Review of Namdrik Atoll Solar Project, RMI

Final Report

Empower Consultants Limited

October 2005

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Acronyms used in this Report

AC	Alternating Current
ADB	Asian Development Bank
CNO	Coconut oil
GoRMI	Government of the Republic of the Marshall Islands
kWhr	Kilowatt hour, unit of electricity
MIMRA	Marshall Islands Marine Resources Authority
NTA	National Telecommunications Authority
PREFACE	Pacific Rural/Renewable Energy France-Australia Common Endeavour
RMI	Republic of the Marshall Islands
SOPAC	South Pacific Applied Geoscience Commission
UNEP	United Nations Environment Programme
Wp	Watt peaks, a measure of solar photovoltaic panel output

Review of Namdrik Atoll Solar Project, Republic of the Marshall Islands

Executive Summary

To be completed in the final report once up to date details are obtained on CNO micro mill performance and final project finance data from MEC.

1 Review of the Namdrik Atoll Solar Project

The Namdrik Atoll solar project has had a somewhat chequered history. Before proceeding with the Outer Island electrification programme, GoRMI wished to understand the issues arising from this experience so as to better scope the forward programme of bringing light to the remaining 20 atolls that have no access to environmentally friendly commercial fuels. Under its PIEPSAP project, the South Pacific Applied Geoscience Commission (SOPAC) agreed to fund an investigation with the main aims of characterising the technical and socio-economic conditions on Namdrik, deriving conclusions and recommendations for the forward programme grounded in the experience of solar electrification on the atoll, and investigating the potential for utilisation of coconut oil (CNO) as a biofuel diesel substitute.

1.1 Background to the study

In this section, salient aspects of the preceding projects are discussed.

The RAFRREP project had the stated goal of 'advancing social and economic development through the use of sustainable renewable energy technologies in the SPC region' (Project Design, April 1999).

1.2 Demand analysis and forecasts

The original system design adopted an approach that saw the solar home systems as a substitute for kerosene, candles or dry cell batteries used for domestic lighting. In this regard the systems have been successful. The original forecast recognised, but did not appear to adequately take into account the inevitable growth in expectation and demand that is typical of newly electrified communities.

A review of documentation shows that the PREFACE team was aware of the growth in demand during the refurbishment project, and noted that use of TV/DVD and radios had grown very significantly (in the case of TV/DVD's this is noted as 6,000%). This rapid growth in demand and the inability of the systems in Namdrik to cope is recognised in

the project final review report of October 2003, and concludes that future systems could proceed with 2 x 75 w panels, instead of the 2 x 40 watt panels installed at Namdrik.

Consideration could have been given in the design phase of the Namdrik project, both one and two, to other options for meeting household demand other than solar home systems. Centralised diesel (or CNO) or diesel/solar hybrid technology could have been viably deployed to meet present demand for around 80% of Namdrik households and allow for future growth in demand. This was not done. The original system sought to meet consumer demands for refrigeration, TV/Radio and washing machines via the installation of community equipment in houses owned by village elders. In practice this was very unlikely to succeed, and the effective gifting of these systems to householders in the PREFACE project has exacerbated the sense of inequity in the community on this score. Given the relatively dense and linear clusters of housing on Namdrik, consideration could have been given to a centralised generation with an AC distribution system. It is recognised that within the Marshall Islands, Namdrik is not a typical atoll community in this regard however given the project's stated mandate of investigating least cost options, and also sustainable, productive uses of electricity, the specification of individual solar home systems seems not to have been the only option worthy of consideration.

In addition, the use of non-connected solar home systems significantly limits future flexibility in coping with growth in demand, or in incorporation of changes in generation technology. It is fully recognised that for isolated and remote households not considered part of a cluster, solar home systems remain a technically viable solution, but adequate training to consumers is required to ensure expectations do not exceed system capabilities.

Given the wide variation of housing density and atoll configurations, it is safe to assume that no two atolls will be exactly the same in terms of technical options open to achieve electrification. Other options could have been:

1. Using a standard, metered distribution system with an underground cable to service viable clusters of houses. Generation from CNO, diesel or solar hybrid.
2. Solar home systems for households too remote to connect to a cable supply, but with education to users to better understand supply constraints.
3. Small CNO or diesel gensets for households or community centres to provide access to AC power needed for communal facilities, and complimenting solar home systems used to meet basic domestic lighting needs.

