff setting system of SIEA is not clear. It seems to be adopting a tariff by adding a certain margin on the power generation cost. According to the following figure, the operating margin rate has been decreased since 1994, it has fell to closely 0% level in 1997.

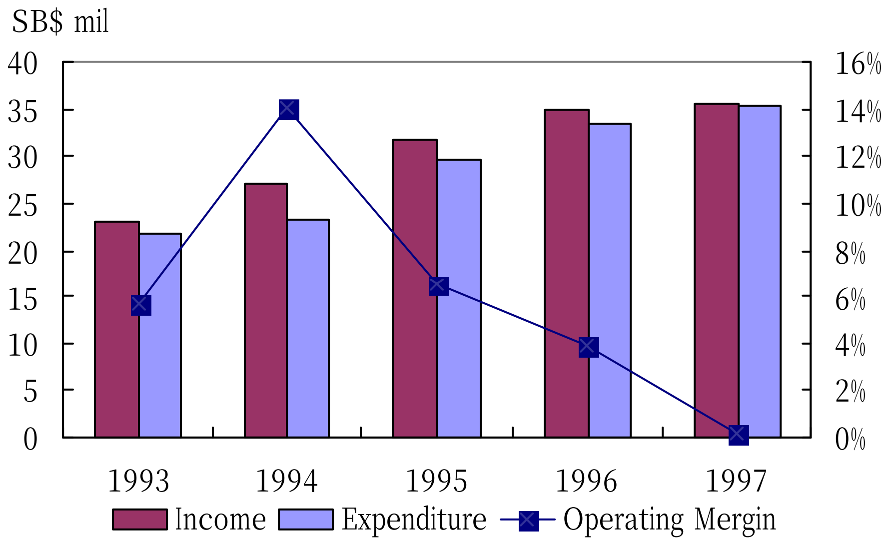


Fig. 12-1-2 Operating Margin

From the view point of the current financial situation of SIEA, since the non-operating cost has been a big burden of it, it shall be necessary to add a certain margin on the tariff rate. Therefore, it shall be adequate to add a further 5.0% margin on the calculated LRAIC.

The tariff rate of LRAIC + 5.0% = US$0.1881 (SB$0.9403) is recommended in the optimum power supply plan. This tariff rate is around 18.8% higher than the current tariff SB$0.7918.

And the same tariff rate shall be used in all the following financial analysis in this report.

Moreover, when it comes to setting the power tariff, the following points should be considered except for the above mentioned margin rate.

1) Periodic review of the power tariff

In spite of the fact that the cost of power generation has gone up every year as a result of currency depreciation and inflation, the power tariff in the Solomon Islands has not been subjected to annual review due to political factors, etc. The annual rate of increase in the power tariff for the 10 years between 1989-1999 is approximately 4.93%, which is well below the inflation rate of 11.5% during the same period. As of 2000, inflation is hovering below 10%, however, it is necessary to carry out a review of the power tariff taking inflation into account at least once per year.

2) Thorough implementation of AFPA control

The AFPA (automatic fuel price adjustment) system was introduced from April 1990 in order to achieve immediate response to increases in fuel prices. Since the AFPA is added onto the service charge and is revised every three months, it has filled the role of giving some flexibility to the power tariff which has so far been rigid. However, existence of the AFPA carries with it potential for making unfair price revisions, and it could even have an adverse impact on the business standing of SIEA. Thorough control of the AFPA is required.

12.2 Economic and financial analysis of the optimum power supply plan

In this section, economic and financial analysis of the optimum power supply plan is carried out. Concerning the analysis technique, the overall project in the plan is regarded as a single project, the costs and benefits of all power plants included in this are totaled, and analysis of economic and financial profitability for the overall plan is performed based on this.

12.2.1 Estimation of financial cost

The plan aims to construct a total of more than 30 power plants, including small hydropower plants and diesel power plants, during the period from 2000 to 2018 (19 years). First of all, the financial cost shall be obtained by totaling the estimated construction cost and O & M cost at market prices for all small hydropower plants and diesel power plants included in the optimum power supply plan. Estimation of the financial cost shall be based on the following contents.

1) Concerning the construction cost and O& M cost of small hydropower plants, the values obtained from cost estimation are used for the candidate site in the Study (Maotapuku No.1 and 2, Rori, Silolo, Kubolata Sorave), while the costs estimated by SIEA are used for the remaining plants (Manakuwai, Ruala'e, Huro) (see Table 10-3-1). The plant life shall be of 50 years shall be assumed for all plants.

2) Concerning the construction and plant factor of diesel power plants are used different figures in each power supply district. The kW cost are used the SIEA provided data[1] in Honiara-Lungga grid, Kirakira, Lata and Choiseul, and the estimated figures in the other districts. While the following uniform parameters are commonly used.

Fixed O & M cost:	3.0% of construction cost
Loss factor:	15.0%
Fuel cost:	US$0.0912/kWh (including variable O&M cost)
Construction period:	1 year
Durable year:	20 years

12.2.2 Estimation of financial benefit

In the case of both small hydropower plants and diesel power plants, the quantity of generated and sold power are sought through the following formula:

Generated power (kWh) = plant capacity (kW) x 8760 hours x plant factor

Sold power (kWh) = generated power (kWh) x loss factor

[1] Rural Electrification 2000 and beyond Project Document July 1999, SIEA

Ordinarily, the tariff US$0.1949 (SB$ 0.9745),which is set in the optimum power supply plan should be used as the financial benefit. The same tariff rate shall be used both in small hydro power and diesel power plant during the construction period and following the start of operation, and price escalation is not taken into account.

12.2.3 Financial profitability analysis

Financial profitability for the plan is carried out using the financial cost and financial benefit estimated above. In the profitability analysis, cash flow over the project life is compiled using cost and benefit, and this is done by seeking the financial internal rate of return (FIRR).

The project life of the optimum power supply plan shall be made the same as the power plant with the longest life in the plan. Since Silolo small hydropower plant has the longest plant life lasting up to 2063, the target period for profitability analysis in the plan shall be 64 years from 2000 to 2063.

The internal rate of return (IRR) expresses the rate of return where the present value of benefit (B) minus cost (C) is zero, and this is derived from the following formula.

$$\sum_{t=1}^{n} \frac{C_t}{(1+R)^t} - \sum_{t=1}^{n} \frac{B_t}{(1+R)^t} = 0$$

C: cost B: benefit t: t year n: plant life r = internal rate of return

As a result of calculation, the FIRR for the optimum power supply plan was found to be 8.38%.

Criteria for financial feasibility

The criteria for financial validity in some projects is considered to be the actual interest rate in the country concerned. The average interest rate on borrowed funds in the Solomon Islands between 1992-1998 was 16.5% and, since the average rate of inflation during the same period was 12.7% (see sections 3.2.8 and 3.2.9), it is estimated that the actual interest rate during the said period was approximately 3.8%.

Since the FIRR calculated above exceeds the actual interest rate of 3.8%, the plan is deemed to be financially feasible.

Table 12-2-3 FIRR calculation for optimum power supply plan

Financial Analysis for Master Plan in Solomon Islands

Tariff
0.9403 SB$/kWh FIRR = 8.38%
0.1881 US$/kWh

Year	H-3 Cost US$	H-3 Sold energy MWh	A-3 Cost US$	A-3 Sold energy MWh	B-1 Cost US$	B-1 Sold energy MWh	K-2 Cost US$	K-2 Sold energy MWh	L-2 Cost US$	L-2 Sold energy MWh	C-1 Cost US$	C-1 Sold energy MWh	G-2 Cost US$	G-2 Sold energy MWh	N-2 Cost US$	N-2 Sold energy MWh	T-2 Cost US$	T-2 Sold energy MWh	Total Cost US$	Total Sold energy MWh	Benefit US$	Net US$
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	7,452,005	11,064	149,400	0	0	0	0	0	0	0	206,960	0	800,000	0	0	0	0	0	8,608,365	11,064	2,080,802	-6,527,563
2001	2,096,041	22,979	7,442,585	124	0	0	413,000	0	0	0	5,434	60	54,335	596	7,200,000	0	0	0	17,211,394	23,758	4,468,143	-12,743,251
2002	2,096,041	22,979	4,172,721	2,357	0	0	1,209,688	298	0	0	1,864,434	60	1,254,335	596	543,350	5,957	0	0	11,140,569	32,246	6,064,559	-5,076,010
2003	9,766,041	22,979	3,188,345	6,983	0	0	341,509	298	0	0	31,434	620	135,838	1,489	543,350	5,957	0	0	14,006,516	38,326	7,208,033	-6,798,482
2004	11,059,894	37,164	691,659	9,217	0	0	42,136	1,263	0	0	31,434	620	135,838	1,489	543,350	5,957	0	0	12,504,310	55,711	10,477,441	-2,026,868
2005	4,683,746	51,348	691,659	9,217	368,000	0	42,136	1,263	461,400	0	31,434	620	135,838	1,489	7,743,350	5,957	300,000	0	14,457,562	69,895	13,145,136	-1,312,426
2006	14,025,206	51,348	691,659	9,217	21,734	238	42,136	1,263	27,168	298	31,434	620	735,838	1,489	1,086,700	11,914	8,150	89	16,670,024	76,477	14,383,058	-2,286,966
2007	25,327,996	51,348	691,659	9,217	21,734	238	42,136	1,263	27,168	298	31,434	620	176,589	1,936	1,086,700	11,914	8,150	89	27,413,565	76,924	14,467,080	-12,946,485
2008	28,293,308	65,533	1,379,686	9,217	1,670,734	238	42,136	1,263	27,168	298	31,434	620	176,589	1,936	1,086,700	11,914	8,150	89	32,715,905	91,109	17,134,775	-15,581,130
2009	13,243,178	65,533	874,552	9,217	44,734	771	42,136	1,263	27,168	298	31,434	620	176,589	1,936	1,086,700	11,914	8,150	89	15,534,641	91,642	17,235,046	1,700,405
2010	6,321,598	79,224	5,787,348	10,826	44,734	771	42,136	1,263	27,168	298	31,434	620	176,589	1,936	8,286,700	11,914	8,150	89	20,725,857	106,942	20,112,535	-613,322
2011	6,321,598	79,224	7,765,618	10,826	44,734	771	537,736	1,263	27,168	298	31,434	620	176,589	1,936	1,630,050	17,870	8,150	89	16,543,077	112,899	21,232,827	4,689,750
2012	13,991,598	79,224	12,852,598	10,826	412,734	771	74,737	1,621	488,568	298	31,434	620	176,589	1,936	1,630,050	17,870	8,150	89	29,666,458	113,256	21,300,045	-8,366,414
2013	7,615,451	93,408	4,656,908	10,826	66,468	1,010	74,737	1,621	54,335	596	31,434	620	176,589	1,936	1,630,050	17,870	8,150	89	14,314,122	127,977	24,068,565	9,754,443
2014	7,615,451	93,408	856,368	20,765	66,468	1,010	74,737	1,621	54,335	596	31,434	620	176,589	1,936	1,630,050	17,870	8,150	89	10,513,582	137,916	25,937,743	15,424,161
2015	7,615,451	93,408	856,368	20,765	66,468	1,010	74,737	1,621	54,335	596	31,434	620	776,589	1,936	1,630,050	17,870	8,150	89	11,113,582	137,916	25,937,743	14,824,161
2016	10,683,451	93,408	856,368	20,765	66,468	1,010	74,737	1,621	54,335	596	31,434	620	217,340	2,383	5,230,050	17,870	8,150	89	17,222,333	138,363	26,021,765	8,799,431
2017	8,132,992	99,082	856,368	20,765	66,468	1,010	74,737	1,621	54,335	596	31,434	620	217,340	2,383	1,901,725	20,849	8,150	89	11,343,549	147,015	27,648,988	16,305,439
2018	8,132,992	99,082	856,368	20,765	66,468	1,010	74,737	1,621	54,335	596	31,434	620	217,340	2,383	1,901,725	20,849	8,150	89	11,343,549	147,015	27,648,988	16,305,439
2019	7,123,787	88,018	856,368	20,765	66,468	1,010	74,737	1,621	54,335	596	31,434	620	217,340	2,383	1,901,725	20,849	8,150	89	10,334,344	135,951	25,568,187	15,233,842
2020	6,036,951	76,103	845,094	20,642	66,468	1,010	74,737	1,621	54,335	596	26,000	561	163,005	1,787	1,901,725	20,849	8,150	89	9,176,465	123,257	23,180,845	14,004,380
2021	6,036,951	76,103	641,337	18,408	66,468	1,010	47,570	1,323	54,335	596	26,000	561	163,005	1,787	1,358,375	14,892	8,150	89	8,402,191	114,768	21,584,429	13,182,238
2022	6,036,951	76,103	438,023	16,174	66,468	1,010	47,570	1,323	54,335	596	26,000	561	81,503	894	1,358,375	14,892	8,150	89	8,117,375	111,641	20,996,276	12,878,901
2023	4,743,098	61,919	234,709	13,940	66,468	1,010	47,570	1,323	54,335	596	26,000	561	81,503	894	1,358,375	14,892	8,150	89	6,620,208	95,223	17,908,472	11,288,264
2024	3,449,246	47,734	234,709	13,940	66,468	1,010	47,570	1,323	54,335	596	26,000	561	81,503	894	1,358,375	14,892	8,150	89	5,326,356	81,038	15,240,778	9,914,422
2025	3,449,246	47,734	234,709	13,940	44,734	771	47,570	1,323	27,168	298	26,000	561	81,503	894	815,025	8,935	0	0	4,725,954	74,456	14,002,855	9,276,901
2026	3,449,246	47,734	234,709	13,940	44,734	771	47,570	1,323	27,168	298	26,000	561	40,751	447	815,025	8,935	0	0	4,685,203	74,009	13,918,833	9,233,631
2027	2,155,393	33,549	234,709	13,940	44,734	771	47,570	1,323	27,168	298	26,000	561	40,751	447	815,025	8,935	0	0	3,391,350	59,824	11,251,139	7,859,789
2028	2,155,393	33,549	234,709	13,940	44,734	771	47,570	1,323	27,168	298	26,000	561	40,751	447	815,025	8,935	0	0	3,391,350	59,824	11,251,139	7,859,789
2029	2,155,393	33,549	234,709	13,940	44,734	771	47,570	1,323	27,168	298	26,000	561	40,751	447	815,025	8,935	0	0	3,391,350	59,824	11,251,139	7,859,789
2030	2,155,393	33,549	234,709	13,940	44,734	771	47,570	1,323	27,168	298	26,000	561	40,751	447	271,675	2,978	0	0	2,848,000	53,868	10,130,847	7,282,847
2031	2,155,393	33,549	234,709	13,940	44,734	771	47,570	1,323	27,168	298	26,000	561	40,751	447	271,675	2,978	0	0	2,848,000	53,868	10,130,847	7,282,847
2032	861,541	19,365	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	40,751	447	271,675	2,978	0	0	1,505,246	39,147	7,362,326	5,857,080
2033	861,541	19,365	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	40,751	447	271,675	2,978	0	0	1,505,246	39,147	7,362,326	5,857,080
2034	861,541	19,365	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	40,751	447	271,675	2,978	0	0	1,505,246	39,147	7,362,326	5,857,080
2035	861,541	19,365	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	271,675	2,978	0	0	1,464,495	38,700	7,278,304	5,813,809
2036	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2037	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2038	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2039	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2040	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2041	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2042	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2043	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2044	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2045	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2046	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2047	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2048	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2049	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2050	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2051	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2052	344,000	13,691	234,709	13,940	23,000	533	47,570	1,323	0	0	26,000	561	0	0	0	0	0	0	675,279	30,048	5,651,081	4,975,802
2053	344,000	13,691	164,709	11,548	23,000	533	47,570	1,323	0	0	0	0	0	0	0	0	0	0	579,279	27,095	5,095,760	4,516,481
2054	344,000	13,691	164,709	11,548	23,000	533	32,601	357	0	0	0	0	0	0	0	0	0	0	564,310	26,129	4,914,156	4,349,845
2055	344,000	13,691	164,709	11,548	23,000	533	32,601	357	0	0	0	0	0	0	0	0	0	0	564,310	26,129	4,914,156	4,349,845
2056	344,000	13,691	164,709	11,548	23,000	533	32,601	357	0	0	0	0	0	0	0	0	0	0	564,310	26,129	4,914,156	4,349,845
2057	344,000	13,691	164,709	11,548	23,000	533	32,601	357	0	0	0	0	0	0	0	0	0	0	564,310	26,129	4,914,156	4,349,845
2058	344,000	13,691	164,709	11,548	23,000	533	0	0	0	0	0	0	0	0	0	0	0	0	531,709	25,772	4,846,938	4,315,229
2059	344,000	13,691	164,709	11,548	0	0	0	0	0	0	0	0	0	0	0	0	0	0	508,709	25,239	4,746,667	4,237,958
2060	0	0	156,000	9,939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	156,000	9,939	1,869,177	1,713,177
2061	0	0	156,000	9,939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	156,000	9,939	1,869,177	1,713,177
2062	0	0	156,000	9,939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	156,000	9,939	1,869,177	1,713,177
2063	0	0	156,000	9,939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	156,000	9,939	1,869,177	1,713,177

12.2.4 Estimation of economic cost

Economic cost expresses consumption of costs seen from the viewpoint of the national economy[2]. The market price used in the above estimate of financial cost is distorted by price controls and taxation, etc., in the country and is not a true representation of cost in the national economy. For example, assuming that tariffs and commodity tax are included in the market price of imports, since the taxation portion eventually returns to the national treasury, the true price in the national economy must be the price obtained by deducting this tax portion from the market price.

Estimation of economic cost should really be done for one cost item at a time, however, because this work is complicated and time-consuming, a simple method is used. In this simple method, financial cost is divided into foreign currency (FC) and local currency (LC), whereby the foreign currency portion is used to estimate the border price and the local currency portion is used to estimate the border price or opportunity cost by using the "conversion factor (CF)".

The foreign currency and domestic currency ratio is as follows:

Small hydropower generation FC : LC = 70%: 30%

Diesel power generation FC : LC = 85%: 15%

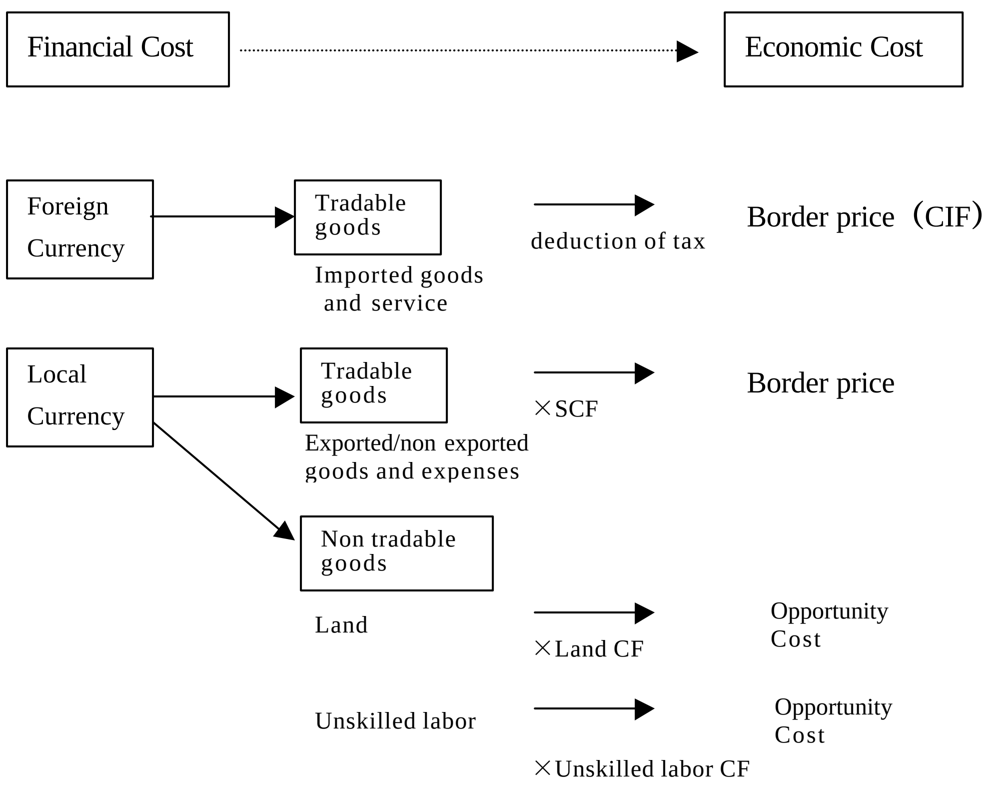


Fig.12-2-4 Economic price calculation process

[2] Economic cost: there is also the expression "opportunity cost in the project concerned", but this has essentially the same meaning.