1.3 Technical parameters and design of the solar home systems

A review of the systems shows no immediate technical deficiencies, other than the output of the systems being now surpassed by the electricity demands of the community. None of the systems inspected showed outright technical failure and the maintenance performed by the MEC technician Osi Jitiam is effective.

Battery condition is variable and impacted by multiple factors. The degree of shading on each installation is ever changing, and household size and appliances connected is also a major variable. The use of sealed lead acid batteries has limitations in hot climates, however in Namdrik the cells appear to be performing adequately, recognising that the finer points of their sizing are lost in the rapid growth in consumer demand. Given that appliances other than lights and small appliances were not allowed for in the original design, battery cycling is now faster than planned and battery failure will start to occur earlier than expected. Two sets of batteries needed replacement in the week that the team were on site after ongoing inability to recover from discharge. This creates a social problem as well, in that neighbouring houses, on seeing the new batteries installed, also demand new batteries. The flat $12 charge is seen to reward those who consume faster by supplying new components.

Charge controllers are faring well and only one board is reported to have failed in the field. The remaining service life is not possible to determine with accuracy and again many variables including board temperature and exposure to moisture or salt are a factor. The boards installed could operate for another 5-7 years or more. Settings on the controllers are field-switchable between 12 and 24 volt systems. In some cases consumers have opened the security boxes (a very easy exercise even without a key) and changed the system voltage from 12 to 24 volts in a bid to increase power. Naturally in a 12 volt system this results in the controller disconnecting output completely, resulting in complaints to MEC for poor service.

Figure 1 Junction box pulled off the base of the panel from the weight of the creeper vines

Figure 2 Rotten wooden support eventually fell. No damage - this time.

The PV panels are in generally good condition, but are starting to show some signs of minor expected wear

and tear. In the absence of catastrophic failure, such as a panel being broken by falling branches or coconuts, these panels could perform for another 10 to 20 years. While not warranted for that long, panel performance and service life is unofficially discussed as up to 40 years, with gradual deterioration occurring over this period. Some care is required to keep installations free from the vegetation, as can be seen from the photo above.

Additional care is required on the support poles where wood has been used instead of concrete. The potential exists for panels to be damaged when the wood rots and the pole falls, as seen above.

The primary technical problem manifesting itself on the atoll at present is the domestic light fittings. The MEC office in Namdrik is out of stock of the ballasts required for the lighting fixtures, as is the Majuro office. Replacements are on order, but in the interim households are left feeling that they have less light than they are paying for in their $12 fee. Confusion exists with the householders on where the responsibility lies for the maintenance and upkeep of these fittings, with many feeling (incorrectly) that MEC should pay for the replacement ballasts. The contractual arrangements left the internal light fittings with the householder, as part of the items purchased in the original $100 connection fee. The cause of failure for the ballasts is intermittent, with some households reporting multiple failures and others reporting no problems at all. While no firm indicators were noted, it is felt that consumer behaviour is a factor here, possibly due to attempts to get the bulbs operating after the charge controller had disconnected power due to low voltage. The exact cause needs to be determined to avoid recurrences in the future. In any case, greater clarity is required in contracts with consumers to avoid confusion on responsibility in the future.

1.4 Community consultations

The community consultation undertaken is noted in the earlier project reports. From a technical perspective, to the extent that consultation was undertaken it did not adequately determine the future growth of demand in the future in the first project. In the second project the growth in demand was identified but not taken into account and the consultation process appeared not to adequately educate the consumers on what performance could be expected.

In sum, there was community consultation undertaken, but it was not effective in modifying the technical or social project parameters of the project in terms of system design or consumer expectations.

1.5 Socio-economic analysis in the PREFACE planning phase

Gender, poverty, financial, economic and environmental impact analysis occupies one page in the RAFRREP project design document. Poverty impacts are addressed in terms of the imposition of costs on the poor, though the potential for night work is discussed. The report expresses the expectation that impacts will be positive in these areas though

notes the potential for pollution by lead acid batteries if they are not properly disposed of. These expectations are study rather than survey-based. It is noted that "Comprehensive socio-economic analyses during identification, feasibility and implementation (including training) stages of the demonstration installations will be crucial to achieving sustainability" with specific reference to management structures as well as technology. The team has not seen the TORs for implementation or a baseline report that would be expected to give expression to this intention.