The standard conversion factor (SCF) is indirectly estimated from national trade statistics using the following expression. As a result of these calculations, a figure of .007 was obtained.

Table 12-2-4-1 Estimation of Standard Conversion Factor

(mil SB$)

Year	Import amount	Export amount	Import duties	Export taxes	Subsidy
1994	468,121	467,877	59,558	84,638	0
1995	526,270	573,153	67,739	74,828	0
1996	536,874	576,648	64,667	83,430	0
1997	685,878	581,776	69,060	65,601	0
1998	770,000	683,000	71,422	48,066	0
1999	659,000	724,000	75,660	56,394	0
Total	3,646,143	3,606,454	408,106	412,957	0
	①	②	③	④	⑤

SCF = 1.0007 ⑥ = (①+②)/(①+②+③-④+⑤)

With regard to compensation expenses for land, etc, it is possible that the candidate sites for small hydropower plants may be in residential zones or in areas of agricultural or timber production, however, for the time being it shall be assumed that idle land is used and that the benefit cost is zero (accordingly, the CF of land is 0.00).

Where personnel expenses for unskilled laborers are concerned, since employment statistics and GDP statistics in the Solomon Islands are inadequate, the figure of 0.25, which was previously used by the British Overseas Development Ministry (ODM), shall be temporarily used here[3].

The results of obtaining weighted averages of these conversion factors using the cost ratio of small hydropower and diesel power plants are shown in the following table.

Table 12-2-4-2 Estimation of Weighted Average Conversion Factor

Estimation of Conversion Factors for Small Hydropower

Work Item	Civil & Mechanical	Unskilled labor	Land acquisition	Engineering Contingency	Conversion factor in weight average
Conversion factor	1.0007	0.2500	0.0000	1.0000	0.8915
Portion	69.21%	13.44%	0.82%	16.53%	100.00%

Estimation of Conversion Factors for Diesel Power

Work Item	Civil & Mechanical	Unskilled labor	Land acquisition	Engineering Contingency	Conversion factor in weight average
Conversion factor	1.0007	0.2500	0.0000	1.0000	0.9855
Portion	89.60%	2.01%	0.00%	8.39%	100.00%

[3] Study and Research of Project Economic Analysis and Evaluation Volume 1", p. 124, Japan International Cooperation Center (March 1995)

From the above results, the formula for deriving economic cost from financial cost in both small hydropower and diesel power plants is as follows. O&M and economic costs are derived in the same way as construction cost.

Case for small hydropower generation

Economic cost = financial cost + 70% + financial cost x 30% x weighted average conversion factor (0.8915)

Case for diesel power generation

Economic cost = financial cost + 85% + financial cost x 15% x weighted average conversion factor (0.9855)

Financial and economic cost for Maotapuku No.1 small hydropower

Financial cost (US$)			Economic cost (US$)	
1st year	4,476,600	→	1st year	4,330,837
2nd year	6,217,500		2nd year	6,015,052
3rd year	10,694,100		3rd year	10,345,889
4th year	3,481,800		4th year	3,368,429
O&M	141,000		O&M	136,409

Financial and economic cost for diesel power plant (example of US$1,300/kW)

Financial cost (US$)			Economic cost (US$)	
kW cost	**1,534/kW**	→	**kWcost**	**1,531/kW**
Fuel cost	**0.0912/kWh**		**Fuel cost**	**0.0910/kWh**

12.2.5 Identification of Economic Benefit

The plan comprises of more than 30 power plants (small hydropower and diesel power), and it is necessary to identify economic benefit for the case where these facilities are considered as one project. If all the plants were small hydropower plants, diesel power generation could be considered as the substitute project and the cost saving could be viewed as the economic benefit. However, in the case of diesel power plants, since there is no substitute plan to take their place[4], it is not possible to identify any benefit by alternative approaches. Here, the "Willingness to Pay" shall be used to find the economic benefit of whole optimum power supply project.

[4] Substitute plan for diesel power generation: no alternative projects for diesel power generation exist in the plan because there is no possibility of small hydropower generation, or construction of coal-fired power plants is unrealistic.

Originally the Willingness to Pay was statistically estimated by conducting questionnaire surveys of consumers, however, the following simple method is usually used. In the simple method, consumers are divided into households, commerce and industry; kerosene lamps are assumed for the former and diesel power generation for the latter; and the weighted average kWh cost is calculated as the Willingness to Pay.

The calculation process of the Willingness to Pay is shown as follows. The price of kerosene lamp and kerosene, hours per day and consumption of kerosene are based on the survey result, and the equivalent wattage of the kerosene lamp is recalculated figure assuming the thermal efficiency is 10%. The costs regarding the diesel power generator are the figures used in the alternative diesel power described in section 12.2.7.

Table 12-2-5 Calculation process of Willingness to Pay

1. Calculation of Upper Limits

Household	kerosine lamp			
Power value	Unit			
Equipment price	SB$	34.84	①	
Durable years	years	5	②	
Annual cost	SB$/year	6.97	③ = ①/②	
Equivalent wattage	watt	36.15	④	
Hours per day	hours	4.80	⑤	
Equivalent kWh per year	kWh/year	63.33	⑥ = ④*⑤*365/1000	
Power value	SB$/kWh	0.1100	⑦ = ③/⑥	
Energy value				Heat Content
Unit price of kerosine	SB$/liter	2.50	⑧	8,900 kcal/liter ⑬
Fuel used per year	liter/year	61.20	⑨	Thermal Efficiency
Fuel Cost per year	SB$/year	153.00	⑩ = ⑧*⑨	10.00% ⑭ = ⑥/(⑨*⑬/860)
Energy value	SB$/kWh	2.4157	⑪ = ⑩/⑥	Energy Content
Total Cost	SB$/kWh	2.5258	⑫ = ⑦+⑪ (A)	1.035 kWh/liter
				⑮ = (⑬*⑭/860)
Commercial & Industry	diesel power generator			
Power value				
Construction Cost	US$/kW	2,300	①	
Durable years	years	20	= n	
Discount rate		8.0%	= r	
CRF		0.1019	CRF = r/(1-(1+r)^(-n))	
Annual Powe value	US$/kW/yea	234.26	② = ①*CRF	
Plant Factor:		20.0%	③	
Total loss		15.0%	④	
Fixed O&M cost		3.0%	⑤	
Equivalent energy value	US$/kWh	0.1620	⑥ = ②/(8760*③)/(1-④)*(1+⑤)	
Energy value				
Price of fuel	US$/liter	0.30	⑦	
Fuel cost	US$/kWh	0.0841	⑧ (see Table 12-2-7-4)	
Eergy loss		5.0%	⑨ (see Table 12-2-7-1)	
Variable O&M cost		3.0%	⑩	
Energy value	US$/kWh	0.0912	⑪ = ⑧/(1-⑨)*(1+⑩)	Excahange rate
Total	US$/kWh	0.2532	⑫ = ⑥+⑪	5.00 SB$/US$
	SB$/kWh	1.2662	⑬ = ⑫*5.0 (B)	

2. Calculation of Consumer Surplus

	Unit	Household		Com/Ind		Weight Average	
Demand Structure	%	25.0%	①	75.0%	②		
Upper limit	SB$/kWh	2.5258	③	1.2662	④		
Lower limit (current price)	SB$/kWh	0.6246	⑤	0.8475	⑥	0.7918	⑦ = ⑤*①+⑥*②
Difference of price	SB$/kWh	1.901	⑧	0.419	⑨ =④-⑥		
Percentage of surplus	%	20%	⑩	30%	⑪		
Consumer surplus	SB$/kWh	0.380	⑫	0.126	⑬	0.1893	⑭ = ⑫+⑬

3. Calculation of Willingness to Pay

Willingness to Pay (WTP)	SB$/kWh	0.9810	⑮ = ⑦+⑭
WTP in economic price	SB$/kWh	0.9789	⑯ = ⑮*0.85+⑮*0.15*CF
	US$/kWh	0.1958	⑰ = ⑯/5.0

CF:Conversion Factor 0.9855 (see Table 12-2-4-2)

From the above calculation, it was estimated that the Willingness to Pay for the electricity consumers in the Solomon Islands is US$0.1958 (SB$0.9789). The Willingness to Pay is assumed to be the same throughout the project life of the optimum power supply plan. Economic benefit in the plan is obtained by multiplying the quantity of sold power by this Willingness to Pay.

12.2.6 Economic profitability analysis

In analysis of the economic profitability, cash flow over the project life is compiled using the economic cost and economic benefit estimated above, and this is done by seeking the economic internal rate of return (EIRR). As a result of calculation, the EIRR for the plan was found to be 9.63%.

Criteria for economic feasibility

The criteria for economic feasibility in some projects is said to be the "social discount rate[5]". However, a method for calculating the social discount rate has not yet been established and the only available figure is 8-12% which has been recommended by the World Bank for developing countries. In this analysis, the minimum level recommended by the World Bank, i.e. 8.0%, shall be used as the social discount rate in the Solomon Islands.

Since the EIRR calculated above exceeds the social discount rate of 8.0%, the plan is deemed to be feasible in terms of economy.

[5] Social discount rate: as well as the approach from the viewpoint of capital opportunity cost (expected return from one unit of invested capital), there is the approach from the market interest rate. If the capital market is complete and the market interest rate is accurately reflected in the scarcity value of capital, the social discount rate will equal the market interest rate. However, in reality, due to market distortions caused by various constraints, these two elements do not correspond.

Table 12-2-6 EIRR calculation for optimum power supply plan

Economic Analysis for Master Plan in Solomon Islands

Willingness to pay
0.9789 SB$/kWh
0.1958 US$/kWh

EIRR = 9.63%

Year	H-3 Cost US$	H-3 Sold energy MWh	A-3 Cost US$	A-3 Sold energy MWh	B-1 Cost US$	B-1 Sold energy MWh	K-2 Cost US$	K-2 Sold energy MWh	L-2 Cost US$	L-2 Sold energy MWh	C-1 Cost US$	C-1 Sold energy MWh	G-2 Cost US$	G-2 Sold energy MWh	N-2 Cost US$	N-2 Sold energy MWh	T-2 Cost US$	T-2 Sold energy MWh	Total Cost US$	Total Sold energy MWh	Benefit US$	Net US$
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	7,435,829	11,064	149,076	0	0	0	0	0	0	0	206,511	0	798,263	0	0	0	0	0	8,589,679	11,064	2,166,137	-6,423,542
2001	2,091,491	22,979	7,282,643	124	0	0	412,104	0	0	0	5,422	60	54,217	596	7,184,371	0	0	0	17,030,247	23,758	4,651,385	-12,378,862
2002	2,091,491	22,979	4,125,442	2,357	0	0	1,171,125	298	0	0	1,803,891	60	1,251,612	596	542,171	5,957	0	0	10,985,732	32,246	6,313,271	-4,672,461
2003	9,744,842	22,979	3,179,738	6,983	0	0	331,214	298	0	0	30,575	620	135,543	1,489	542,171	5,957	0	0	13,964,083	38,326	7,503,640	-6,460,443
2004	11,035,886	37,164	688,913	9,217	0	0	41,590	1,263	0	0	30,575	620	135,543	1,489	542,171	5,957	0	0	12,474,677	55,711	10,907,129	-1,567,548
2005	4,673,579	51,348	688,913	9,217	367,201	0	41,590	1,263	460,398	0	30,575	620	135,543	1,489	7,726,542	5,957	299,349	0	14,423,690	69,895	13,684,228	-739,462
2006	13,710,872	51,348	688,913	9,217	21,687	238	41,590	1,263	27,109	298	30,575	620	734,240	1,489	1,084,341	11,914	8,133	89	16,347,459	76,477	14,972,918	-1,374,541
2007	24,878,725	51,348	688,913	9,217	21,687	238	41,590	1,263	27,109	298	30,575	620	176,205	1,936	1,084,341	11,914	8,133	89	26,957,277	76,924	15,060,386	-11,896,892
2008	27,553,711	65,533	1,354,537	9,217	1,616,994	238	41,590	1,263	27,109	298	30,575	620	176,205	1,936	1,084,341	11,914	8,133	89	31,893,194	91,109	17,837,485	-14,055,710
2009	12,993,628	65,533	865,851	9,217	43,938	771	41,590	1,263	27,109	298	30,575	620	176,205	1,936	1,084,341	11,914	8,133	89	15,271,370	91,642	17,941,868	2,670,498
2010	6,297,422	79,224	5,618,681	10,826	43,938	771	41,590	1,263	27,109	298	30,575	620	176,205	1,936	8,268,712	11,914	8,133	89	20,512,365	106,942	20,937,366	425,001
2011	6,297,422	79,224	7,532,537	10,826	43,938	771	536,114	1,263	27,109	298	30,575	620	176,205	1,936	1,626,512	17,870	8,133	89	16,278,544	112,899	22,103,601	5,825,057
2012	13,950,773	79,224	12,453,879	10,826	411,139	771	74,120	1,621	487,507	298	30,575	620	176,205	1,936	1,626,512	17,870	8,133	89	29,218,844	113,256	22,173,575	-7,045,268
2013	7,588,466	93,408	4,525,049	10,826	65,625	1,010	74,120	1,621	54,217	596	30,575	620	176,205	1,936	1,626,512	17,870	8,133	89	14,148,902	127,977	25,055,635	10,906,733
2014	7,588,466	93,408	848,259	20,765	65,625	1,010	74,120	1,621	54,217	596	30,575	620	176,205	1,936	1,626,512	17,870	8,133	89	10,472,112	137,916	27,001,469	16,529,357
2015	7,588,466	93,408	848,259	20,765	65,625	1,010	74,120	1,621	54,217	596	30,575	620	774,903	1,936	1,626,512	17,870	8,133	89	11,070,810	137,916	27,001,469	15,930,660
2016	10,649,806	93,408	848,259	20,765	65,625	1,010	74,120	1,621	54,217	596	30,575	620	216,868	2,383	5,218,698	17,870	8,133	89	17,166,301	138,363	27,088,937	9,922,636
2017	8,104,884	99,082	848,259	20,765	65,625	1,010	74,120	1,621	54,217	596	30,575	620	216,868	2,383	1,897,597	20,849	8,133	89	11,300,278	147,015	28,782,894	17,482,616
2018	8,104,884	99,082	848,259	20,765	65,625	1,010	74,120	1,621	54,217	596	30,575	620	216,868	2,383	1,897,597	20,849	8,133	89	11,300,278	147,015	28,782,894	17,482,616
2019	7,097,869	88,018	848,259	20,765	65,625	1,010	74,120	1,621	54,217	596	30,575	620	216,868	2,383	1,897,597	20,849	8,133	89	10,293,263	135,951	26,616,757	16,323,494
2020	6,013,392	76,103	837,009	20,642	65,625	1,010	74,120	1,621	54,217	596	25,153	561	162,651	1,787	1,897,597	20,849	8,133	89	9,137,898	123,257	24,131,509	14,993,611
2021	6,013,392	76,103	633,695	18,408	65,625	1,010	47,011	1,323	54,217	596	25,153	561	162,651	1,787	1,355,427	14,892	8,133	89	8,365,304	114,768	22,469,623	14,104,319
2022	6,013,392	76,103	430,381	16,174	65,625	1,010	47,011	1,323	54,217	596	25,153	561	81,326	894	1,355,427	14,892	8,133	89	8,080,665	111,641	21,857,349	13,776,684
2023	4,722,348	61,919	227,067	13,940	65,625	1,010	47,011	1,323	54,217	596	25,153	561	81,326	894	1,355,427	14,892	8,133	89	6,586,307	95,223	18,642,912	12,056,605
2024	3,431,304	47,734	227,067	13,940	65,625	1,010	47,011	1,323	54,217	596	25,153	561	81,326	894	1,355,427	14,892	8,133	89	5,295,263	81,038	15,865,813	10,570,550
2025	3,431,304	47,734	227,067	13,940	43,938	771	47,011	1,323	27,109	298	25,153	561	81,326	894	813,256	8,935	0	0	4,696,164	74,456	14,577,123	9,880,959
2026	3,431,304	47,734	227,067	13,940	43,938	771	47,011	1,323	27,109	298	25,153	561	40,663	447	813,256	8,935	0	0	4,655,501	74,009	14,489,655	9,834,154
2027	2,140,261	33,549	227,067	13,940	43,938	771	47,011	1,323	27,109	298	25,153	561	40,663	447	813,256	8,935	0	0	3,364,458	59,824	11,712,556	8,348,099
2028	2,140,261	33,549	227,067	13,940	43,938	771	47,011	1,323	27,109	298	25,153	561	40,663	447	813,256	8,935	0	0	3,364,458	59,824	11,712,556	8,348,099
2029	2,140,261	33,549	227,067	13,940	43,938	771	47,011	1,323	27,109	298	25,153	561	40,663	447	813,256	8,935	0	0	3,364,458	59,824	11,712,556	8,348,099
2030	2,140,261	33,549	227,067	13,940	43,938	771	47,011	1,323	27,109	298	25,153	561	40,663	447	271,085	2,978	0	0	2,822,287	53,868	10,546,321	7,724,034
2031	2,140,261	33,549	227,067	13,940	43,938	771	47,011	1,323	27,109	298	25,153	561	40,663	447	271,085	2,978	0	0	2,822,287	53,868	10,546,321	7,724,034
2032	849,217	19,365	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	40,663	447	271,085	2,978	0	0	1,482,448	39,147	7,664,261	6,181,813
2033	849,217	19,365	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	40,663	447	271,085	2,978	0	0	1,482,448	39,147	7,664,261	6,181,813
2034	849,217	19,365	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	40,663	447	271,085	2,978	0	0	1,482,448	39,147	7,664,261	6,181,813
2035	849,217	19,365	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	271,085	2,978	0	0	1,441,785	38,700	7,576,793	6,135,008
2036	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2037	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2038	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2039	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2040	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2041	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2042	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2043	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2044	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2045	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2046	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2047	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2048	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2049	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2050	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2051	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2052	332,799	13,691	227,067	13,940	22,251	533	47,011	1,323	0	0	25,153	561	0	0	0	0	0	0	654,282	30,048	5,882,836	5,228,554
2053	332,799	13,691	159,346	11,548	22,251	533	47,011	1,323	0	0	0	0	0	0	0	0	0	0	561,408	27,095	5,304,740	4,743,333
2054	332,799	13,691	159,346	11,548	22,251	533	32,530	357	0	0	0	0	0	0	0	0	0	0	546,926	26,129	5,115,689	4,568,762
2055	332,799	13,691	159,346	11,548	22,251	533	32,530	357	0	0	0	0	0	0	0	0	0	0	546,926	26,129	5,115,689	4,568,762
2056	332,799	13,691	159,346	11,548	22,251	533	32,530	357	0	0	0	0	0	0	0	0	0	0	546,926	26,129	5,115,689	4,568,762
2057	332,799	13,691	159,346	11,548	22,251	533	32,530	357	0	0	0	0	0	0	0	0	0	0	546,926	26,129	5,115,689	4,568,762
2058	332,799	13,691	159,346	11,548	22,251	533	0	0	0	0	0	0	0	0	0	0	0	0	514,396	25,772	5,045,715	4,531,319
2059	332,799	13,691	159,346	11,548	0	0	0	0	0	0	0	0	0	0	0	0	0	0	492,145	25,239	4,941,331	4,449,186
2060	0	0	150,920	9,939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150,920	9,939	1,945,834	1,794,913
2061	0	0	150,920	9,939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150,920	9,939	1,945,834	1,794,913
2062	0	0	150,920	9,939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150,920	9,939	1,945,834	1,794,913
2063	0	0	150,920	9,939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150,920	9,939	1,945,834	1,794,913

12.2.7 Economic and financial analysis of small hydropower in potential sites

The Study Team surveyed 10 potential sites for small hydropower generation, and economic and financial analysis for these 10 small hydropower sites is carried out for reference purposes.