1.6 Maintenance and Operation planning (manuals, procedures)

Maintenance and operational planning was well recognised as a potential problem and steps taken to mitigate this risk. The utilisation of the LGC as a management entity had merit, in that it encouraged community involvement, but the LGC itself lack the focus and specific skills needed to run an electricity entity, and ran into managerial problems, including maintenance and payment issues. The subsequent adoption of project responsibility by the Marshalls Energy Company (MEC) is retrospectively adding the commercial experience and managerial oversight lacking previously.

The provision of manuals was seriously deficient in both projects, with only manuals provided in French, let alone English, and none translated into local language. Only when a SOPAC manager, Mr Gerhard Zieroth visited and noted the deficiency were technical manuals translated into English.

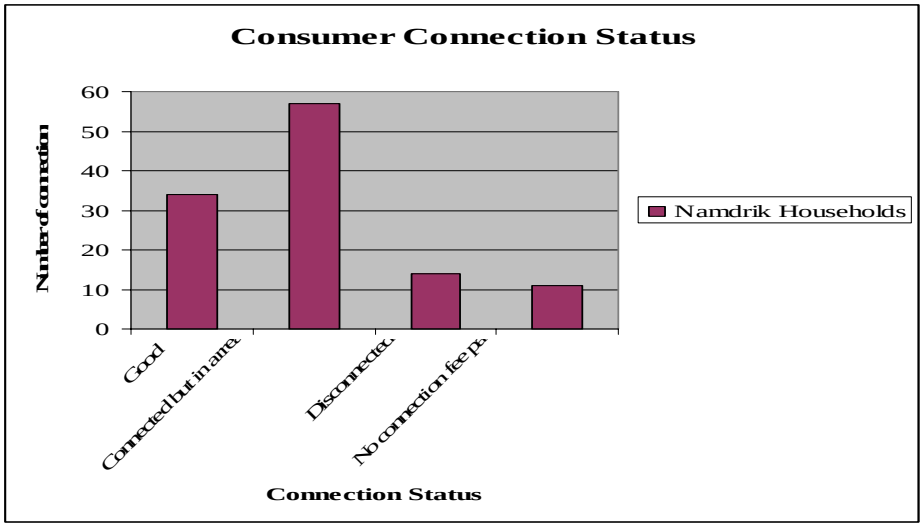
Training was felt to be minimal by the local technician and additional training is now desired. In practice, after several years of field work, the original training that may have been challenging and sufficient at the start has become 'old hat' and greater understanding is wanted. Ensuring a second technician is available on the atoll in the event of a loss of staff for whatever reason is very desirable in terms of future-proofing the installation, but it is recognised that there are budgetary implications that must be considered carefully, or perhaps an arrangement found that has a standby staff member available on an as-required basis thus minimising on-going financial impacts.

Training in the repair of appliances and other system components has been discussed. In principle and where possible, this can be encouraged, such as the repair of light fittings. Other components such as inverters and charge controllers however involve very complex circuitry and in practice are not field serviceable.

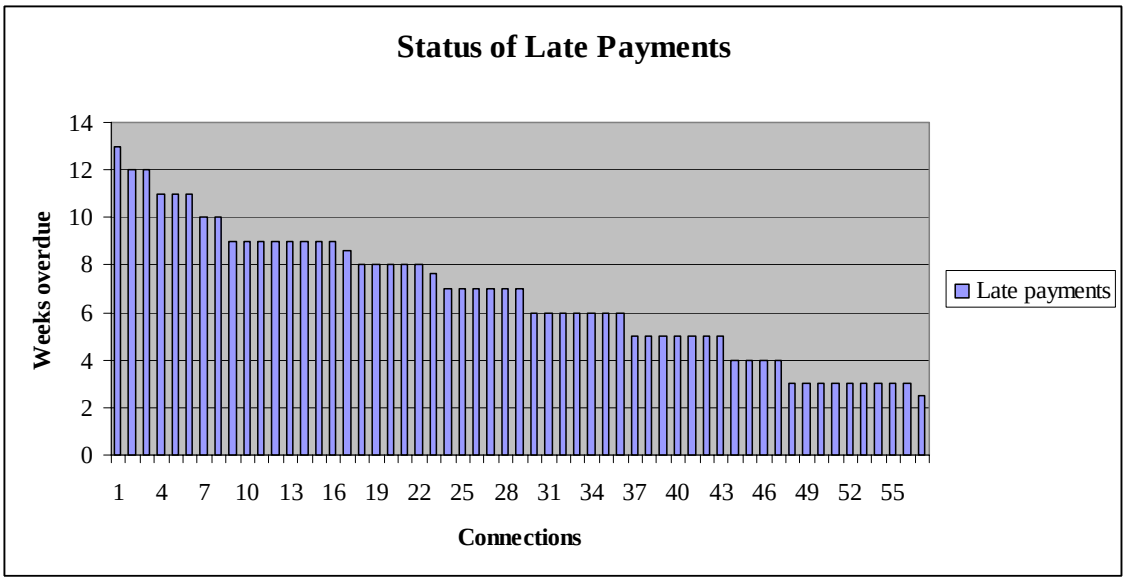
2 Current financial status of project

While the physical condition of the installations is quite healthy, financial status of the project remains problematic after the rehabilitation project.

2.1 Payments status



From the graph above it can be deduced that the overall financial performance of the project remains poor. Only 29 % of households are classed as up to date as at May 2005. 57% are connected but are behind in payments, collectively owe US$4,600 and are an average of 7 weeks behind. 12% of households have been disconnected and a further 11% are disconnected having never paid the $100 connection fee. Since May, monthly collections have deteriorated sharply and additional information will be sought from MEC up to the month of August for inclusion in the final report.



Financially, the project would not be regarded viable without grant funding of the equipment. Bill payment has never exceeded 57% on a monthly basis, underscoring community difficulties either with ability or willingness to pay.

The present status of the project is stable from a technical perspective, and the MEC management and maintenance model appears to be working well, but the acid test will come when capital cost items such as batteries and charge controllers require replacement from project savings.

2.2 Creditors

The payment status has been slowly improving, but MEC notes a significant backwards slide in recent months. Only 10% of consumers paid their bill in July, 12% in June, and 27% in May. MEC commented that the lack of recent field trips, and financial pressure from the start of the school term, had impacted on ability to pay.

MEC keeps very good records on payment status of individual consumers. Cash management is transparent and well documented with numbered receipts being used to match payments to consumers. This review has not identified problems with bill collection stemming from present financial management.

2.3 Financial viability

MEC is willing to manage project on a cost recovery basis, but for sustainability to be assured it is preferred to generate a surplus. Thus far into the project the revenues collected have not been required to fund capital replacement demands other than holding stock of lighting components for on-sale. Battery replacements will be increasingly likely with the higher demands placed on the systems and the subsequent deeper and more frequent cycling of the batteries. Pressure on revenues will therefore expected to grow in the next 12 to 24 months.

Presently the operational costs of the project are low, and while specifically required by MEC's board to operate in a manner that does not use the financial resources of the Majuro operation to support or subsidise the Namdrik installations, the project does benefit from cross subsidy in other areas such as the time spent on the project by MEC management staff in Majuro, and office overheads such as printers, copying, communications etc. The cost of an operator in Namdrik costs around $50 per week, or $2,600 per year. Thus the project is able to cover its basic operational costs to date.

Additional up to date information will be sought from MEC to clarify the financial reserves held by the project at the end of August 2005, and the ability of the project to meet future calls on capital for equipment replacement.

2.4 Copra for power

The utilisation of copra to pay for power has advantages and disadvantages. These are summarised below:

Advantages	Disadvantages
Households will probably part with copra more easily than cash	MEC are not in the business of brokering copra sales
More visible and tangible basis for households to interact with MEC.	The value of copra is not constant (i.e adjustment may be required in the amount of copra collected)
MEC may lobby the Ministry of Transportation for more regular shipping	Irregular shipping schedules may require MEC to advance funding for the solar systems for long periods

MEC has explored this already, and a solution is underway. A new shop and copra trading building is under construction by a local investor close to the existing copra store. This shop will pay MEC $10 per month for consumer power connections and take $12 worth of copra from a household for the service.