The list of financial cost and economic cost of the 10 potential sites for small hydropower is shown in the next page. Concerning the tariff, which is the financial benefit, the LRAIC + 5% (US$0.1881) shall be used. However, in cases where the construction period lasts for one year or more, it shall be assumed that the power tariff includes a price rise of 5.00% per year. The economic cost is calculated by the same method explained in the section on the optimum power supply plan.

The economic analysis is carried out by using the "alternative thermal power method[6]", which is commonly used for small hydropower plants. In the case of the Solomon Islands, diesel power plants are the most realistic alternative to small hydropower plants, so the cost incurred in these substitute diesel power facilities shall be estimated as the economic benefit.

In the alternative thermal power method, the alternative thermal power plant cost is divided into construction cost and fuel cost by seeking the unit rate of each. The unit rate of construction cost is sought as kW cost and is referred to as the power value or kW value. The unit rate of fuel cost is sought as the kWh cost and is referred to as the energy value or kWh value.

Moreover, in thermal power plants and small hydropower plants, because the power loss factor which arises from generating terminals to receiving terminals is different, an adjustment factor like the one shown in the following page is normally used to adjust the power value and energy value.

Table12-2-7-1 Calculation of adjustment factor

Calculation of Adjustment Factor

Item	Planned Hydropower Station		Diesel Power Station	
Power own use	0.30%	①	2.0%	⑤
Force outage	0.50%	②	5.0%	⑥
Overhaul & Inspection	0.50%	③	5.0%	⑦
Transmission/ leakage loss	4.00%	④	3.0%	⑧
Total loss	5.30%		15.00%	
kW -adjustment factor			1.1045	⑨
kWh -adjustment factor			1.0069	⑩

(Note) 1. ⑨ = (1-①)*(1-②)*(1-③)*(1-④)/(1-⑤)*(1-⑥)*(1-⑦)*(1-⑧)

2. ⑩ = (1-①)*(1-④)/(1-⑤)*(1-⑧)

[6] There are two types of alternative thermal power method - the European/American type, and the Japanese type. In the former, whereas the construction cost of alternative thermal power is used directly as the benefit, in the latter, the construction cost is annualized and is counted as the yearly benefit. The European/American approach, which is widely used throughout the world, is adopted here.

Table12-2-7-2 List of the financial and economic cost of the small hydropower potential sites

Islands		Guadalcanal			Malaita			Santa Isabel	San Cristobal	Choiseul	Santa Cruz
Site		Maotapuku 1	Maotapuku 2	Sasa	Silolo	Rori	Kware'a	Kubolata	Waimapuru	Sorave	Luembalele
Term of construction (year)		4	4	2	4	2	4	1	1	1	1
Installed capacity (kW)		1,600	1,400	280	2,100	300	600	80	20	70	50
Energy output (MWh) p.a.		7,838	6,619	2,396	10,495	2,526	2,541	563	170	592	432
Plant factor		55.92%	53.97%	97.68%	57.05%	96.12%	48.34%	80.34%	97.00%	96.54%	98.63%
Weighted average plant factor		55.01%			61.93%						
Capital cost		24,870,000	27,027,000	6,211,000	28,261,000	5,989,000	18,185,000	1,649,000	912,000	1,859,000	4,117,000
US$ / kW		15,544	19,305	22,182	13,458	19,963	30,308	20,613	45,600	26,557	82,340
O&M cost		141,000	203,000	62,000	156,000	70,000	123,000	23,000	18,000	26,000	51,000
		0.57%	0.75%	1.00%	0.55%	1.17%	0.68%	1.39%	1.97%	1.40%	1.24%
Financial Cost											
1st year	18% 79%	4,476,600	4,864,860	4,906,690	5,086,980	4,731,310	3,273,300	1,649,000	912,000	1,859,000	4,117,000
2nd year	25% 21%	6,217,500	6,756,750	1,304,310	7,065,250	1,257,690	4,546,250	0	0	0	0
3rd year	43%	10,694,100	11,621,610	0	12,152,230	0	7,819,550	0	0	0	0
4th year	14%	3,481,800	3,783,780	0	3,956,540	0	2,545,900	0	0	0	0
O&M cost		141,000	203,000	62,000	156,000	70,000	123,000	23,000	18,000	26,000	51,000
Economic Cost											
1st year		4,330,837	4,706,455	4,746,923	4,921,343	4,577,254	3,166,718	1,595,307	882,304	1,798,469	3,982,946
2nd year		6,015,052	6,536,743	1,261,840	6,835,198	1,216,738	4,398,219	0	0	0	0
3rd year		10,345,889	11,243,198	0	11,756,541	0	7,564,937	0	0	0	0
4th year		3,368,429	3,660,576	0	3,827,711	0	2,463,003	0	0	0	0
O&M cost		136,409	196,390	59,981	150,920	67,721	118,995	22,251	17,414	25,153	49,339

Conversion Factor (Weighted average) = 0.8915

Economic cost = Financial cost *70% +Financial cost * 30% * Conversion Factor(weighted average)

Tariff (LRAIC * 1.05) 0.1881 US$/kWh

Exchange rate as of Dec. 1999 5.00 SB$/US$

Envisaged annual price increase 5.00%

Construction period	year	4	4	2	4	2	4	1	1	1	1
Envisaged tariff in operation	US$/kWh	0.2286	0.2286	0.2073	0.2286	0.2073	0.2286	0.1975	0.1975	0.1975	0.1975

Estimation of Annual Revenue

Total loss 5.30%

Annual generated energy	MWh	7,838	6,619	2,396	10,495	2,526	2,541	563	170	592	432
Annual sold energy	MWh	7,423	6,268	2,269	9,939	2,392	2,406	533	161	561	409
Annual revenue in US$	US$	1,696,800	1,432,906	470,472	2,271,997	495,998	550,085	105,285	31,781	110,708	80,787

Internal Rate of Return		Maotapuku 1	Maotapuku 2	Sasa	Silolo	Rori	Kware'a	Kubolata	Waimapuru	Sorave	Luembalele
	FIRR	5.244%	3.400%	5.880%	6.432%	6.429%	0.313%	4.379%	-1.143%	3.836%	-3.568%
	EIRR	3.280%	1.416%	2.726%	10.365%	6.794%	1.227%	8.224%	-2.252%	6.694%	-4.610%

Table 12-2-7-3 Calculation of the power value
(In the case of alternative diesel for Maotapuku small hydro)

Power value (kW value)

kW construction cost	US$/kW	1,534	①
kW adjustment factor		1.1045	②
Plant Factor		38.1%	③
Fixed O&M Cost		3.00%	④
Power value (kW value)	**US$/kW**	**4,580**	⑤ = ①*②/③*(1+④)

Table 12-2-7-4 Calculation of the energy value
(same in each alternative diesel)

Energy value (kWh value)

Fuel type		Diesel Oil	
Fuel Price	US$/liter	0.30	①
Heat Content	kcal/liter	9,200	②
Thermal Efficiency	%	35.0%	③
Heat rate	kcal/kWh	2,457.14	④ = 860/③
Fuel Consumption per kWh	liter/kWh	0.2671	⑤ = ④/②
Lubricant Oil	% of Fuel cost	5.0%	⑥
Fuel Cost	US$/kWh	0.0841	⑦ = ⑤*①*(1+⑥)
kWh -adjustment factor		1.0069	⑧
Variable O&M Cost		3.0%	⑨
Energy value	**US$/kWh**	**0.0872**	⑩ = ⑦*⑧*(1+⑨)

Below is shown a list of FIRR and EIRR at the 10 potential sites as calculated according to the above procedure.

Table 12-2-7-5 FIRR and EIRR for the small hydropower potential site

	Maotapuku 1	Maotapuku 2	Sasa	Silolo	Rori
FIRR	5.244%	3.400%	5.880%	6.432%	6.429%
EIRR	3.280%	1.416%	2.726%	10.365%	6.794%

	Kware'a	Kubolata	Waimapuru	Sorave	Luembalele
FIRR	0.313%	4.379%	-1.143%	3.836%	-3.568%
EIRR	1.227%	8.224%	-2.252%	6.694%	-4.610%

According to this result, almost of all FIRR of the small hydropower potential sites included in the optimum power supply plan exceeds 3.8%, the real interest rate in the Solomon Islands, therefore these projects are thought to be feasible financially. On the other hand, the FIRR of Kware'a, Waimapuru and Luembalele show negative value which indicates that the cost of construction could not be recovered even if 50 years were given.

Moreover, if it is assumed that the social discount rate is 8.00%, EIRR which exceed this are only Silolo and Kubolata, and the Rori and Sorave showed close values. The other small hydropower sites offer lower returns economically than other projects in the Solomon Islands.

Table 12-7-6 Calculation of FIRR, EIRR for Maotapuku - 1 small hydropower

Maotapku-1

FIRR = **5.244%**

US$

Year	Cost	O&M	Sold Energy MWh	Benefit	NET
1	4,476,600	0		0	-4,476,600
2	6,217,500	0		0	-6,217,500
3	10,694,100	0		0	-10,694,100
4	3,481,800	0		0	-3,481,800
5		141,000	7,423	1,696,800	1,555,800
6		141,000	7,423	1,696,800	1,555,800
7		141,000	7,423	1,696,800	1,555,800
8		141,000	7,423	1,696,800	1,555,800
9		141,000	7,423	1,696,800	1,555,800
10		141,000	7,423	1,696,800	1,555,800
11		141,000	7,423	1,696,800	1,555,800
12		141,000	7,423	1,696,800	1,555,800
13		141,000	7,423	1,696,800	1,555,800
14		141,000	7,423	1,696,800	1,555,800
15		141,000	7,423	1,696,800	1,555,800
16		141,000	7,423	1,696,800	1,555,800
17		141,000	7,423	1,696,800	1,555,800
18		141,000	7,423	1,696,800	1,555,800
19		141,000	7,423	1,696,800	1,555,800
20		141,000	7,423	1,696,800	1,555,800
21		141,000	7,423	1,696,800	1,555,800
22		141,000	7,423	1,696,800	1,555,800
23		141,000	7,423	1,696,800	1,555,800
24		141,000	7,423	1,696,800	1,555,800
25		141,000	7,423	1,696,800	1,555,800
26		141,000	7,423	1,696,800	1,555,800
27		141,000	7,423	1,696,800	1,555,800
28		141,000	7,423	1,696,800	1,555,800
29		141,000	7,423	1,696,800	1,555,800
30		141,000	7,423	1,696,800	1,555,800
31		141,000	7,423	1,696,800	1,555,800
32		141,000	7,423	1,696,800	1,555,800
33		141,000	7,423	1,696,800	1,555,800
34		141,000	7,423	1,696,800	1,555,800
35		141,000	7,423	1,696,800	1,555,800
36		141,000	7,423	1,696,800	1,555,800
37		141,000	7,423	1,696,800	1,555,800
38		141,000	7,423	1,696,800	1,555,800
39		141,000	7,423	1,696,800	1,555,800
40		141,000	7,423	1,696,800	1,555,800
41		141,000	7,423	1,696,800	1,555,800
42		141,000	7,423	1,696,800	1,555,800
43		141,000	7,423	1,696,800	1,555,800
44		141,000	7,423	1,696,800	1,555,800
45		141,000	7,423	1,696,800	1,555,800
46		141,000	7,423	1,696,800	1,555,800
47		141,000	7,423	1,696,800	1,555,800
48		141,000	7,423	1,696,800	1,555,800
49		141,000	7,423	1,696,800	1,555,800
50		141,000	7,423	1,696,800	1,555,800

Alternative Diesel

kW coat	1,534	US$kW
Plant Factor	38.1%	
Power value	4,580	US$kW

EIRR = **3.280%**

US$

Year	Cost	O&M Cost	Sold Energy MWh	Benefit Construction	Benefit Fuel	NET
1	4,330,837	0		0	0	-4,330,837
2	6,015,052	0		0	0	-6,015,052
3	10,345,889	0		0	0	-10,345,889
4	3,368,429	0		7,328,669	0	3,960,240
5		136,409	7,423	0	647,611	511,202
6		136,409	7,423	0	647,611	511,202
7		136,409	7,423	0	647,611	511,202
8		136,409	7,423	0	647,611	511,202
9		136,409	7,423	0	647,611	511,202
10		136,409	7,423	0	647,611	511,202
11		136,409	7,423	0	647,611	511,202
12		136,409	7,423	0	647,611	511,202
13		136,409	7,423	0	647,611	511,202
14		136,409	7,423	0	647,611	511,202
15		136,409	7,423	0	647,611	511,202
16		136,409	7,423	0	647,611	511,202
17		136,409	7,423	0	647,611	511,202
18		136,409	7,423	0	647,611	511,202
19		136,409	7,423	0	647,611	511,202
20		136,409	7,423	0	647,611	511,202
21		136,409	7,423	0	647,611	511,202
22		136,409	7,423	0	647,611	511,202
23		136,409	7,423	0	647,611	511,202
24		136,409	7,423	7,328,669	647,611	7,839,871
25		136,409	7,423	0	647,611	511,202
26		136,409	7,423	0	647,611	511,202
27		136,409	7,423	0	647,611	511,202
28		136,409	7,423	0	647,611	511,202
29		136,409	7,423	0	647,611	511,202
30		136,409	7,423	0	647,611	511,202
31		136,409	7,423	0	647,611	511,202
32		136,409	7,423	0	647,611	511,202
33		136,409	7,423	0	647,611	511,202
34		136,409	7,423	0	647,611	511,202
35		136,409	7,423	0	647,611	511,202
36		136,409	7,423	0	647,611	511,202
37		136,409	7,423	0	647,611	511,202
38		136,409	7,423	0	647,611	511,202
39		136,409	7,423	0	647,611	511,202
40		136,409	7,423	0	647,611	511,202
41		136,409	7,423	0	647,611	511,202
42		136,409	7,423	0	647,611	511,202
43		136,409	7,423	0	647,611	511,202
44		136,409	7,423	7,328,669	647,611	7,839,871
45		136,409	7,423	0	647,611	511,202
46		136,409	7,423	0	647,611	511,202
47		136,409	7,423	0	647,611	511,202
48		136,409	7,423	0	647,611	511,202
49		136,409	7,423	0	647,611	511,202
50		136,409	7,423	0	647,611	511,202

12.3 Economic and financial analysis for rural electrification plan

In this section, economic and financial analysis for the rural electrification plan is carried out. In the case of uniform standards in SHS, regardless of the position of candidate sites, the plant cost, works cost and O&M cost shall all be viewed as the same. Moreover, regardless of the number of SHS units, financial and economic profitability shall be assumed to be the same. Therefore, here, economic and financial analysis shall be carried out with respect to a single SHS.

12.3.1 Estimation of financial cost

First of all, the SHS plant cost, works cost and O&M cost are estimated. SHS is currently sold in the Solomon Islands, however, the market price is the price after custom duty and good tax have been charged. In the case where the rural electrification plan is carried out as a national project, it is normal that tax exemption measures are taken. Here, both with tax price and without tax price are used as the financial cost.

Table 12-2-1 Financial cost of SHS

	With tax			Without tax		(US$)
	36Wp	55Wp	75Wp	36Wp	55Wp	75Wp
PV set	1,195	1,398	1,640	996	1,160	1,301
Battery	248	290	364	202	237	297
C/C	144	144	144	117	117	117
O&M	12	12	12	12	12	12

* C/C = Charge controller

Out of the above cost, since the duration life of batteries is seven years, replacement is necessary after 8 and 15 years; moreover, since charge controllers have a duration life of 10 years, replacement needs to be carried out in the 11th year (see Chapter 7 for details).

12.3.2 Financial benefit and FIRR

The set SHS tariff is used as the financial benefit of SHS. The features of SHS fundamentally differ between thermal power generation and hydropower generation, so setting of tariffs in terms of kWh rates is impossible. The most realistic method of setting SHS tariffs is to first collect a uniform down payment and then collect the remainder in monthly installments over a certain period.

In Chapter 7, the SHS tariff is set so as to allow the plant cost and O&M cost to be retrieved. 84 alternative tariff settings exist depending on differences in conditions.

1) Panel specifications: 3 types (36 WP, 55 WP, 75 WP)
2) Taxation: 2 types (with tax, without tax)
3) Years of payment: 7 types (0, 3, 5, 7, 10, 15, 20 years)
4) Interest charge: 2 types (4%, 0%)

Table 12-3-2-1 Tariff system for SHS

Discount Rate	4.0%	
Charged Interest	4.0%	
Down payment	30	US$

Exchange rate
5.00 SB$/US$

With tax (Charged Interest 4.0%)

	36Wp	NPV	55Wp	NPV	75Wp	NPV
PV set	1,195	1,195	1,398	1,398	1,640	1,640
Battery	248	332	290	388	364	487
C/C	144	97	144	97	144	97
O&M	12	163	12	163	12	163
Total		1,787		2,046		2,387

year	annual	monthly US$	SB$	annual	monthly US$	SB$	annual	monthly US$	SB$
0	1,757		8,782.7	2,016		10,078.5	2,357		11,783.4
3	633	52.7	263.7	726	60.5	302.6	849	70.8	353.8
5	395	32.9	164.4	453	37.7	188.7	529	44.1	220.6
7	293	24.4	121.9	336	28.0	139.9	393	32.7	163.6
10	217	18.0	90.2	249	20.7	103.5	291	24.2	121.1
15	158	13.2	65.8	181	15.1	75.5	212	17.7	88.3
20	129	10.8	53.9	148	12.4	61.8	173	14.5	72.3

Without tax (Charged Interest 4.0%)

	36Wp	NPV	55Wp	NPV	75Wp	NPV
PV set	996	996	1,160	1,160	1,301	1,301
Battery	202	270	237	317	297	397
C/C	117	79	117	79	117	79
O&M	12	163	12	163	12	163
Total		1,508		1,719		1,940

year	annual	monthly US$	SB$	annual	monthly US$	SB$	annual	monthly US$	SB$
0	1,478		7,388.9	1,689		8,442.9	1,910		9,549.2
3	533	44.4	221.9	608	50.7	253.5	688	57.4	286.8
5	332	27.7	138.3	379	31.6	158.0	429	35.7	178.7
7	246	20.5	102.6	281	23.4	117.2	318	26.5	132.6
10	182	15.2	75.9	208	17.3	86.7	235	19.6	98.1
15	133	11.1	55.4	152	12.7	63.3	172	14.3	71.6
20	109	9.1	45.3	124	10.4	51.8	141	11.7	58.6

Discount Rate	4.0%	
Charged Interest	0.0%	
Down payment	30	US$

With tax (Charged Interest 0.0%)

	36Wp	NPV	55Wp	NPV	75Wp	NPV
PV set	1,195	1,195	1,398	1,398	1,640	1,640
Battery	248	332	290	388	364	487
C/C	144	97	144	97	144	97
O&M	12	163	12	163	12	163
		1,787		2,046		2,387

year	annual	monthly US$	SB$	annual	monthly US$	SB$	annual	monthly US$	SB$
0	1,757		8,782.7	2,016		10,078.5	2,357		11,783.4
3	586	48.8	244.0	672	56.0	280.0	786	65.5	327.3
5	351	29.3	146.4	403	33.6	168.0	471	39.3	196.4
7	251	20.9	104.6	288	24.0	120.0	337	28.1	140.3
10	176	14.6	73.2	202	16.8	84.0	236	19.6	98.2
15	117	9.8	48.8	134	11.2	56.0	157	13.1	65.5
20	88	7.3	36.6	101	8.4	42.0	118	9.8	49.1

Without tax (Charged Interest 0.0%)

	36Wp	NPV	55Wp	NPV	75Wp	NPV
PV set	996	996	1,160	1,160	1,301	1,301
Battery	202	270	237	317	297	397
C/C	117	79	117	79	117	79
O&M	12	163	12	163	12	163
		1,508		1,719		1,940

year	annual	monthly US$	SB$	annual	monthly US$	SB$	annual	monthly US$	SB$
0	1,478		7,388.9	1,689		8,442.9	1,910		9,549.2
3	493	41.0	205.2	563	46.9	234.5	637	53.1	265.3
5	296	24.6	123.1	338	28.1	140.7	382	31.8	159.2
7	211	17.6	88.0	241	20.1	100.5	273	22.7	113.7
10	148	12.3	61.6	169	14.1	70.4	191	15.9	79.6
15	99	8.2	41.0	113	9.4	46.9	127	10.6	53.1
20	74	6.2	30.8	84	7.0	35.2	95	8.0	39.8

In the next step, it was examined how FIRR will change according to the monthly tariff setting. The following table shows that the calculation result of FIRR in case the tariff rate are set in the range of SB$10 to SB$100. The installment period is set to 20 years in all case.