A Philippines community that Empower Consultants has an existing centralised, metered solar diesel hybrid project with also uses this model. There, the village power management committee allows consumers to pay for power by accepting copra at 95% of the commercial rate in the community, and on-sells it at the full rate. The margin is used to cover the cost of the transportation and time to act as a broker and seems acceptable to the community.

The use of the CNO powered generator model takes this a step further by converting the raw copra to copra oil on site, and then either taking a percentage of the oil as payment, or payment for overheads plus a larger percentage of the oil to run the plant and generator. These models and the technology used require

3 Current socio-economic status on Namdrik

The team consulted relevant reports prior to arrival in Majuro. The programme in country comprised meetings with key institutional stakeholders in Majuro before the team of one Marshallese and two New Zealand consultants departed for field work on the atoll. The team met Local Government Council members, a number of key informants, held a community meeting and conducted a sample household survey. It had been intended to spend two weeks on the atoll, but half the key informants were on Majuro attending conferences during the school holidays, so team members completed gathering the available primary data from members of the LGC, the copra cooperative, the Women's Union, the health assistant, MEC technician, community members and householders on the island, then returned to Majuro after a week to meet the Mayor, senior teacher, religious leaders and the *Leroj* in Majuro. A family bereavement prevented this last meeting. Debriefings were held with the Energy Office, MEC and Tobolar Copra Processing Authority. A multi-stakeholder workshop was arranged to present findings to date and preliminary conclusions. Lists of stakeholders who were met and attended the workshop are at Annex A.

The information in this report was derived from secondary data source, semi-structured meetings with central and local government stakeholders in Majuro, and consultations with key informants, focus groups and households on the atoll, and feedback from key informants and stakeholders at the workshop.

3.1 Geography, climate

The Marshall Islands comprises 31 atolls and islands, some 1225 islets in two chains lying between four and fourteen degrees latitude north, and 160 and 173 degrees east. Only four islands, Arno, Ailinglaplap, Kwajalein and Mili have land masses above five square miles; most of the remaining atolls are rings of islets around lagoons, with a height above sea level rarely exceeding 5 metres.

The country usually escapes cyclones, though tropical storms have occasionally hit the islands and inflicted damage and loss of life. The country is regarded as very vulnerable to climate change, is a signatory to the 1982 Rio International Convention on Climate Change, and has a conscious commitment to green energy.

Above: GPS mapping of Namdrik, July 2005. Data file available

The country has a tropical oceanic climate with temperatures averaging 80 degrees Fahrenheit throughout the year, and rarely dropping below 75 degrees, even at night. The southern islands, of which Namdrik is one, receive around 160 inches of rainfall per annum, twice the precipitation of the northern islands. Especially in the north, the atolls feature some of the lowest biodiversity indicators in the world, though they appear lush and green where there is sufficient soil to support plant life.

Namdrik is situated in the Ralik (western) chain of the Marshall Islands, 385 kms south west of Majuro at lat North 5.5999 and longitude E 168.1034. The main atoll is along strip of land typically 200 metres wide, but up to 700 metres at place. It is almost 9 kilometres long. The island is 2.6 kms from the western tip of the main atoll.

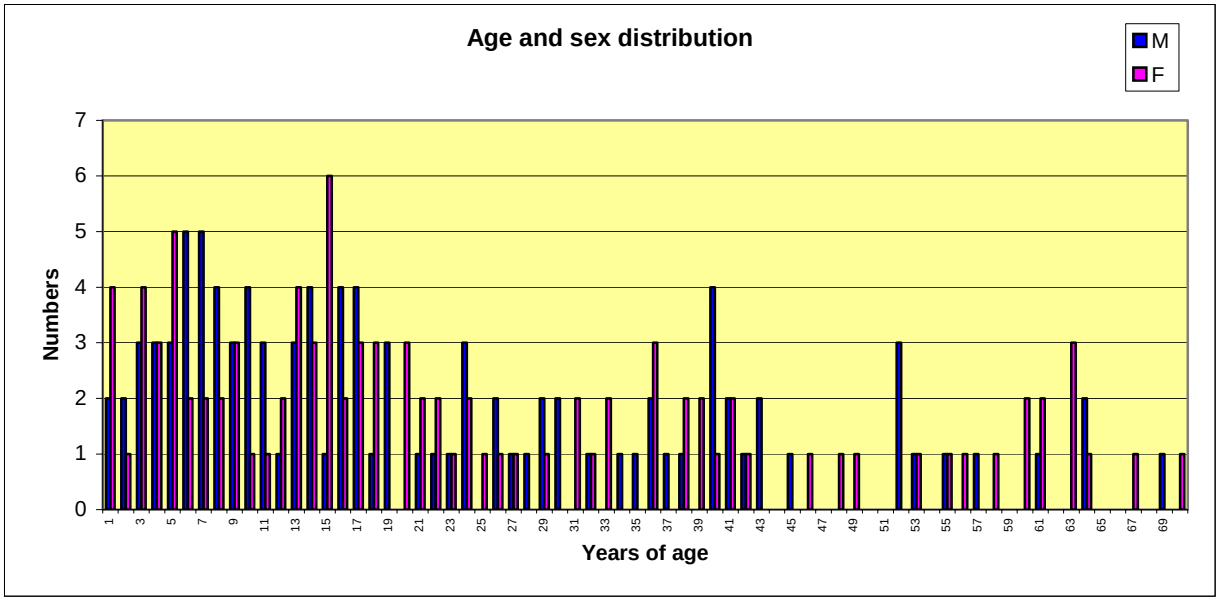
3.2 People – age and sex distribution

The people of the Marshall Islands are Micronesian, with influences from their colonial past of European and Japanese ethnicity. The total population at the last census, 1999, was 50,840. The population of Namdrik is quite homogeneous, and according the Local Government Council (LGC) members is relatively stable. There is a small number of in-married Kiribatis. The LGC has no office facility on the atoll, and does not maintain any records or statistics. The last authoritative information on population characteristics is therefore the 1999 Census, according to which the atoll's population was 772 in 118 households. The male/female split and age distributions are not specified by atoll.

Key informants in the LGC, and the medical assistant on the island believe that population is growing slightly from natural increase exceeding out migration. Last year, the medical assistant reports there were about ten births, and three deaths. It is believed locally that the island now has a slight majority of females. Other studies of the Outer Islands report a tendency for the age pyramid to narrow in the economically active age brackets, resulting in a high dependency ratio where grandparents sometimes care for children whose parents have left in quest of employment opportunities. This is said not to be the case on Namdrik, where officials say that there are few old people, and if parents leave, they generally take their children with them from Namdrik.

A survey of 31 households was undertaken. Thirteen men and eighteen women responded. The average household size was 6.3, a little smaller but within range of the 1999 census result of 6.5. Though Marshallese society is matrilineal, households are generally male-headed. Five in the sample were female-headed. Joint and extended families are quite common; about half the households are home to three generations, and/or collateral kin.

The age/sex distribution of people normally resident in the 31 households surveyed is tabulated below. It covers 191 of the 197 persons included in the household surveys. Some ages were not known. In a few cases of pre-school children the team member guessed the age, where they could see the children and the informant was not sure of their birthday.



Data source: Household survey, Namdrik, July 2005

The sample covers around 27% of the total population. Informants stated that migration does not cause a significant narrowing in the age pyramid in the economically active population. The survey sample generally confirms this, as well as the assertion that there are not many elderly people.

3.3 Social structure, institutions, levels of authority and respect

Local governments are formed under the provisions of the Local Government Act, though like the other 23 local government bodies, the exact structure of the Local Government Council (LGC) on Namdrik is determined to some extent locally, and reflects and accommodates traditional structures. The Council comprises an elected Mayor, three *Alap* and twelve elected Council members. All men and women of eighteen years and over are eligible to vote.