Table 12-3-2-2 FIRR of SHS in each tariff setting

FIRR by monthly payment
Payment period = 20 years
Down payment = SB$ 150

With tax (SB$)

	10	20	30	40	50	60	70	80	90	100
36Wp	-28.74%	-12.78%	-5.76%	-1.04%	2.71%	5.94%	8.86%	11.57%	14.14%	16.61%
55Wp	-30.73%	-14.70%	-7.69%	-3.10%	0.47%	3.49%	6.19%	8.67%	10.99%	13.21%
75Wp	-33.64%	-17.40%	-10.13%	-5.50%	-2.00%	0.91%	3.46%	5.77%	7.92%	9.94%

Without tax (SB$)

	10	20	30	40	50	60	70	80	90	100
36Wp	-25.76%	-10.03%	-3.05%	1.81%	5.79%	9.29%	12.51%	15.55%	18.46%	21.29%
55Wp	-27.83%	-11.93%	-5.02%	-0.34%	3.40%	6.64%	9.58%	12.32%	14.93%	17.44%
75Wp	-30.77%	-14.32%	-7.12%	-2.40%	1.29%	4.43%	7.24%	9.83%	12.27%	14.61%

As can be inferred from the above calculation results, in order for the FIRR to be positive, it is necessary for the monthly tariff to be more than SB$40 for 36Wp, and more than SB$50 for 55Wp and 75Wp, both with tax and without tax. In order to achieve 4.0% in the FIRR, the monthly tariff shall be set as SB$45.3, SB$51.8 and SB$58.6 for 36Wp, 55Wp and 75Wp, respectively.

Table 12-3-2-3 FIRR calculation for SHS

（for example of 36Wp、SB$40/month）

Assumption

36Wp	US$	SB$		US$	SB$
PV set	996	4,978	Monthly charge	8	40
Battery	202	1,010	Down Payment	30	150
C/C	117	585	Payment Period	20	years
O&M Cost	12	60	Exchange rate	5.00	SB$/US$

FIRR = 1.81%

	Cost				Benefit	Net	Annual Charge US$	Monthly Charge US$	Monthly Charge SB$
	PV	battery	C/C	O&M					
0	996				30	-966	30		
1				12	96	84	96	8	40
2				12	96	84	96	8	40
3				12	96	84	96	8	40
4				12	96	84	96	8	40
5				12	96	84	96	8	40
6				12	96	84	96	8	40
7		202		12	96	-118	96	8	40
8				12	96	84	96	8	40
9				12	96	84	96	8	40
10			117	12	96	-33	96	8	40
11				12	96	84	96	8	40
12				12	96	84	96	8	40
13				12	96	84	96	8	40
14		202		12	96	-118	96	8	40
15				12	96	84	96	8	40
16				12	96	84	96	8	40
17				12	96	84	96	8	40
18				12	96	84	96	8	40
19				12	96	84	96	8	40
20				12	96	84	96	8	40

12.3.3 Willingness to Pay and tariff for SHS

In terms of Willingness to Pay (or Payable income[7]), a questionnaire survey was conducted in many villages on the SHS potential site survey (see Chapter 7) and the rural village survey (see Chapter 8). According the results of the survey, it is too expensive for low-income people (monthly income less than SB$100) to pay a monthly tariff of more than SB$10-20 and it is possible for high-income people (monthly income more than SB$800) to pay around SB$100. From this result, it can be said that there is a wide range of Willingness to Pay depending on the income level of consumers. This can be explained in the following curve (demand curve).

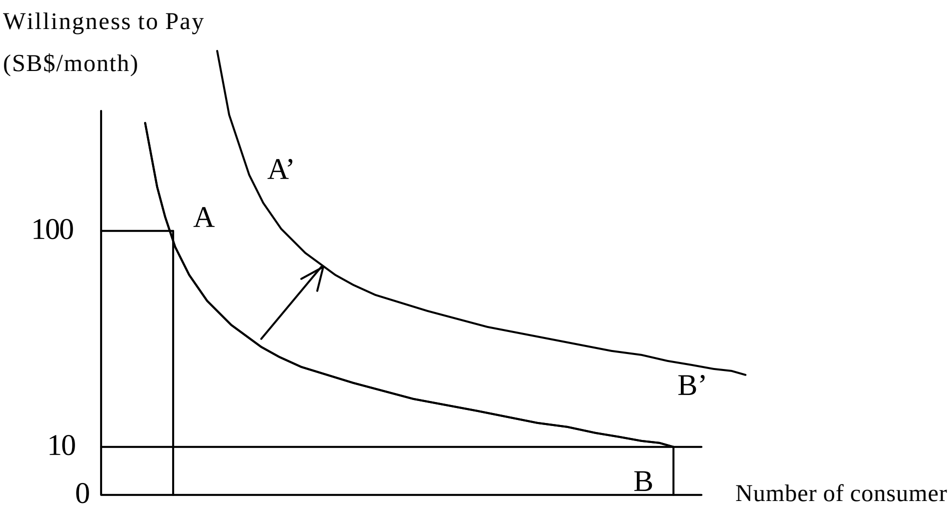


Fig. 12-3-3 Willingness to Pay for SHS

In this figure, the residents located in A are high-income people (monthly income around $800) who are able to pay the monthly tariff of SB$100, and the residents located in B are low-income people who can only pay around SB$10 for the monthly tariff. According to the rural survey in Chapter 8, the cash income of the rural people in the Solomon Islands differs depending on the province, the high-income people live in the small areas of Guadalcanal and Western province.

[7] Willingness to Pay and Payable income: In microeconomics, "Willingness to Pay" means a "Demand Price" which is determined by the "budget restriction" and "consumer preference". On the other hand, "Payable income" is not a general term of microeconomics, however, it is also thought to be determined by the budget restriction and consumer preference, so these two words have essentially the same meaning. In this report, these two words are not used separately, it is only used

Willingness to Pay will increase by change of the "budget restriction" and "consumer preference". In the case of SHS, the Willingness to Pay will increase in line with rising income level or awareness and preference for the SHS of the rural people. In this case the Curve AB will be shifted to curve A'B'.

The utility of the SHS is thought to be higher than is aware by the rural people in Solomon Islands (see next section). It is possible that the Willingness to Pay will increase in line with rising of awareness for SHS through the dissemination of SHS.

Tariff setting for the SHS

For the purpose of the rural electrification, it is necessary to set the tariff rate to the lower level of Willingness to Pay of the rural people (monthly tariff SB$10-20 in low-income area). In this report, it is recommended that the tariff of SHS set as follows.

35Wp	down payment	US$20 (SB$100), monthly US$2.00 (SB$10.00)
55Wp		US$20 (SB$100), monthly US$2.60 (SB$13.00)
75Wp		US$20 (SB$100), monthly US$3.00 (SB$15.00)

If the SHS tariff is set as above level, FIRR will become substantial negative figure (see Table 12-3-2-2), it is utterly unfeasible financially. To cover this negative portion, it is recommended that a "Rural Electrification Fund" be charged additionally on the tariff of optimum power supply plan (see Clause 12-4-3)

12.3.4 Economic benefit and EIRR

In this section, the economic benefit and economic cost shall be estimated, and examine of the economic profitability will be attempted.

The economic cost shall be used the no tax price in the financial cost (see Table 12-3-1). (Assuming the opportunity cost to be 1.0 for the local trader's benefit, CIF*0.15)

The estimation of the economic benefit of SHS has been tried in other projects, however, it has not been established a concrete methodology[8]. The following two kind of methods are adopted in this section.

"Willingness to Pay" as unified term.

[8] In the "Study on the promotion of photovoltaic rural electrification in the Republic of Zimbabwe"(JICA, 1999.3), the economic benefit was estimated by using saved cost of transmission line. However, it is impossible for the Solomon Islands, because it needs long distance submarine cable for transmission and it is not realistic for the alternative project.

Economic analysis –1 : Alternative equipment approach

A small diesel power plant is set as alternative equipment for the SHS, and the saved cost for the equipment and fuel cost of the diesel plat is thought to be the economic benefit. According to other examinations, a small diesel power generator with an actual capacity of 720W is equal to 50 SHS sets of 36Wp panel in terms of power capacity. The using time was estimated to be 3 hours per day in a household and the O&M cost was assumed to be SB$300/month multiplied by two people for the diesel power generation[9].

The calculation result of EIRR was - 1.41%. This means that the cost of SHS is higher than that of diesel generator. In brief, on a comparison basis by the alternative diesel power station, it is found that the economical profitability of SHS is fairly low.

Table 12-3-4-1 EIRR by alternative diesel power

Alternative Small Diesel

SHS	Cost (US$)	Life	Diesel	Cost (US$)	Life
PV set	996	20	Diesel	702	5
Battery	202	7	Distribution	12,000	20
C/C	117	10	Fuel	3	SB$/liter
O&M	12		Hours	3	per day
No.Unit	50		days	216	per year

(US$)

EIRR = -1.41%

	Cost				Benefit			Net
	PV	battery	C/C	O&M	Diesel	Fuel	O&M	
0	49,775				12,702			-37,073
1				600		1,944	1,440	2,784
2				600		1,944	1,440	2,784
3				600		1,944	1,440	2,784
4				600		1,944	1,440	2,784
5				600	702	1,944	1,440	3,486
6				600		1,944	1,440	2,784
7		10,100		600		1,944	1,440	-7,316
8				600		1,944	1,440	2,784
9				600		1,944	1,440	2,784
10			5,850	600	702	1,944	1,440	-2,364
11				600		1,944	1,440	2,784
12				600		1,944	1,440	2,784
13				600		1,944	1,440	2,784
14		10,100		600		1,944	1,440	-7,316
15				600	702	1,944	1,440	3,486
16				600		1,944	1,440	2,784
17				600		1,944	1,440	2,784
18				600		1,944	1,440	2,784
19				600		1,944	1,440	2,784
20				600		1,944	1,440	2,784

[9] Strictly saying, the utility of the SHS and diesel are not the same because the diesel power generator can be used for large capacity electric appliances such as refrigerator, except for lightning and radio cassette. This is the main problem in this

Economic analysis –2 : Utility approach

Here it is tried to calculate the economic profitability using the "Utility" of SHS as the economic benefit.

"Utility" is a term of microeconomics, and means the satisfied level of the consumer when the products are consumed. For example, reading books or meeting at nighttime can be counted as the utility of the SHS. However, it is difficult to numerate the level of such utility. In this report, it is tried to evaluate the utility of SHS based on the indirectly saved cost of the kerosene and dry batteries for radio-cassettes.

According to the field survey, the average cost of the kerosine and dry battery is set as follows.

a) Cost for kerosine SB$25/month[10]

b) Cost for dry battery for radio-cassettes SB$20/month

SB$2.0 × 10 SB$20
price of size #1 number of piece

c) Cost for kerosine lamp SB$20/year

SB$35 × 2.8 ÷ 5 SB$20
average price average number of unit years of duration

Following is evaluation of how many times the utility of SHS shall be considered.

According to the study, a 36Wp SHS allow the use of an 11 W fluorescent lamp for 4 hours and a 6 W radio cassette for 2 hours per day. According to other examination, the illumination of one 11 W florescent lamp is about 33 times the illumination of a standard kerosene lamp, and the hours of duration of dry batteries for the 6 W radio-cassette (6 piece of #1 size battery) is estimated to be around 2 hours. Thus, in comparison with kerosine and dry batteries, the utility of one set of SHS (36Wp) is estimated as follows.

a) Utility compared with kerosine SB$300/month

SB$25 ÷ 2.8 units× 33times SB$300

b) Utility compared with dry batteries SB$360/month

SB$20 ÷ 10piece × 180times SB$360

c) Utility compared with kerosine lamp SB$240/year

SB$20 ÷ 2.8units × 33times SB$240

method.

[10] According to the survey result presented in Chapters 7 and 8, the monthly cost for kerosine is widely ranged as SB$5.0-38 and SB$10.0-36.4, respectively.

It is thought that if the whole utility will be changed to the economic added value, the actual economic added value will be much less than the utility. For example, although the illumination produced by the SHS is 33 times of the kerosene lamp, the actual utility will not be 33 times. Assuming that the actual utility is about 1/10 of it, the produced utility of SHS will be estimated follows.

kerosene	SB$300/m・house×1/10	SB$30/m・house
dry battery	SB$360/m・house×1/10	SB$36/m・house
kerosene lamp	SB$240/y・house×1/10	SB$24/y・house

By using these utilities as the economic benefit, the calculation result of the EIRR is as follows.

Table 12-2-3-4 EIRR by Utility of SHS

Utility of SHS

SHS	Cost (US$)	Life (year)	Kerosine and Dry battery	(SB$/y)	(US$/y)
PV set	996	20	Kerosine	360	72
Battery	202	7	Dry battery	432	86
C/C	117	10	Lamp	24	5
O&M	12		Total		163

EIRR = 11.38%

	Cost PV	battery	C/C	O&M	Benefit Kerosine + Dry battery	Net
0	996					-996
1				12	163	151
2				12	163	151
3				12	163	151
4				12	163	151
5				12	163	151
6				12	163	151
7		202		12	163	-51
8				12	163	151
9				12	163	151
10			117	12	163	34
11				12	163	151
12				12	163	151
13				12	163	151
14		202		12	163	-51
15				12	163	151
16				12	163	151
17				12	163	151
18				12	163	151
19				12	163	151
20				12	163	151

Result of calculations is EIRR = 11.38. This figure will be different depending on the setting level of the utility, however, this result means that the utility of SHS is much larger than the benefit by the currently used kerosene lamp and dry batteries.

Moreover, environmental benefit such as deduction of CO_2 emission is possible to be considered as another economic benefit. In the next step, comprehensive economic analysis by Life Cycle Assessment will be necessary for it.

12.3.5 Financial analysis of rural electrification plan

As mentioned in the start of this section, the profitability of SHS basically remains the same regardless of single or multiple SHS units. Therefore, economic and financial analysis for the overall rural electrification plan will simply be the same as the process described in the previous pages.

Here, the financial analysis is carried out for the national expansion plan. The tariff, which was set in Clause 12-3-3, is used as financial benefit. And the cash flow was prepared during three-time replacement of SHS on the assumption that the SHS will be replaced in every 20 years, the duration life.

Calculation result is substantial negative figure and it is utterly unfeasible in financially, which is same as Clause 12-3-3. To cover this negative portion, it is recommended that a "Rural Electrification Fund" be charged additionally on the tariff of optimum power supply plan (see Clause 12-4-3)

Following is the cash flow table for the nationwide scheme of the rural electrification plan.

Table 12-3-5 FIRR calculation of Rural Electrification Plan

(Nationwide Scheme)

			36Wp	75Wp		
With tax						
4.00%		PV set	1,195	1,640	1.37254	
20 year		Battery	248	364		
		C/C	144	144		
		O&M	12	12		Down payment (D/P)
	Monthly tariff		2.0	3.0		20

FIRR = #DIV/0!

(Unit: US$)

	Year	Cost						Revenue			Cash Balance	Cash
		PV set	Battery1	Battery2	C/C	O&M	Total	Tariff	D/P	Total		Accumulated
1	2005	366,782				3,564	370,346	7,452	5,940	13,392	-356,954	-356,954
2	2006	366,782				7,128	373,910	14,904	5,940	20,844	-353,066	-710,019
3	2007	366,782				10,692	377,474	22,356	5,940	28,296	-349,178	-1,059,197
4	2008	366,782				14,256	381,038	29,808	5,940	35,748	-345,290	-1,404,486
5	2009	366,782				17,820	384,602	37,260	5,940	43,200	-341,402	-1,745,888
6	2010	366,782				21,384	388,166	44,712	5,940	50,652	-337,514	-2,083,401
7	2011	366,782				24,948	391,730	52,164	5,940	58,104	-333,626	-2,417,027
8	2012	366,782	76,788			28,512	472,082	59,616	5,940	65,556	-406,526	-2,823,552
9	2013	366,782	76,788			32,076	475,646	67,068	5,940	73,008	-402,638	-3,226,190
10	2014	366,782	76,788			35,640	479,210	74,520	5,940	80,460	-398,750	-3,624,939
11	2015	366,782	76,788		42,768	39,204	525,542	81,972	5,940	87,912	-437,630	-4,062,569
12	2016	366,782	76,788		42,768	42,768	529,106	89,424	5,940	95,364	-433,742	-4,496,310
13	2017	366,782	76,788		42,768	46,332	532,670	96,876	5,940	102,816	-429,854	-4,926,164
14	2018	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-5,352,129
15	2019		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-5,494,041
16	2020		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-5,635,953
17	2021		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-5,777,865
18	2022		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-5,919,777
19	2023		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-6,061,689
20	2024		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-6,203,601
1	2025	366,782	76,788	76,788	42,768	49,896	613,022	104,328	5,940	110,268	-502,754	-6,706,355
2	2026	366,782		76,788	42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-7,132,320
3	2027	366,782		76,788	42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-7,558,286
4	2028	366,782		76,788	42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-7,984,251
5	2029	366,782		76,788		49,896	493,466	104,328	5,940	110,268	-383,198	-8,367,449
6	2030	366,782		76,788		49,896	493,466	104,328	5,940	110,268	-383,198	-8,750,646
7	2031	366,782		76,788		49,896	493,466	104,328	5,940	110,268	-383,198	-9,133,844
8	2032	366,782		76,788		49,896	493,466	104,328	5,940	110,268	-383,198	-9,517,041
9	2033	366,782	76,788			49,896	493,466	104,328	5,940	110,268	-383,198	-9,900,239
10	2034	366,782	76,788			49,896	493,466	104,328	5,940	110,268	-383,198	-10,283,436
11	2035	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-10,709,402
12	2036	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-11,135,367
13	2037	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-11,561,333
14	2038	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-11,987,298
15	2039		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-12,129,210
16	2040		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-12,271,122
17	2041		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-12,413,034
18	2042		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-12,554,946
19	2043		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-12,696,858
20	2044		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-12,838,770
1	2045	366,782	76,788	76,788	42,768	49,896	613,022	104,328	5,940	110,268	-502,754	-13,341,524
2	2046	366,782		76,788	42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-13,767,489
3	2047	366,782		76,788	42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-14,193,455
4	2048	366,782		76,788	42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-14,619,420
5	2049	366,782		76,788		49,896	493,466	104,328	5,940	110,268	-383,198	-15,002,618
6	2050	366,782		76,788		49,896	493,466	104,328	5,940	110,268	-383,198	-15,385,815
7	2051	366,782		76,788		49,896	493,466	104,328	5,940	110,268	-383,198	-15,769,013
8	2052	366,782		76,788		49,896	493,466	104,328	5,940	110,268	-383,198	-16,152,210
9	2053	366,782	76,788			49,896	493,466	104,328	5,940	110,268	-383,198	-16,535,408
10	2054	366,782	76,788			49,896	493,466	104,328	5,940	110,268	-383,198	-16,918,605
11	2055	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-17,344,571
12	2056	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-17,770,536
13	2057	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-18,196,502
14	2058	366,782	76,788		42,768	49,896	536,234	104,328	5,940	110,268	-425,966	-18,622,467
15	2059		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-18,764,379
16	2060		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-18,906,291
17	2061		76,788	76,788	42,768	49,896	246,240	104,328		104,328	-141,912	-19,048,203

12.4 Funding plan and Repayability analysis

In this section, the funding plan will be studied by considering funding records in the past. After this, the repayability analysis will be carried out using the cash flow simulation.

12.4.1 Funding records and repayment situation in the past

The recent funding records and repayment situation is described as follows.

<u>Grant Aid</u>

1) British Aid

In July 1997, 6 units of diesel power station in Auki and Gizo were provided by the government of UK. The manufacturer of the diesel engine was INTEX Engineering Limited (brand name "Perkins"). The name of the assisting organization was British Bilateral AID Program, Overseas Development Administration UK

2) Grant aid by the Taiwan Government

The Memorandum of grant aid amounting SB$14.2mil was signed between the Taiwan government and Solomon Islands in October 1997. The fund was provided for the three diesel units in the Honiara power station (Units No.1 to No.3, 1.5MW each, Perkins UK).

3) Grant aid by the Japanese Government

The Exchange Note of grant aid between Japan and Solomon Islands was formalized in June 1998. The target project is for the expansion plan of the Lungga No.9 diesel unit (4.2MW). The construction was already completed in September 1999, and began operation in November 1999.

4) Grant aid by the German Government (GTZ)

In 1994, the feasibility study was carried out in the four potential sites of small hydropower in Malaita and Santa Isabel Islands by German grant. After this, Buala small hydropower station was constructed in 1996. The name of the institution is GTZ.

5) Grant aid by New Zealand Government

In 1984, a small hydropower station was constructed in Malu'u by grant aid from New Zealand government.

<u>Funding by loan</u>

1) National Provident fund (NPF)

Funding from NPF was executed out more than 10 times including funding for Lungga No.7 in 1987. The interest rate is fairly high of 14%. The loan defaulted from 1997, and it is currently being settled in court. The accumulated debt including arrears on the debt reached SB$20mil by the end of 1999.

2) Asian Development bank (ADB)

The outstanding debt to ADB has around an 80% share of total long-term liabilities of SIEA. Funding from ADB was carried out twice in the past.

ADB	No.803-SOL(SF)	1987, Lungga No.6 and Noro No.1-3 SDR 3.452mil（=US$4.49mil）
ADB	No.1064-SOL(SF)	1993, Lungga No.8 SDR 3.285mil（=US$4.49mil）

The terms and condition of these loans were set by ADB as 1.0% in interest, 10 years grace period and 30 years repayment period (total 40 years), however, these were re-lent by the Solomon government to SIEA with the conditions of 7.65% and 6.36% interest and 15 years repayment. These loans defaulted in both principal repayment and interest payment. Due to this, it is very difficult to introduce a new loan from ADB.

3) ANZ Bank

A small amount of debt from ANZ bank is outstanding and also defaulted.

4) World Bank

SIEA has not received a loan from World Bank, however, the funding source for the Lungga No.10 diesel power station which will be constructed in 2000 was IDA (International Development Association), an institution of World Bank. The terms and conditions are as follows.

IDA No.3252 SOL、June 1999, SDR 8.9mil (=US$6.7mil)
interest 0.5%、grace period 10 years repayment 30 years

A part of this loan was re-lent by Solomon government to SIEA with the following terms and conditions.

amount SB$14.0mil (equivalent to US$2.8mil)
interest 5.0%, no grace period, repayment 5 years

Table 12-4-1 List of funding source of SIEA's power station

Existing Power Station and Each Funding Source

Name of Province/Island	Name of P/S	Type of P/S	Unit No.	Name plate Rating (kW)	Instaaled Year	Maker	Fund Source
Guadalcanal P./Guadalcanal				24,540			
	Lungga			18,040			
		Diesel	4	1,900	1971	Mirrless-Blachstone	
			5	1,900	1971	Mirrless-Blachstone	
			6	2,840	1987	Allens (UK)	ADB No.803-SOL(SF)
			7	3,000	1987	Allens (UK)	National Providend Fund
			8	4,200	1993	Wartsila (Finland)	ADB No.1064-SOL(SF)
			9	4,200	1999	Mitsubishi (Japan)	Japanese grant Aid
			10	4,200	2000	Wartsila (Finland)	SIG Loan / IDA No.3252 SOL
	Honiara			6,500			
		Diesel	1	1,500	1998	Perkins (UK)	SIG Loan / Taiwan Aid
			2	1,500	1998	Perkins (UK)	SIG Loan / Taiwan Aid
			3	1,500	1998	Perkins (UK)	SIG Loan / Taiwan Aid
			5	1,000	1984	Mirrless-Blachstone	
			6	1,000	1984	Mirrless-Blachstone	
Malaita P./Malaita				818			
	Auki			780			
		Diesel	1	260	1991	Perkins (UK)	UK grant Aid
			2	260	1991	Perkins (UK)	UK grant Aid
			3	260	1991	Perkins (UK)	UK grant Aid
	Malu'u			37.5			
		Hydro	1	37.5	1984		NZ Aid
Isabel P./Santa Isabel				238			
	Buala			238			
		Diesel	1	88	1993	Perkins (UK)	
		Hydro	1	150	1996		GTZ Aid
Makira P./San cristobal				235			
	Kirakira			235			
		Diesel	1	80	1992	Catapillar	SIG subsidy
			2	91	1993	Perkins (UK)	SIG subsidy
			3	64			SIG subsidy
Temotu P./San Cruz				264			
	Lata			264			
		Diesel	1	88	1993	Perkins (UK)	SIG subsidy
			2	88	1993	Perkins (UK)	SIG subsidy
			3	88	1995	Perkins (UK)	SIG subsidy
Western P./New Georgia				4,277			
	Gizo			624			
		Diesel	1	208	1991	Perkins (UK)	UK grant Aid
			2	208	1991	Perkins (UK)	UK grant Aid
			3	208	1991	Perkins (UK)	UK grant Aid
	Noro			3,600			
		Diesel	1	1,200	1987	Allens (UK)	ADB No.803-SOL(SF)
			2	1,200	1987	Allens (UK)	ADB No.803-SOL(SF)
			3	1,200	1987	Allens (UK)	ADB No.803-SOL(SF)
	Munda			53			
		Diesel	1	53			
Central P./Tulagi				320			
	Tulagi			320			
		Diesel	1	120		Catapillar	
			2	200	1993	Perkins (UK)	Lease from Marina Ltd.
Choiseul P./Choiseul							
				30,692			

12.4.2 Funding and repayment plan for the optimum power supply plan

The total construction cost and O&M cost for the optimum power supply plan in the period of 2000 - 2018 is around US$172mil and US$141mil respectively. Here, the funding and repayment plan for these construction cost was examined.

The optimum power supply plan includes 8 units of hydropower and 26 units of diesel power total 34 units of power plants. According the result of the financial analysis, if the recommended tariff LRAIC + 5.0% is charged, the FIRR = 8.38% is possible for the period until 2063, and the whole costs including the construction, fuel and O&M will be covered (see 12.2.3). However, the above financial analysis was calculated on the assumption that all the construction cost was provided by the own fund, and it does not consider the case of borrowing by the loan.

Here, the case study was conducted using cash flow simulation for each case that three type of fund, i.e. loan, grant and own fund are provided for the initial construction cost. And the most efficient complex was considered in order that SIEA will not fall into cash shortage.

Terms and conditions of the loan

The terms and conditions is the important issue for preparing a funding plan. Two ADB loans were executed in the past by two step style in which the first loan took place between the ADB and the Government, and the sub-loan took place between the Government and SIEA at the same time. The terms and conditions were as follows.

		ADB－government		government－SIEA
ADB （803）	Interest	1.00%	→	7.65%
	Maturity	30 year	→	15 year
	Grace period	10 year	→	3 year
ADB （1064）	interest	1.00%	→	6.36%
	Maturity	30 year	→	15 year
	Grace period	10 year	→	3 year

According to the cash flow analysis, if the soft loan with low interest and long maturity is executed between ADB and SIEA directly, the debt service will be possible enough, however, if the re-lending with high interest and short maturity is executed between government and SIEA for the second step, almost of all loan will fall into cash shortage. (see the cash flow table in the next page)

Table 12-4-2-1 Repayability analysis (example of Diesel Bina#1)

Case-1 Direct loan (ADB - SIEA)

Diesel Bina#1

Capacity	1,500 kW			
kW cost	1,800 US$/kW			
Plant factor	20.0%	Tariff	0.1881	US$/kWh
Loss factor	15.0%	Fuel/OM	0.0912	US$/kWh

	Foreign	Local	
Grace	**10**	**3**	**year**
Maturity	**30**	**15**	**year**
Interest	**1.00%**	**6.50%**	

Borrowing Total	Foreign	Local	Grant Total	
2,700	1,890	810	0	(US$ '000)
	70%	30%		

Year	Outflow: Cost	Fuel O&M	Foreign borrow Repayment	Foreign borrow Interest	Local borrow Repayment	Local borrow Interest	Total out flow	Inflow: Sold Energy MWh	Foreign borrow	Local borrow	Grant	Benefit	Total in flow	Cash Balance	Cash Accumulated
2000															
2001	2,700	0	0	19	0	53	2,772	0	1,890	810	0	0	2,700	-72	-72
2002		204	0	19	0	53	275	2,234	0	0		420	420	145	73
2003		204	0	19	0	53	275	2,234	0	0		420	420	145	218
2004		204	0	19	54	49	326	2,234	0	0		420	420	94	312
2005		204	0	19	54	46	322	2,234	0	0		420	420	98	410
2006		204	0	19	54	42	319	2,234	0	0		420	420	101	512
2007		204	0	19	54	39	315	2,234	0	0		420	420	105	616
2008		204	0	19	54	35	312	2,234	0	0		420	420	108	725
2009		204	0	19	54	32	308	2,234	0	0		420	420	112	837
2010		204	0	19	54	28	305	2,234	0	0		420	420	115	952
2011		204	63	18	54	25	364	2,234	0	0		420	420	57	1,008
2012		204	63	18	54	21	359	2,234	0	0		420	420	61	1,069
2013		204	63	17	54	18	355	2,234	0	0		420	420	65	1,134
2014		204	63	16	54	14	351	2,234	0	0		420	420	69	1,203
2015		204	63	16	54	11	347	2,234	0	0		420	420	73	1,276
2016		204	63	15	54	7	343	2,234	0	0		420	420	77	1,353
2017		204	63	14	54	4	339	2,234	0	0		420	420	81	1,434
2018		204	63	14	54	0	335	2,234	0	0		420	420	85	1,520
2019		204	63	13	0	0	280	2,234	0	0		420	420	140	1,660
2020		204	63	13	0	0	279	2,234	0	0		420	420	141	1,801

Case-2 Two step loan (Government - SIEA)

Diesel Bina#1

	Foreign	Local	
Grace	**0**	**3**	**year**
Maturity	**0**	**15**	**year**
Interest	**0.00%**	**6.50%**	

Borrowing Total	Foreign	Local	Grant Total	
2,700	0	2,700	0	(US$ '000)
	0%	100%		

Year	Outflow: Cost	Fuel O&M	Foreign borrow Repayment	Foreign borrow Interest	Local borrow Repayment	Local borrow Interest	Total out flow	Inflow: Sold Energy MWh	Foreign borrow	Local borrow	Grant	Benefit	Total in flow	Cash Balance	Cash Accumulated
2000															
2001	2,700	0	0	0	0	176	2,876	0	0	2,700	0	0	2,700	-176	-176
2002		204	0	0	0	176	379	2,234	0	0		420	420	41	-135
2003		204	0	0	0	176	379	2,234	0	0		420	420	41	-94
2004		204	0	0	180	164	548	2,234	0	0		420	420	-127	-221
2005		204	0	0	180	152	536	2,234	0	0		420	420	-116	-337
2006		204	0	0	180	140	524	2,234	0	0		420	420	-104	-441
2007		204	0	0	180	129	512	2,234	0	0		420	420	-92	-533
2008		204	0	0	180	117	501	2,234	0	0		420	420	-81	-614
2009		204	0	0	180	105	489	2,234	0	0		420	420	-69	-683
2010		204	0	0	180	94	477	2,234	0	0		420	420	-57	-740
2011		204	0	0	180	82	466	2,234	0	0		420	420	-46	-786
2012		204	0	0	180	70	454	2,234	0	0		420	420	-34	-820
2013		204	0	0	180	59	442	2,234	0	0		420	420	-22	-842
2014		204	0	0	180	47	431	2,234	0	0		420	420	-10	-852
2015		204	0	0	180	35	419	2,234	0	0		420	420	1	-851
2016		204	0	0	180	23	407	2,234	0	0		420	420	13	-838
2017		204	0	0	180	12	395	2,234	0	0		420	420	25	-813
2018		204	0	0	180	0	384	2,234	0	0		420	420	36	-777
2019		204	0	0	0	0	204	2,234	0	0		420	420	216	-561
2020		204	0	0	0	0	204	2,234	0	0		420	420	216	-344

Accordingly, it is assumed that all the loans will be executed directly to SIEA by soft loan with low interest and long maturity in this analysis. The terms and conditions are setup as follows.

Foreign currency portion (70%) : interest 1.0%, grace 10 years, repayment 30 years
Local currency portion (30%) : interest 6.5%, grace 3 years, repayment 15 years
(interest will be charged during grace period)

The large sized projects more than US$20mil such as Maotapuku1.2 hydro (total US$51.90mil) and Silolo hydro (US$28.3mil) are funded by the loan.

The projects by grant will be limited for small project less than US$10mil which is specially including all the hydropower projects except for the Maotapuku and Silolo.

Diesel power project in the latter half of the optimum power supply plan will be funded by own fund as much as possible.

According to the result of the cash flow analysis, in order to avoid cash shortage during the optimum power supply plan, it is necessary to provide US$100mil by loan and US$29mil by grant for the total cost US$172mil, and if so, the remaining US$43mil will be possible to provided by the own retained fund.

The most efficient funding plan for the optimum power supply plan was setup in the next page.

All of the analysis was carried out on the assumption that all the loan are provided by low interest and long maturity. Therefore, in the case of SIEA receiving the loan for the project, it is necessary that the soft loan be executed directly by negotiation with the Solomon government.

Moreover, the currency risk which was not mentioned above has been the big burden for SIEA because the income of SIEA is only by the Solomon dollar. Therefore, the currency risk also shall be burdened by the Solomon government directly by negotiation.

Table 12-4-2-2 The optimum funding plan

Construction Cost and Funding Source

(Unit: US$, '000)

Honiara-Lungga plan-3

Diesel Lungga#10	6,443	Loan
Diesel Lungga#11	7,670	Grant
Diesel Lungga#12	7,670	Loan
Diesel Lungga#13	7,670	Own
Hydro Maotapku-1	24,870	Loan
Hydro Maotapku-2	27,027	Loan
Diesel Lungga#14	7,670	Own
Diesel Lungga#15	3,068	Own

Auki-Malu'u-Bina plan-3

Diesel Malu'u#1	149	Grant
Diesel Bina#1	2,700	Loan
Diesel Bina#2	2,700	Loan
Diesel Bina#3	2,700	Own
Hydro Roli	5,989	Grant
Hydro Ruala'e	871	Grant
Hydro Silolo	28,261	Loan

Buala plan1

Diesel Buala#2	368	Own
Hydro Kubolata	1,649	Grant
Diesel Buala#2	368	Own

Kirakira plan-2

Diesel Kirakira#4	413	Own
Hydro Huro	1,497	Grant
Diesel Kirakira#5	496	Own

Lata plan-2

Diesel Lata#4	461	Grant
Diesel Lata#5	461	Grant

Choiseul plan-1

Diesel Choiseul#1&2	207	Grant
Hydro Sorave	1,859	Grant

Gizo plan-2

Diesel Gizo#2&3	800	Grant
Diesel Gizo#4&5	1,200	Own
Diesel Gizo#6	600	Own
Diesel Gizo#7	600	Own

Noro-Munda plan-2

Diesel Noro#4&5	7,200	Grant
Diesel Noro#6&7	7,200	Own
Diesel Noro#8&9	7,200	Own
Diesel Noro#10	3,600	Own

Tulagi plan-2

Diesel Tulagi#3	300	Own

Total	171,937
Loan	99,671
Grant	28,814
Own	43,453

Loan ： funding by loan
Grant ： funding by grant
Own ： funding by own retained fund

Table 12-4-2-3 Repayment plan for the optimum power supply plan

	Foreign	Local	
Grace	**10**	**3**	**year**
Maturity	**30**	**15**	**year**
Interest	**1.00%**	**6.50%**	

Borrowing			Grant
Total	Foreign	Local	Total
99,671	69,770	29,901	28,814
	70%	30%	

(US$ '000)