In Namdrik, the *Iroij* (supreme Chief) has an automatic place on the Council, though until the last elections, this position was not taken up. At present it is held by a woman. Three Council positions are reserved to *Alap*, holders of rights to land use granted traditionally, and for practical purposes inalienable, by the *Iroij*. The *Alap*, of whom there are currently about sixty, elect their peers to these positions. The remaining twelve positions are determined by popular vote. On the current Council, one of these positions is held by a popularly elected *Alap*, and the remaining eleven positions are held by *Rijerbal*, commoners or workers. The Council elects a Cabinet of five, responsible for the portfolios of finance, health, education, public order and transport. At present all incumbents are of the chiefly class. Neither the mayor nor the traditional leaders are resident on the atoll. There is still considerable respect for the traditional leaders, and the population does not openly question their authority or rights. The Local Government Council is politically conservative, though the Senator for Namdrik is from the United Democratic Party.

Traditional organisational structures are further discussed in the context of access to and control of assets.

Protestant, Assembly of God and Catholic churches serve the population. Not all churches have resident ordained ministers on the island at all times, but numerous respected community members are deacons or celebrants, and conduct generally well attended Sunday services. The churches own halls that serve as local meeting venues; there are no traditional community meeting houses like the Kiribati *maneaba* or the Maori *marae*.

Two policemen serve the island, but it is a basically peaceable population, and their main work is investigation of minor crimes of dishonesty, principally youth stealing the ubiquitous but well recognised and vehemently claimed chickens, often expropriated as a high-spirited dare. However, MEC has urged community members alleging theft of electricity revenue to take their complaints to the police. Significantly, no-one has followed through with this so far.

3.4 Physical, commercial, social and cultural infrastructure

Public physical infrastructure on the island is minimal. There is a grassed airstrip, adequate for the needs of the weekly Air Marshall Islands 19-seater Dornier 228 service. A small terminal building is due to be opened. An unsealed road, maintained by a store owner as quid pro quo for the right to borrow the island's single motor vehicle, a 5 ton Daihatsu truck granted to the LGC, connects the airstrip to the far end of the main land area. Local people do not know the exact length of road, as the speedometer on the truck has broken, but it measures eight kilometres by GPS. Shipping is erratic; typically Government field trip ships arrive four times a year. There is no harbour or wharfage; sea freight is loaded and unloaded by canoes and small boats. There is no public water supply or sanitation on the island. There is presently no evidence of the street lights that were installed under the original 1996 French funded solar home system programme.

Communication is by way of seven HF radio sets, held at the dispensary, one at a shop, one with the Local Government Council. Post operates via the weekly air service, but there is no collection or distribution service on the island. Mails are taken out and delivered by safe hand – friends or neighbours who are travelling between Majuro and Namdrik.

Two shops currently serve the basic needs of the islanders for consumer items such as rice, flour, sugar, canned foods, lighters and matches, cigarettes, candies and kerosene. The shops carry very little by way of clothing, footwear, household or workshop hardware. At the time the team was in the field, both shops had run out of kerosene and footwear. A third shop is due to open soon. MEC is currently negotiating an agency arrangement with the owner under which he will pay all electricity bills at a discount monthly in advance, and collect cash or kind from consumers at the full value of $12 per consumer.

Pharmaceuticals are supplied by the Majuro-trained Health Assistant from the Dispensary, a Spartan but clean four-room structure with a solar home system, but no other electrical facilities such as a vaccine refrigerator. There is an HF radio telephone at the Dispensary, but the Health Assistant finds it functionally limited, since sometimes it does not work, and as an open channel, does not meet his requirements to communicate patient-confidential information.

The eight-classroom school has 12 teachers, and provides education for 173 students (down from 180 in 2003), 104 boys and 69 girls, from Grades 1 to 8. On the evidence of the household survey, the gender difference in attendance is not due to demographics; in the sample there are 36 boys aged 5-15, and 31 girls. Though boys are much more numerous, they drop out earlier than girls. Only the staff room is solar electrified, and the Principal has a cassette player that is used for enrichment of the school curriculum through audio media; the last period on Fridays is devoted to playing music and watching video material in the office.