Year	Cost	Fuel O&M	Outflow: Foreign borrow Repayment	Outflow: Foreign borrow Interest	Outflow: Local borrow Repayment	Outflow: Local borrow Interest	Total out flow	Sold Energy MWh	Inflow: Foreign borrow	Inflow: Local borrow	Inflow: Grant	Inflow: Benefit	Total in flow	Cash Balance	Cash Accumulated
2000	7,599	0	0	45	0	126	7,770	0	4,510	1,933	1,156	0	7,599	-171	-171
2001	15,044	1,158	0	64	0	178	16,444	12,694	1,890	810	11,931	2,387	17,019	574	403
2002	8,199	1,932	0	83	0	231	10,445	21,182	1,890	810	4,299	3,984	10,983	538	941
2003	10,684	2,313	0	83	129	223	13,432	27,262	0	0	7,984	5,179	13,163	-269	672
2004	7,670	3,820	0	137	183	360	12,169	44,646	5,369	2,301	0	8,467	16,137	3,967	4,639
2005	8,329	5,175	0	137	237	345	14,223	58,831	0	0	461	11,134	11,596	-2,627	2,013
2006	9,941	5,775	0	500	237	1,341	17,795	65,413	6,539	2,802	0	12,372	21,714	3,919	5,931
2007	20,644	5,816	0	500	390	1,316	28,666	65,860	9,082	3,892	0	12,456	25,431	-3,236	2,695
2008	24,653	7,110	0	500	390	1,291	33,943	80,045	15,621	6,695	2,337	15,124	39,777	5,833	8,529
2009	7,448	7,133	0	500	1,428	1,198	17,707	80,578	5,086	2,180	183	15,229	22,678	4,970	13,499
2010	12,287	7,486	150	696	1,428	1,656	23,703	95,878	3,561	1,526	0	18,693	23,780	76	13,575
2011	7,561	8,090	213	694	1,428	1,563	19,550	101,835	4,946	2,120	0	19,813	26,878	7,328	20,904
2012	20,652	8,123	276	691	1,428	1,470	32,641	102,192	8,507	3,646	461	19,880	32,494	-147	20,757
2013	3,957	9,466	276	689	1,993	1,341	17,721	116,913	2,770	1,187	0	22,649	26,605	8,884	29,641
2014	0	9,622	455	684	1,993	1,211	13,966	126,852	0	0	0	24,921	24,921	10,955	40,596
2015	600	9,622	455	679	1,993	1,082	14,431	126,852	0	0	0	24,921	24,921	10,489	51,085
2016	6,668	9,662	1,666	663	1,993	952	21,605	127,299	0	0	0	25,005	25,005	3,400	54,485
2017	0	10,452	1,666	646	1,993	823	15,580	135,951	0	0	0	26,632	26,632	11,052	65,537
2018	0	10,452	1,666	629	1,865	701	15,313	135,951	0	0	0	26,632	26,632	11,319	76,855
2019	0	10,452	1,666	613	1,811	584	15,125	135,951	0	0	0	26,632	26,632	11,507	88,362
2020	7,599	10,452	2,326	590	1,757	470	23,192	135,951	0	0	0	26,632	26,632	3,440	91,802
2021	10,313	10,452	2,326	566	1,757	355	25,768	135,951	0	0	0	26,632	26,632	864	92,666
2022	3,900	10,452	2,326	543	1,603	251	19,075	135,951	0	0	0	26,632	26,632	7,557	100,223
2023	10,370	10,452	2,326	520	1,603	147	25,417	135,951	0	0	0	26,632	26,632	1,215	101,438
2024	7,670	10,452	2,326	496	565	110	21,619	135,951	0	0	0	26,632	26,632	5,013	106,451
2025	8,329	10,452	2,326	473	565	73	22,219	135,951	0	0	0	26,632	26,632	4,413	110,864
2026	600	10,452	2,326	450	565	37	14,429	135,951	0	0	0	26,632	26,632	12,203	123,067
2027	7,670	10,452	2,326	427	565	-0	21,439	135,951	0	0	0	26,632	26,632	5,193	128,260
2028	0	10,452	2,326	403	0	0	13,181	135,951	0	0	0	26,632	26,632	13,451	141,711
2029	0	10,452	2,326	380	0	0	13,157	135,951	0	0	0	26,632	26,632	13,475	155,186
2030	7,200	10,452	2,326	357	0	0	20,334	135,951	0	0	0	26,632	26,632	6,298	161,484
2031	496	10,452	2,326	334	0	0	13,607	135,951	0	0	0	26,632	26,632	13,025	174,509
2032	8,499	10,452	2,326	310	0	0	21,587	135,951	0	0	0	26,632	26,632	5,045	179,554
2033	0	10,452	2,326	287	0	0	13,064	135,951	0	0	0	26,632	26,632	13,568	193,121
2034	0	10,452	2,326	264	0	0	13,041	135,951	0	0	0	26,632	26,632	13,591	206,712
2035	600	10,452	2,326	241	0	0	13,618	135,951	0	0	0	26,632	26,632	13,014	219,726
2036	6,668	10,452	2,326	217	0	0	19,663	135,951	0	0	0	26,632	26,632	6,969	226,696
2037	0	10,452	2,326	194	0	0	12,971	135,951	0	0	0	26,632	26,632	13,661	240,356
2038	0	10,452	2,326	171	0	0	12,948	135,951	0	0	0	26,632	26,632	13,684	254,040
2039	0	10,452	2,326	148	0	0	12,925	135,951	0	0	0	26,632	26,632	13,707	267,747
2040	7,599	10,452	2,175	126	0	0	20,352	135,951	0	0	0	26,632	26,632	6,280	274,027
2041	10,313	10,452	2,112	105	0	0	22,982	135,951	0	0	0	26,632	26,632	3,650	277,677
2042	3,900	10,452	2,049	84	0	0	16,485	135,951	0	0	0	26,632	26,632	10,147	287,824
2043	10,370	10,452	2,049	64	0	0	22,935	135,951	0	0	0	26,632	26,632	3,697	291,521
2044	7,670	10,452	1,870	45	0	0	20,037	135,951	0	0	0	26,632	26,632	6,595	298,116
2045	8,329	10,452	1,870	26	0	0	20,678	135,951	0	0	0	26,632	26,632	5,954	304,071
2046	600	10,452	659	20	0	0	11,731	135,951	0	0	0	26,632	26,632	14,901	318,972
2047	7,670	10,452	659	13	0	0	18,794	135,951	0	0	0	26,632	26,632	7,838	326,810
2048	0	10,452	659	7	0	0	11,118	135,951	0	0	0	26,632	26,632	15,514	342,324
2049	0	10,452	659	-0	0	0	11,111	135,951	0	0	0	26,632	26,632	15,521	357,845
2050	7,200	10,452	0	0	0	0	17,652	135,951	0	0	0	26,632	26,632	8,980	366,825
2051	496	10,382	0	0	0	0	10,877	133,559	0	0	0	26,136	26,136	15,259	382,084
2052	8,499	10,286	0	0	0	0	18,785	132,032	0	0	0	25,825	25,825	7,040	389,124
2053	0	10,286	0	0	0	0	10,286	132,032	0	0	0	25,825	25,825	15,539	404,664
2054	0	10,286	0	0	0	0	10,286	132,032	0	0	0	25,825	25,825	15,539	420,203
2055	600	10,286	0	0	0	0	10,886	132,032	0	0	0	25,825	25,825	14,939	435,142
2056	6,668	9,942	0	0	0	0	16,610	118,342	0	0	0	22,695	22,695	6,086	441,228

12.4.3 Funding and repayment plan for the rural electrification plan

The total necessary equipment cost for the Pilot Scheme in the rural electrification plan (2001-2003) is estimated US$0.37mil. Since this scheme is examination stage of the rural electrification plan, the equipment cost is recommended to be provided by grant.

The total necessary equipment cost and O&M cost for the Nationwide Scheme in the rural electrification plan (2005-2018) is estimated US$5.2mil (US$0.37mil per year) and US$1.0mil respectively. Here, the cash flow analysis for the funding and repayment plan of these cost was carried out.

The total equipment cost US$5.2mil is assumed to be provided by foreign currency loan at one time by low interest and long maturity, which is same as the optimum power supply plan.

<u>Introduction of Rural Electrification Fund</u>

In case that SHS tariff is set as the low level which the rural people is payable to, the FIRR will be substantial negative figure and it in impossible to cover the equipment cost only by the charged tariff (see Clause 12-3-3). Therefore, in this study, it is suggested that a Rural Electrification Fund be charged on the tariff of optimum power supply plan to cover the negative portion of the SHS tariff.

Tariff of the optimum power supply plan	US$0.1881	(SB$0.9403)
Additional charge for Rural Electrification	US$0.0036	(SB$0.0182)
Tariff after additional charge	US$0.1917	(SB$0.9585)

It is suggested that all of the fund for the rural electrification is managed by REAC, the implementation body. In detail, it is suggested that REAC open a special account in a certain financial institution such as DBSI (Development Bank of Solomon Islands), and manage it as a Revolving Fund. The additional charge on the tariff for the rural electrification fund will be collected by SIEA for the first, and transferred to the account of REAC.

According to the result of the cash flow analysis, the Fund will be decreased during the debt service period (2015 - 2044), however, it will be increased gradually and it will be found that it is possible to maintain the initial number of SHS (see Table 12-4-3-1). On the other hand, it is found that in the case of initial investment by grant, the Fund will increase gradually, it will become possible enough to enlarge the number of SHS in the future (see Table 12-4-3-2).

Accordingly, to enlarge the number of SHS after the nationwide scheme, it is desirable that initial investment is provided by grant.

Table 12-4-3-1 Funding and repayment plan for the rural electrification plan (1)
(Nationwide Scheme, in the case of initial investment by loan)

Grace 10 years
Maturity 30 years
Interest 1.00%

Tariff for Optimum Supply Plan
0.1881 → 0.1917 →
0.9403 0.9585

Suusidy for Rural Electrification Fund
0.0036 US$/kWh
0.0182 SB$/kWh

(US$ '000)

Year	Outflow				Inflow						
	Cost SHS	Foreign borrow		Total out flow	Foreign borrow	Tariff SHS	Down Payment	Subsidy	Total in flow	Cash Balance	Cash Accumulated
		Repayment	Interest								
2000	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	46	46	46	46
2002	0	0	0	0	0	0	0	77	77	77	123
2003	0	0	0	0	0	0	0	99	99	99	222
2004	0	0	0	0	0	0	0	162	162	162	384
2005	370	0	52	422	5,200	7	6	214	5,427	5,005	5,389
2006	374	0	52	426	0	15	6	237	258	-168	5,221
2007	377	0	52	429	0	22	6	239	267	-162	5,059
2008	381	0	52	433	0	30	6	291	326	-107	4,952
2009	385	0	52	437	0	37	6	293	336	-101	4,852
2010	388	0	52	440	0	45	6	348	399	-41	4,810
2011	392	0	52	444	0	52	6	370	428	-16	4,794
2012	472	0	52	524	0	60	6	371	437	-88	4,707
2013	476	0	52	528	0	67	6	424	497	-30	4,677
2014	479	0	52	531	0	75	6	461	541	10	4,686
2015	526	173	50	749	0	82	6	461	548	-201	4,486
2016	529	173	49	751	0	89	6	462	558	-193	4,292
2017	533	173	47	753	0	97	6	494	596	-156	4,136
2018	536	173	45	755	0	104	6	494	604	-151	3,985
2019	246	173	43	463	0	104	0	494	598	135	4,120
2020	246	173	42	461	0	104	0	494	598	137	4,257
2021	246	173	40	459	0	104	0	494	598	138	4,395
2022	246	173	38	458	0	104	0	494	598	140	4,535
2023	246	173	36	456	0	104	0	494	598	142	4,677
2024	246	173	35	454	0	104	0	494	598	144	4,821
2025	613	173	33	819	0	104	6	494	604	-215	4,606
2026	536	173	31	741	0	104	6	494	604	-137	4,469
2027	536	173	29	739	0	104	6	494	604	-135	4,334
2028	536	173	28	737	0	104	6	494	604	-133	4,200
2029	493	173	26	693	0	104	6	494	604	-89	4,111
2030	493	173	24	691	0	104	6	494	604	-87	4,024
2031	493	173	23	689	0	104	6	494	604	-85	3,938
2032	493	173	21	688	0	104	6	494	604	-84	3,855
2033	493	173	19	686	0	104	6	494	604	-82	3,773
2034	493	173	17	684	0	104	6	494	604	-80	3,692
2035	536	173	16	725	0	104	6	494	604	-121	3,571
2036	536	173	14	723	0	104	6	494	604	-120	3,452
2037	536	173	12	722	0	104	6	494	604	-118	3,334
2038	536	173	10	720	0	104	6	494	604	-116	3,218
2039	246	173	9	428	0	104	0	494	598	170	3,387
2040	246	173	7	427	0	104	0	494	598	171	3,559
2041	246	173	5	425	0	104	0	494	598	173	3,732
2042	246	173	3	423	0	104	0	494	598	175	3,907
2043	246	173	2	421	0	104	0	494	598	177	4,083
2044	246	173	0	420	0	104	0	494	598	178	4,262
2045	613	0	0	613	0	104	6	494	604	-9	4,252
2046	536	0	0	536	0	104	6	494	604	68	4,320
2047	536	0	0	536	0	104	6	494	604	68	4,388
2048	536	0	0	536	0	104	6	494	604	68	4,455
2049	493	0	0	493	0	104	6	494	604	110	4,566
2050	493	0	0	493	0	104	6	494	604	110	4,676
2051	493	0	0	493	0	104	6	485	595	102	4,778
2052	493	0	0	493	0	104	6	479	590	96	4,874
2053	493	0	0	493	0	104	6	479	590	96	4,970
2054	493	0	0	493	0	104	6	479	590	96	5,066
2055	536	0	0	536	0	104	6	479	590	53	5,120
2056	536	0	0	536	0	104	6	430	540	4	5,123
2057	536	0	0	536	0	104	6	430	540	4	5,127
2058	536	0	0	536	0	104	6	422	532	-4	5,123

Table 12-4-3-2 Funding and repayment plan for the rural electrification plan (2)
(Revolving fund, in the case of initial investment by grant)

Tariff for Optimum Supply Plan: 0.1881 → 0.1917 ; 0.9403 → 0.9585

Suusidy for Rural Electrification Fund: 0.0036 US$/kWh ; 0.0182 SB$/kWh

(US$ '000)

Year	Outflow: Cost SHS	Outflow: Foreign borrow Repayment	Outflow: Foreign borrow Interest	Total out flow	Inflow: Grant	Inflow: Tariff	Inflow: Down Payment	Inflow: Subsidy	Total in flow	Cash Balance	Cash Accumulated
2000	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	46	46	46	46
2002	0	0	0	0	0	0	0	77	77	77	123
2003	0	0	0	0	0	0	0	99	99	99	222
2004	0	0	0	0	0	0	0	162	162	162	384
2005	370	0	0	370	5,200	7	6	214	5,427	5,057	5,441
2006	374	0	0	374	0	15	6	237	258	-116	5,325
2007	377	0	0	377	0	22	6	239	267	-110	5,215
2008	381	0	0	381	0	30	6	291	326	-55	5,160
2009	385	0	0	385	0	37	6	293	336	-49	5,112
2010	388	0	0	388	0	45	6	348	399	11	5,122
2011	392	0	0	392	0	52	6	370	428	36	5,158
2012	472	0	0	472	0	60	6	371	437	-36	5,123
2013	476	0	0	476	0	67	6	424	497	22	5,145
2014	479	0	0	479	0	75	6	461	541	62	5,206
2015	526	0	0	526	0	82	6	461	548	23	5,229
2016	529	0	0	529	0	89	6	462	558	28	5,258
2017	533	0	0	533	0	97	6	494	596	64	5,321
2018	536	0	0	536	0	104	6	494	604	68	5,389
2019	246	0	0	246	0	104	0	494	598	352	5,741
2020	246	0	0	246	0	104	0	494	598	352	6,092
2021	246	0	0	246	0	104	0	494	598	352	6,444
2022	246	0	0	246	0	104	0	494	598	352	6,796
2023	246	0	0	246	0	104	0	494	598	352	7,147
2024	246	0	0	246	0	104	0	494	598	352	7,499
2025	613	0	0	613	0	104	6	494	604	-9	7,490
2026	536	0	0	536	0	104	6	494	604	68	7,558
2027	536	0	0	536	0	104	6	494	604	68	7,625
2028	536	0	0	536	0	104	6	494	604	68	7,693
2029	493	0	0	493	0	104	6	494	604	110	7,803
2030	493	0	0	493	0	104	6	494	604	110	7,914
2031	493	0	0	493	0	104	6	494	604	110	8,024
2032	493	0	0	493	0	104	6	494	604	110	8,134
2033	493	0	0	493	0	104	6	494	604	110	8,245
2034	493	0	0	493	0	104	6	494	604	110	8,355
2035	536	0	0	536	0	104	6	494	604	68	8,423
2036	536	0	0	536	0	104	6	494	604	68	8,490
2037	536	0	0	536	0	104	6	494	604	68	8,558
2038	536	0	0	536	0	104	6	494	604	68	8,626
2039	246	0	0	246	0	104	0	494	598	352	8,977
2040	246	0	0	246	0	104	0	494	598	352	9,329
2041	246	0	0	246	0	104	0	494	598	352	9,681
2042	246	0	0	246	0	104	0	494	598	352	10,032
2043	246	0	0	246	0	104	0	494	598	352	10,384
2044	246	0	0	246	0	104	0	494	598	352	10,736
2045	613	0	0	613	0	104	6	494	604	-9	10,726
2046	536	0	0	536	0	104	6	494	604	68	10,794
2047	536	0	0	536	0	104	6	494	604	68	10,862
2048	536	0	0	536	0	104	6	494	604	68	10,929
2049	493	0	0	493	0	104	6	494	604	110	11,040
2050	493	0	0	493	0	104	6	494	604	110	11,150
2051	493	0	0	493	0	104	6	485	595	102	11,252
2052	493	0	0	493	0	104	6	479	590	96	11,348
2053	493	0	0	493	0	104	6	479	590	96	11,444
2054	493	0	0	493	0	104	6	479	590	96	11,540
2055	536	0	0	536	0	104	6	479	590	53	11,594
2056	536	0	0	536	0	104	6	430	540	4	11,597
2057	536	0	0	536	0	104	6	430	540	4	11,601
2058	536	0	0	536	0	104	6	422	532	-4	11,597

12.4.4 Budget for electrification in the Solomon Government

According to the budget speech in 2000 by the government, the total national budget in the Solomon Island is SB$593mil, and the amount allocated for the development of the infrastructure is SB$196.2mil. It can be understood from the following figure, almost all development expenditure was covered by foreign loans and grants in the past. In the development budget in 2000, the amount for the electrification is SB$9.1mil which shares 4.64% of the total budget for development. It means that around 4.64% of total foreign loans and grants will be used for electrification in the future.

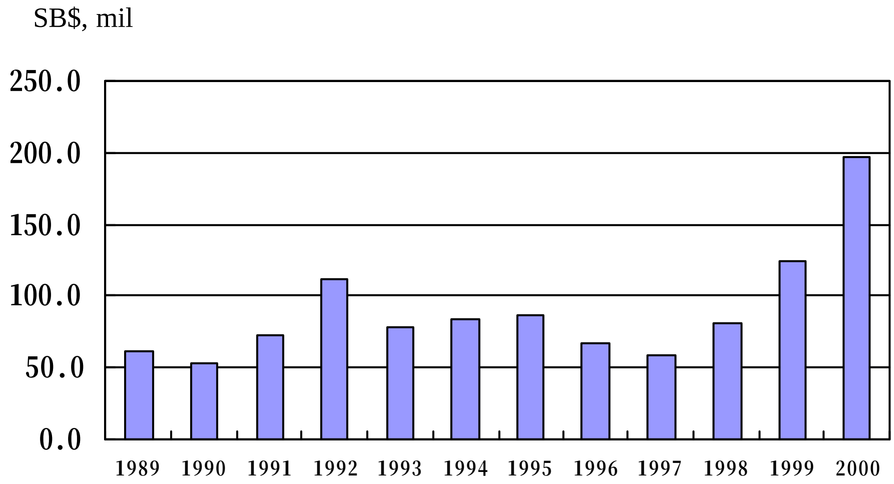


Fig. 12-4-4-1 Budget for Development Expenditure

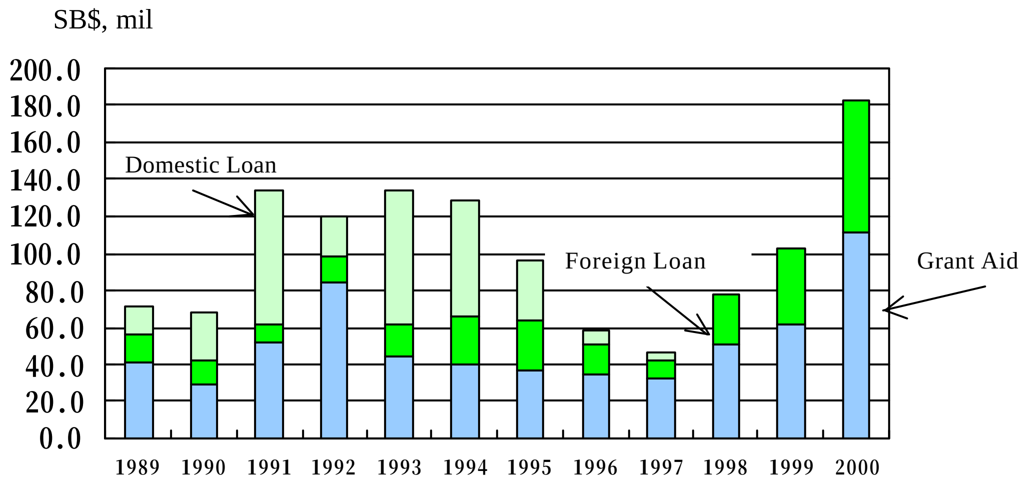


Fig. 12-4-4-2 Loan and Grand Aid

The total development budget during 1989-1999 (10 years) was SB873mil and thus, the total development budget during 2000-2018 (19years) is estimated as follows.

SB$873mil * 1.9 = SB$1,659mil = US$332mil

And assuming the budget for electrification is the same portion as in 2000, the amount will be estimated as follows.

US$332mil * 4.64% = US$15.4mil

It means that, the fundable amount by loan and grant in the optimum power supply plan is around US$15.4mil,.

The optimum funding plan set up above is including large amount of loan and grant which is far exceeding the estimated funding amount of loan and grant. However, assuming the loan will be executed in low interest and long maturity, the debt service will be possible, and therefore, this funding plan is thought to be feasible enough.

For reference, the repayment plans are shown in the next pages in case that the soft loans are executed for the construction of the Maotapuku –1 and Silolo hydropower. In both project, although it will occur cash shortage the initial several years because the interest payment is charged during grace period in ADB loan, however, it is possible to be supplement by retained own fund of SIEA.

Table 12-4-4-1 Funding and repayment plan for the small hydropower (example for Maotapuku -1 small hydropower project)

Hydro Maotapku-1

Direct loan (ADB - SIEA)

	Foreign	Local	
Grace	**10**	**3**	**year**
Maturity	**30**	**15**	**year**
Interest	**1.00%**	**6.50%**	

Borrowing Total	Foreign	Local	Grant Total
24,870	17,409	7,461	0
	70%	30%	

(US$ '000)

Year	Cost	O&M	Outflow: Foreign borrow Repayment	Foreign borrow Interest	Local borrow Repayment	Local borrow Interest	Total out flow	Sold Energy MWh	Inflow: Foreign borrow	Local borrow	Grant	Benefit	Total in flow	Cash Balance	Cash Accumulated
2000															
2001															
2002															
2003															
2004															
2005															
2006	4,477	0	0	174	0	485	5,136	0	3,134	1,343	0	0	4,477	-659	-659
2007	6,218	0	0	174	0	485	6,877	0	4,352	1,865		0	6,218	-659	-1,318
2008	10,694	0	0	174	0	485	11,353	0	7,486	3,208		0	10,694	-659	-1,977
2009	3,482	0	0	174	497	453	4,606	0	2,437	1,045		0	3,482	-1,124	-3,101
2010		141	0	174	497	420	1,233	7,423	0	0		1,697	1,697	464	-2,637
2011		141	0	174	497	388	1,200	7,423	0	0		1,697	1,697	496	-2,141
2012		141	0	174	497	356	1,168	7,423	0	0		1,697	1,697	529	-1,612
2013		141	0	174	497	323	1,136	7,423	0	0		1,697	1,697	561	-1,051
2014		141	0	174	497	291	1,103	7,423	0	0		1,697	1,697	593	-458
2015		141	0	174	497	259	1,071	7,423	0	0		1,697	1,697	626	168
2016		141	580	168	497	226	1,613	7,423	0	0		1,697	1,697	83	251
2017		141	580	162	497	194	1,575	7,423	0	0		1,697	1,697	122	373
2018		141	580	157	497	162	1,537	7,423	0	0		1,697	1,697	160	533
2019		141	580	151	497	129	1,499	7,423	0	0		1,697	1,697	198	731
2020		141	580	145	497	97	1,461	7,423	0	0		1,697	1,697	236	967
2021		141	580	139	497	65	1,423	7,423	0	0		1,697	1,697	274	1,241
2022		141	580	133	497	32	1,385	7,423	0	0		1,697	1,697	312	1,553
2023		141	580	128	497	0	1,346	7,423	0	0		1,697	1,697	350	1,903
2024		141	580	122	0	0	843	7,423	0	0		1,697	1,697	854	2,757
2025		141	580	116	0	0	837	7,423	0	0		1,697	1,697	859	3,617
2026		141	580	110	0	0	832	7,423	0	0		1,697	1,697	865	4,482
2027		141	580	104	0	0	826	7,423	0	0		1,697	1,697	871	5,353
2028		141	580	99	0	0	820	7,423	0	0		1,697	1,697	877	6,230
2029		141	580	93	0	0	814	7,423	0	0		1,697	1,697	883	7,112
2030		141	580	87	0	0	808	7,423	0	0		1,697	1,697	888	8,001
2031		141	580	81	0	0	803	7,423	0	0		1,697	1,697	894	8,895
2032		141	580	75	0	0	797	7,423	0	0		1,697	1,697	900	9,795
2033		141	580	70	0	0	791	7,423	0	0		1,697	1,697	906	10,701
2034		141	580	64	0	0	785	7,423	0	0		1,697	1,697	912	11,613
2035		141	580	58	0	0	779	7,423	0	0		1,697	1,697	917	12,530
2036		141	580	52	0	0	774	7,423	0	0		1,697	1,697	923	13,453
2037		141	580	46	0	0	768	7,423	0	0		1,697	1,697	929	14,382
2038		141	580	41	0	0	762	7,423	0	0		1,697	1,697	935	15,317
2039		141	580	35	0	0	756	7,423	0	0		1,697	1,697	941	16,258
2040		141	580	29	0	0	750	7,423	0	0		1,697	1,697	946	17,204
2041		141	580	23	0	0	745	7,423	0	0		1,697	1,697	952	18,157
2042		141	580	17	0	0	739	7,423	0	0		1,697	1,697	958	19,115
2043		141	580	12	0	0	733	7,423	0	0		1,697	1,697	964	20,079
2044		141	580	6	0	0	727	7,423	0	0		1,697	1,697	970	21,048
2045		141	580	0	0	0	721	7,423	0	0		1,697	1,697	975	22,024
2046		141	0	0	0	0	141	7,423	0	0		1,697	1,697	1,556	23,580
2047		141	0	0	0	0	141	7,423	0	0		1,697	1,697	1,556	25,136
2048		141	0	0	0	0	141	7,423	0	0		1,697	1,697	1,556	26,691
2049		141	0	0	0	0	141	7,423	0	0		1,697	1,697	1,556	28,247
2050		141	0	0	0	0	141	7,423	0	0		1,697	1,697	1,556	29,803
2051		141	0	0	0	0	141	7,423	0	0		1,697	1,697	1,556	31,359
2052		141	0	0	0	0	141	7,423	0	0		1,697	1,697	1,556	32,915
2053		141	0	0	0	0	141	7,423	0	0		1,697	1,697	1,556	34,470

Table 12-4-4-2 Funding and repayment plan for the small hydropower (example for Silolo hydropower project)

Hydro Silolo

Direct loan (ADB - SIEA)

	Foreign	Local	
Grace	**10**	**3**	**year**
Maturity	**30**	**15**	**year**
Interest	**1.00%**	**6.50%**	

Borrowing Total	Foreign	Local	Grant Total	
28,261	19,783	8,478	0	(US$ '000)
	70%	30%		

Year	Cost	O&M	Outflow: Foreign borrow Repayment	Foreign borrow Interest	Local borrow Repayment	Local borrow Interest	Total out flow	Sold Energy MWh	Inflow: Foreign borrow	Local borrow	Grant	Benefit	Total in flow	Cash Balance	Cash Accumulated
2000															
2001															
2002															
2003															
2004															
2005															
2006															
2007															
2008															
2009															
2010	5,087	0	0	198	0	551	5,836	0	3,561	1,526	0	0	5,087	-749	-749
2011	7,065	0	0	198	0	551	7,814	0	4,946	2,120		0	7,065	-749	-1,498
2012	12,152	0	0	198	0	551	12,901	0	8,507	3,646		0	12,152	-749	-2,247
2013	3,957	0	0	198	565	514	5,234	0	2,770	1,187		0	3,957	-1,277	-3,524
2014		156	0	198	565	478	1,397	9,939	0	0		2,272	2,272	875	-2,649
2015		156	0	198	565	441	1,360	9,939	0	0		2,272	2,272	912	-1,737
2016		156	0	198	565	404	1,323	9,939	0	0		2,272	2,272	949	-788
2017		156	0	198	565	367	1,286	9,939	0	0		2,272	2,272	986	198
2018		156	0	198	565	331	1,250	9,939	0	0		2,272	2,272	1,022	1,220
2019		156	0	198	565	294	1,213	9,939	0	0		2,272	2,272	1,059	2,279
2020		156	659	191	565	257	1,829	9,939	0	0		2,272	2,272	443	2,722
2021		156	659	185	565	220	1,786	9,939	0	0		2,272	2,272	486	3,208
2022		156	659	178	565	184	1,742	9,939	0	0		2,272	2,272	530	3,738
2023		156	659	171	565	147	1,699	9,939	0	0		2,272	2,272	573	4,311
2024		156	659	165	565	110	1,656	9,939	0	0		2,272	2,272	616	4,927
2025		156	659	158	565	73	1,612	9,939	0	0		2,272	2,272	660	5,587
2026		156	659	152	565	37	1,569	9,939	0	0		2,272	2,272	703	6,290
2027		156	659	145	565	-0	1,526	9,939	0	0		2,272	2,272	746	7,036
2028		156	659	138	0	0	954	9,939	0	0		2,272	2,272	1,318	8,354
2029		156	659	132	0	0	947	9,939	0	0		2,272	2,272	1,325	9,679
2030		156	659	125	0	0	941	9,939	0	0		2,272	2,272	1,331	11,010
2031		156	659	119	0	0	934	9,939	0	0		2,272	2,272	1,338	12,348
2032		156	659	112	0	0	928	9,939	0	0		2,272	2,272	1,344	13,692
2033		156	659	106	0	0	921	9,939	0	0		2,272	2,272	1,351	15,043
2034		156	659	99	0	0	914	9,939	0	0		2,272	2,272	1,358	16,401
2035		156	659	92	0	0	908	9,939	0	0		2,272	2,272	1,364	17,765
2036		156	659	86	0	0	901	9,939	0	0		2,272	2,272	1,371	19,136
2037		156	659	79	0	0	895	9,939	0	0		2,272	2,272	1,377	20,514
2038		156	659	73	0	0	888	9,939	0	0		2,272	2,272	1,384	21,898
2039		156	659	66	0	0	881	9,939	0	0		2,272	2,272	1,391	23,288
2040		156	659	59	0	0	875	9,939	0	0		2,272	2,272	1,397	24,685
2041		156	659	53	0	0	868	9,939	0	0		2,272	2,272	1,404	26,089
2042		156	659	46	0	0	862	9,939	0	0		2,272	2,272	1,410	27,500
2043		156	659	40	0	0	855	9,939	0	0		2,272	2,272	1,417	28,917
2044		156	659	33	0	0	848	9,939	0	0		2,272	2,272	1,424	30,340
2045		156	659	26	0	0	842	9,939	0	0		2,272	2,272	1,430	31,770
2046		156	659	20	0	0	835	9,939	0	0		2,272	2,272	1,437	33,207
2047		156	659	13	0	0	829	9,939	0	0		2,272	2,272	1,443	34,651
2048		156	659	7	0	0	822	9,939	0	0		2,272	2,272	1,450	36,101
2049		156	659	-0	0	0	815	9,939	0	0		2,272	2,272	1,457	37,557
2050		156	0	0	0	0	156	9,939	0	0		2,272	2,272	2,116	39,673
2051		156	0	0	0	0	156	9,939	0	0		2,272	2,272	2,116	41,789
2052		156	0	0	0	0	156	9,939	0	0		2,272	2,272	2,116	43,905
2053		156	0	0	0	0	156	9,939	0	0		2,272	2,272	2,116	46,021

12.5 Analysis of financial conditions in SIEA

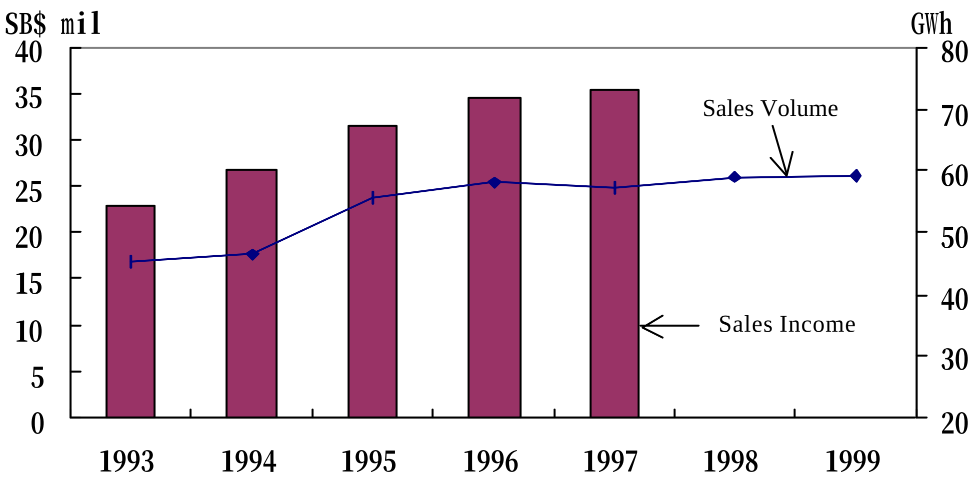
In this clause, further analysis on the financial situation of SIEA is carried out, and characteristics and problems of its operation and management are pointed out.

In recent years, SIEA has been facing a difficult financial situation mainly by cost pressure of fuel oil and equipment parts, interest payment of loans and substantial exchange loss by the currency devaluation and the accumulating number of tariff arrears, etc. In October 1998 and August in 1999, SIEA increased tariff sharply after 5 years, and it is making a plan for improving the operation. The financial performance of SIEA will be expected to improve certainly in the near future.

In this field survey, we collected the financial statements of SIEA from 1993 to 1997, while the statement of 1997 is unaudited (see table 12-4-1-1 and table 12-4-1-2). The financial statements after 1998 have not been prepared.

12.5.1 Electricity Sales

Electricity sales shares 99% of total revenue of SIEA. Sales volume is maintaining almost the same level since 1996, and the electricity sales revenue is supposed to be maintaining same level although no formal data from 1998 is corrected.



Source: SIEA

Fig. 12-5-1 Electricity Sales by SIEA

The sales revenue per kWh was SB$0.509 in 1993 and SB$0.620 in 1997.

The breakdown of the sales revenue is 24% for residents, 62.2% for commercial and industrial, 11.3% for government institutions and 2.4% for others in total sales volume (around 60GWh) in 1998.

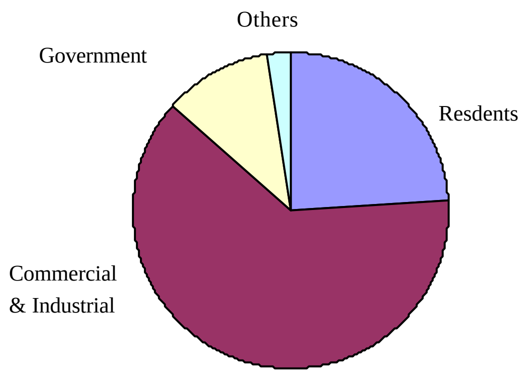


Fig. 12-5-2 Breakdown of Sales Volume (1998)

12.5.2 Tariff Increase

SIEA has increased tariffs irregularly to improve its financial situation since 1980. In recent several years, the tariff has not been changed since last increase in November 1993 (12% residential, 31% commercial/industrial). Due to continuous devaluation of currency, high cost pressure and accumulation of electricity debtors, the operating result declined sharply to minus SB$5.4mil in operating profits in 1996, thus the financial situation of SIEA deteriorated soon.

SIEA has submitted tariff increase repeatedly to the government and 25% of tariff increase was finally approved after 5 years in July 1998. This tariff increase was executed separately because of the regulation in the Electricity Act (10% in October 1998, 12% - 13% in August 1998). These increases will be expected to contribute to certain improve on the financing situation of SIEA. (The record of the tariff increase, see section 12.1.2)

12.5.3 Sales Cost

In the sales cost, the fuel and lubricant oil shares around 45% of the total, and then depreciation, manpower and maintenance costs share around 15% each. The main material of the fuel is diesel oil (light oil) for diesel generators, and all this fuel is supplied by Mobil Oil.

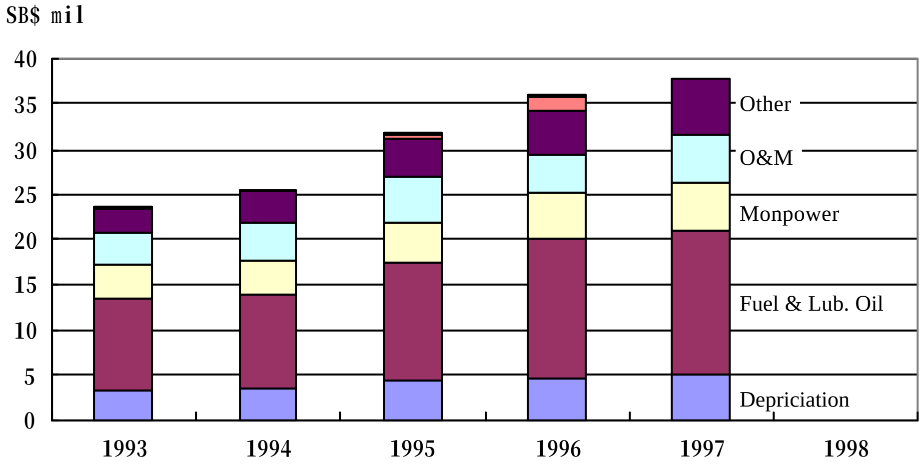


Fig. 12-5-3-1 Sales Cost

The cost of fuel and lubricant oil shared 45% to 46% in average until 1997, and then the percentage was not increased but the unit price is increasing every year.

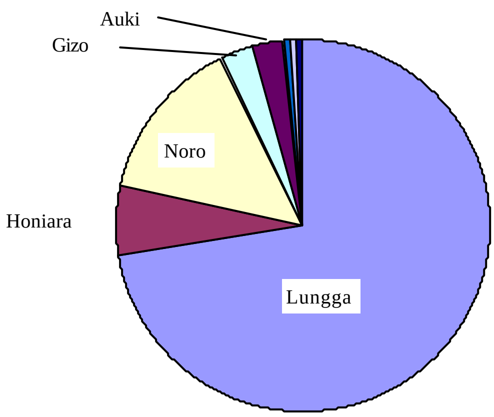


Fig.12-5-3-2 Fuel consumption in each power station (1997)

The Price Advisory Committee controls the price of petroleum goods in the market, however, the fuel price supplied to SIEA is decided through negotiation with Mobil Oil Co. directly. The price for SIEA is slightly lower than the market price. The fuel price was SB$1.14 to SB$1.51 in October 1999, which is increasing gradually every year.

In November 1999, the Price Advisory Committee announced 15 to 30% increases on the price of petroleum goods. The diesel oil price was increased in average about 20%. The main reason was a sharp increase of the oil price in the refinery factory in Singapore. This will augment the cost pressure of the fuel oil and will make evident the weakest point of SIEA operation: the heavy dependency on diesel.

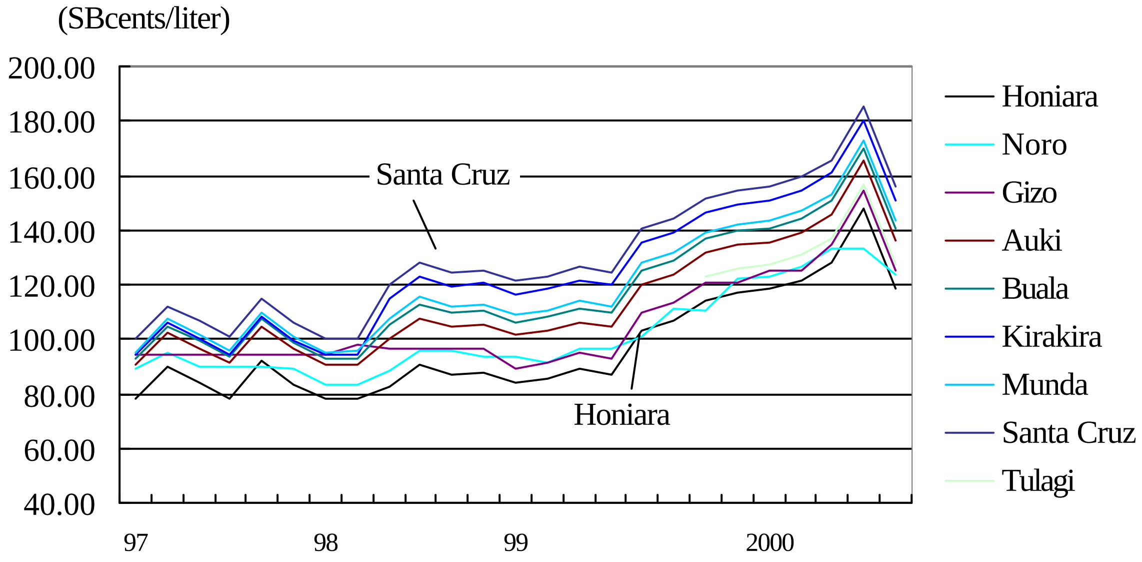


Fig. 12-5-3-3 Diesel oil price

12.5.4 Operating Margin

Operating margin is decreasing since the peak in 1994, falling to 0.21% in 1997. The main reason is that the operation cost is increasing every year, and the electricity tariff has kept same level since 1993. After sharp increase of tariff this time, the operating margin in 1999 will be expected to improve largely. However, due to the price increase of petroleum goods, the operating margin is possible to decline again after 2000.

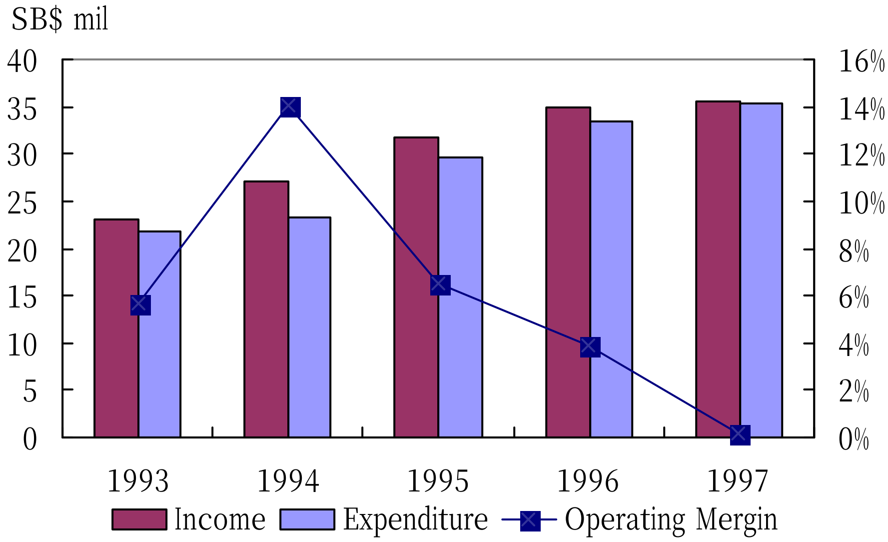


Fig. 12-5-4 Operating Margin

12.5.5 Non-operating Profit and Loss

Non-operating expenditure is mainly shared by the interest payment and exchange loss on the external debt. Interest payment is mainly for the NPF and ADB loan, and the exchange loss is originated by the ADB loan (denominated in SDR). The debt service has suspended since 1997 and has caused a huge amount of amortized debt in arrears. The ADB loan was re-lent by Solomon government to SIEA. This also forms a big pressure in the non-operating expenditure. On the other hand, non-operating income is mainly provided by government subsidy and foreign grant aid, however, the government subsidy has suspended since 1997. The non-operating profit and loss account have shown a huge amount of deficit, being the main reason of the deteriorating operation of SIEA.

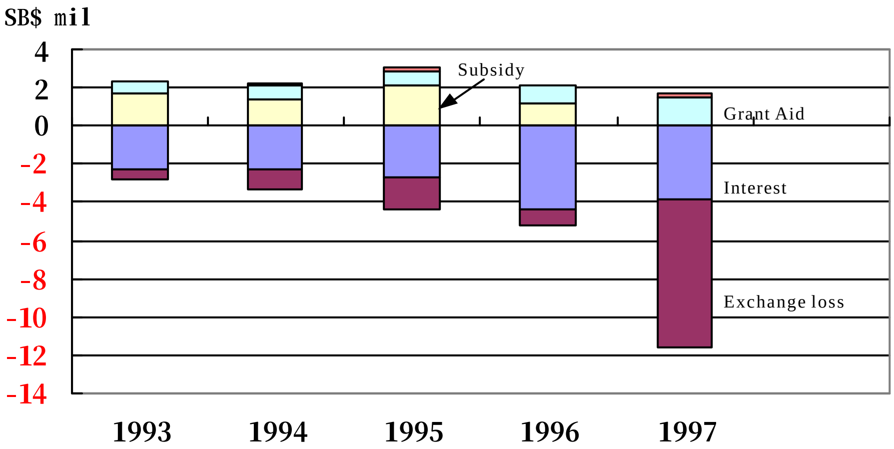


Fig.12-5-5 Non Operating plofit / loss

12.5.6 Net Profit

Due to the declining operating margin and accumulated non-operating loss, the operating profit before income tax was dropped to substantial amount of loss after 1996, and the retained profit also became a huge loss. Although the income tax on electricity sales by SIEA is exempted and the actual amount of income tax is very small, the operating profit after tax (net profit) was at a loss of SB$4.45mil and SB$9.83mil in 1996 and 1997, respectively. The retained profit also declined to deficit over SB$14mil by the end of 1997.

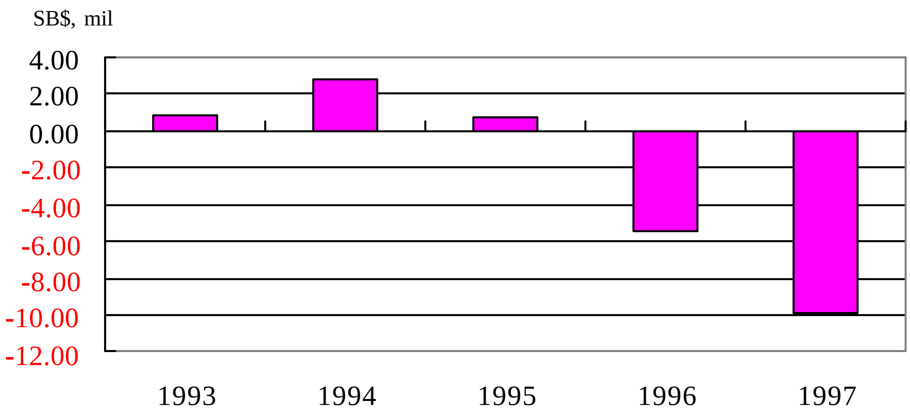


Fig.12-5-6 Net profit / loss

12.5.7 Situation of Assets

Approximately 85% of total assets are shared by fixed assets including property and generating equipment. Almost all fixed assets are shared by generating equipment. The depreciation expense originated from these fixed assets shares around 15% of the total operating expenditure.

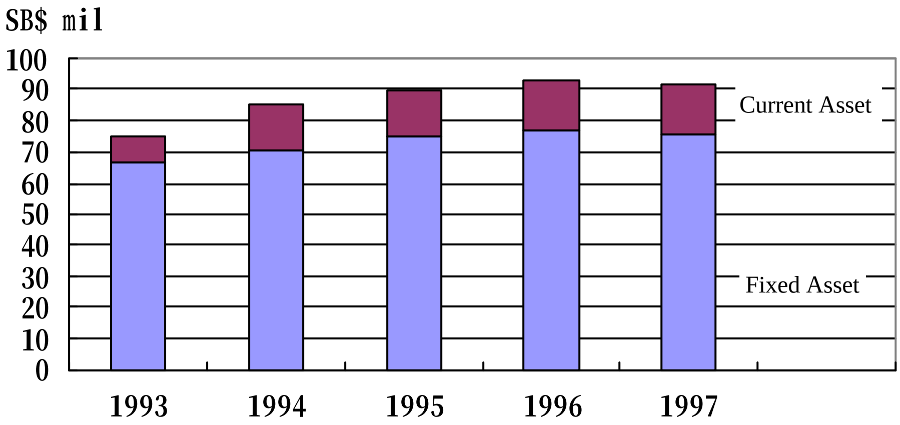


Fig.12-5-7 Total asset of SIEA

12.5.8 Current Assets

According to the amount of current assets, the receivables are increasing every year, and the cash and deposit position is getting tight. The amount of cash and deposit dropped to SB$32,472, extremely low level, the liquidity is getting worse.

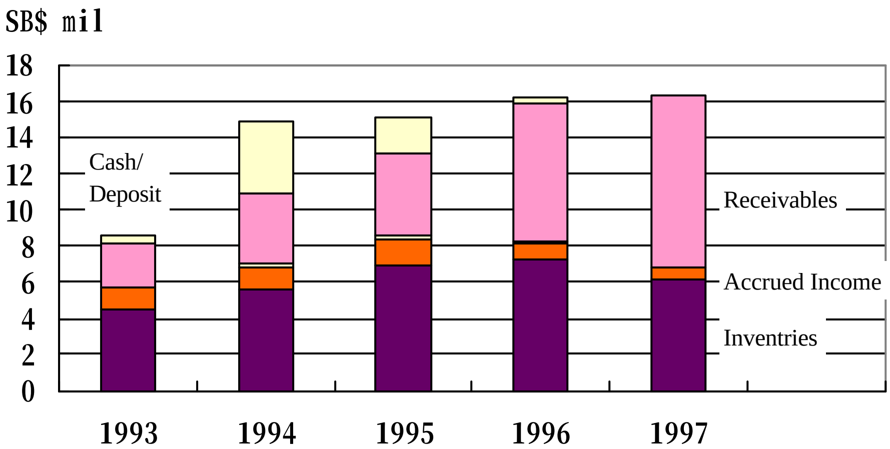


Fig.12-5-8 Current assets

The amount of receivables reached to SB$9.47mil in 1997, which is around 30% of the total sales income SB$35.5mil. The receivables actually consist of a number of electricity debtors including big consumers such as government offices and institutions. SIEA is now planning to install as a measure the compulsory disconnection of electricity supply against the long-term electricity debtors indiscriminately, to secure the stable revenue of electricity generation.

Inventories, shared by generation equipment and fuel stock, are decreasing every. SIEA is now negotiating with the fuel supplier to relax the condition of payment such as installments, and making effort to ease cash flow position and recover the stock volume to the normal level.

12.5.9 Liabilities

Around one half of the current liabilities (short-term debts less than one year) are funded from NPF. And around 80% of long term liabilities are funded from ADB. The interest rates of debts are 14% in NPF, 7.65% or 6.36% in ADB and 15.75% in ANZ Bank, the huge amount of interest payment is giving a big pressure to the operation of SIEA.

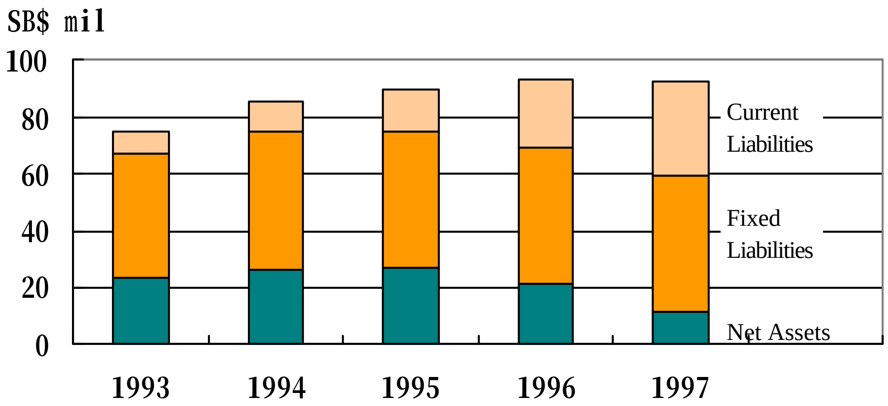


Fig.12-5-9 Liabilities and Net assets

12.5.10 Financial criteria requested by ADB

ADB loan was executed two times in the past, and the third loan for the Lungga No.9 diesel power station was proposed by ADB in September 1994, however, it was not executed because the following criteria requested by ADB were not satisfied.

1) Audited financial statements to be completed within six months after the end of financial year.
2) Return on asset (ROA[11]) of more than 8.0%

[11] Return On Asset

3) Debt Service Ratio (operating profit against total principal and interest payment) more than 1.5.

4) Debt/equity ratio not more than 60%.

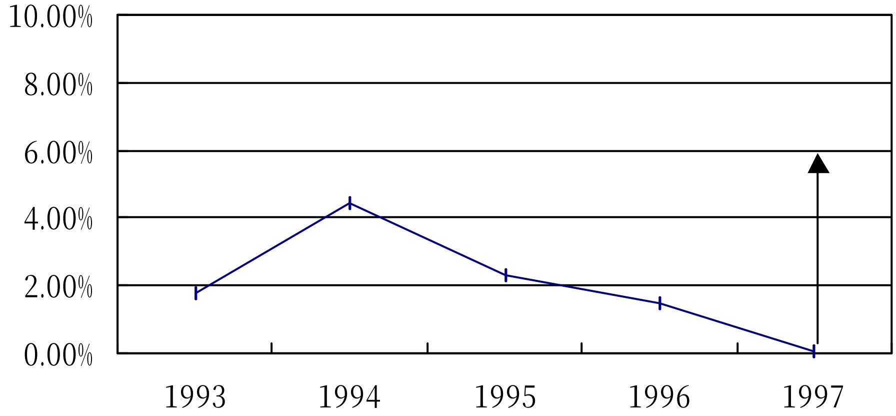


Fig. 12-5-10-1 Trend of ROA

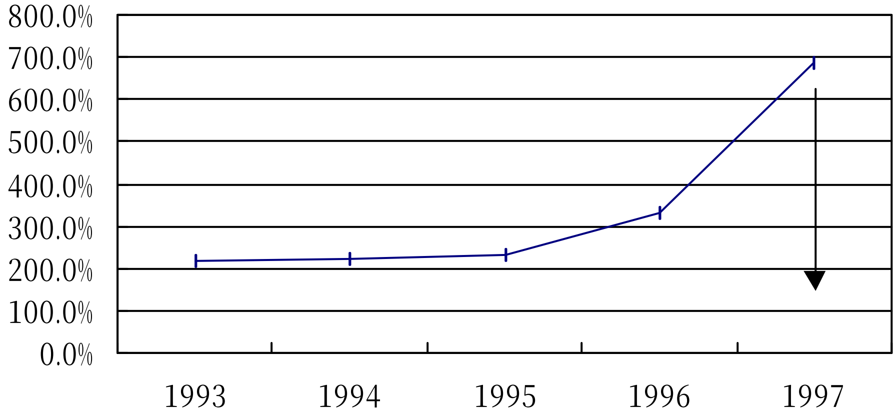


Fig. 12-5-10-2 Trend Debt Equity Ratio

12.5.11 Financial Strategy by SIEA

In order to improve the present financial position, SIEA is now planning the following financial strategies, others than the recent tariff increase. (see Chapter 11)

1) Negotiation with suppliers about payment measures
2) Compulsory disconnection to electricity debtors
3) Installation of prepaid scheme called “Cash Power 2000”
4) Improved performance of loss-making outstations

Table 12-5-1-1 Income Statement of SIEA

SB$

	1993	1994	1995	1996	1997
Income					
Electricity Sales	23,021,131	26,856,089	31,454,397	34,387,161	35,502,201
Commercial Sales	35,397	20,985	0	135,251	0
Rent Received	6,450	11,165	5,524	12,740	3,750
Interests on Deposits	109	51,643	70,981	179,293	377
Other Income	52,082	57,565	211,048	177,005	0
Total Income	23,115,169	26,997,447	31,741,950	34,891,450	35,506,328
Expenditure					
Depreciation	3,188,450	3,490,730	4,413,271	4,667,998	4,928,030
Fuel, Oil and Lubricant	10,328,486	10,547,513	12,852,170	15,572,662	15,888,007
Manpower	3,584,845	3,710,266	4,657,076	4,978,457	5,504,885
Repairs and Maintenance	3,560,076	4,086,777	4,930,365	4,241,832	5,307,898
Other Expenses	2,706,447	3,417,039	4,321,517	4,768,842	6,276,466
Bad and doubtful debts	26,422	0	478,732	1,439,080	0
Internal Charges	58,370	185,387	192,665	219,137	0
Charge for works	-1,126,101	-1,718,837	-1,701,466	-1,772,645	-2,450,254
Costs recharged	-524,571	-510,147	-479,826	-579,038	-23,589
Total Expenditure	21,802,424	23,208,728	29,664,504	33,536,325	35,431,443
Profit before financial charges and other income	**1,312,745**	**3,788,719**	**2,077,446**	**1,355,125**	**74,885**
Financial Charges					
Interest paid or due and payable	-2,216,490	-2,182,816	-2,695,927	-4,375,322	-3,788,995
Foreign exchange losses	-630,960	-1,077,603	-1,646,822	-853,753	-7,806,061
Other income					
Government subsidy of outstation losses	1,744,092	1,420,446	2,141,047	1,220,523	0
Amortization of grants and contribution	669,420	739,047	817,372	924,022	1,534,775
Obsolete stocks written off	0	0	-115,900	0	0
Loss on write off of non-current assets	0	0	0	-3,720,347	0
Profit on sale of non-current assets	0	67,930	156,992	0	157,747
Total of non-operation Profit	-433,938	-1,032,996	-1,343,238	-6,804,877	-9,902,534
Operating profit before income tax	**878,807**	**2,755,723**	**734,208**	**-5,449,752**	**-9,827,649**
Income tax attributable to sales not derived from electricity	32,876	30,475	82,603	0	
Operating profit after income tax	**845,931**	**2,725,248**	**651,605**	**-5,449,752**	**-9,827,649**
Retained profits at the begging of year	-3,563,154	-2,717,223	8,025	659,630	-4,790,122
Retained profits at the end of year	**-2,717,223**	**8,025**	**659,630**	**-4,790,122**	**-14,617,771**

* Figures in 1997 are unaudited.

Source: SIEA

Table 12-5-1-2 Balance Sheet of SIEA

SB$

	1993	1994	1995	1996	1997
Current Assets					
Cash	484,060	4,014,943	1,989,186	228,851	32,472
Receivables	2,435,605	3,863,772	4,496,375	7,729,772	9,469,480
Prepayments		211,817	175,142	23,371	0
Accrued Income	1,161,069	1,177,844	1,573,838	935,412	718,745
Inventories	4,487,668	5,593,314	6,846,682	7,218,616	6,091,495
sub-total	8,568,402	14,861,690	15,081,223	16,136,022	16,312,192
Non-current Assets					
Property, Plant and Equipment	66,332,059	70,410,736	74,654,999	76,906,509	75,609,209
Total Assets	**74,900,461**	**85,272,426**	**89,736,222**	**93,042,531**	**91,921,401**
Current Liabilities					
Bank overdraft	0	5,800		1,148,661	2,075,736
Creditors and Accruals	3,557,177	2,982,379	5,163,421	8,949,294	9,390,921
Consumer Deposits	520,962	573,532	624,584	689,432	741,752
Secured Loan	3,811,874	6,681,347	8,954,551	13,018,430	19,706,909
Provisions	344,884	302,526	353,329	281,674	248,633
sub-total	8,234,897	10,545,584	15,095,885	24,087,491	32,163,951
Non-current Liabilities					
Secured Loan - non-current	30,981,448	35,440,999	33,947,948	32,503,413	33,011,731
Government Grants	4,079,117	3,852,500	3,625,882	3,399,263	3,474,214
Overseas Grants	5,209,696	4,922,157	5,259,481	6,273,581	5,858,642
Capital Contributions by Consumers	2,812,751	4,209,186	4,847,621	5,269,130	5,730,859
sub-total	43,083,012	48,424,842	47,680,932	47,445,387	48,075,446
Total Liabilities	**51,317,909**	**58,970,426**	**62,776,817**	**71,532,878**	**80,239,397**
Net Assets	**23,582,552**	**26,302,000**	**26,959,405**	**21,509,653**	**11,682,004**

Accumulated Funds

Assets Revaluation	26,299,775	26,299,775	26,299,775	26,299,775	26,299,775
Retain Profits/Losses	-2,717,223	8,025	659,630	-4,790,122	-14,617,771
Total Accumulated Funds	**23,582,552**	**26,307,800**	**26,959,405**	**21,509,653**	**11,682,004**

* Figures in 1997 are unaudited.

Source: SIEA