3.5 Economy, assets, ownership and control, occupations, incomes

Namdrik has relatively rich land and marine assets. Its lagoon has been identified as highly suitable for natural raising of pearl oysters, and some work has been undertaken to seed these. Initial attempts met with limited success, and maturation takes up to fifteen years, so it will be some time before this initiative bears fruit. Access to marine resources is free to all, though by convenience, convention and out of courtesy people tend to take lagoon species such as sea snails close to their habitation. The lagoon supports an abundance of edible reef fish, gathered by casting nets from which undesirable by-catch is thrown back. Namdrik residents take canoes and small boats beyond the reef to line-fish for high value tuna, but the market is limited to other residents by lack of cold storage and transport.

Situated in the wetter western Ralik chain of the Marshalls, Namdrik is lusher than the drier islands of the Ratak atolls, and its relatively rich humus supports a greater diversity of land-based plant and animal species. Around the inhabited areas, people generally gather plant waste into heaps that are left to compost under trees. No-one can recall any soil analysis having been performed.

Coconut palms predominate amongst the economically exploited species in the vegetated areas that ring the lagoon. They grow in a loosely controlled wilderness, sharing space with breadfruit, bananas and pandanus with an understorey of lianas and ground cover plants that yield medicines and herbal treatments. Few people cultivate home gardens, but some families have bananas, lime trees, taro pits and pumpkin patches close to their homesteads, and some have decorative hibiscus, frangipani, croton or ginger plant near their homes. *Noni* has also been successfully introduced, and is used locally as a medicinal drink. Namdrik bananas have the reputation of being the best in the country, and are frequently sent back to relatives in Majuro, but their

viability as a commercial crop is compromised by perishability and poor transport. The two varieties of pandanus are important, one as a food crop, and the other for handicrafts. Namdrik mats also enjoy a reputation for fine quality, and have a steady market on Majuro.

At 721 per square mile at the 1999 census, population densities are the highest of the far Outer Islands, where lowest is Wotho at 87 per square mile, and the mean is 373. Cultivable land has long been divided into *weto*, plots over which the *Iroij* (paramount chief) granted customary usufruct to the *Alap* (lineage heads), who organise copra production. This feature of social organisation dates back to the commencement of commodity trading in copra with European buyers, interposing the new role of *Alap* between chiefs and commoners specifically to manage copra production, which is now central to social and economic relations of production in Marshallese society.

There are some 100 *weto* in Namdrik. Though these parcels of land are not formally titled, they are for practical purposes inalienable and unalterable; the *Iroij* in lore and living memory have never resumed land or altered boundaries. The *Alap* who have the right to manage these plots are female heads of lineages. Usually the female *Alap* will assign responsibility for oversight of the *weto* to close male kin, such as a brother or adult son. When she dies, the position of *Alap* passes to the next most senior female in the lineage, in order of succession her younger sister if she has one, her daughter, or her niece. Only if there are no female successors does the title descend to a male. Her sons and male collateral kin are designated as *Rijerbal*, workers, whose job it is to collect the coconuts, husk them, and bring them to the homestead for the communal task of splitting the nuts, scooping out the flesh and setting it to dry. This stratification is less hierarchical than it might appear. Ideologically, *Rijerbal* are not inferiors or slaves; the system refers less to social ordination than to division of lineage labour that reinforces the cultural norm that women should not be responsible for heavy work. However, the main political parties in the Marshalls, and in Namdrik are drawn essentially along chief/commoner lines.

Each *Alap* delivers a small proportion, 0.2% of the production to the *Iroij* in return for the right to use the *weto.* Lineage numbers change with the chances of reproductive success, but it is rare for a member of a numerous lineage to seek to exploit the rights of a less numerous or absentee lineage to take coconuts from their land. This results in some families of numerous lineages have gathering rights limited to perhaps only three months of the year, after which a collateral line of the family assumes gathering rights.

Unlike some other Pacific cultures, the Marshallese do not have public lineage gathering places. Instead, meetings between *Iroij* and *Alap,* or *Alap* and *Rijerbal* usually take place in some shady clearing near the home of the social superior. Though there are conceptually twelve different categories of land in traditional society, the copra economy has broken this down on Namdrik, and all land is conceptually *weto* under the management of an *alap.* There is no public land that is differently named, used or conceptualised. This has important implications for location of public infrastructure.

4 Energy issues and options

In the preceding projects, the selection of technology was made before energy demands or resources were considered. In this section, other options will be discussed with reference to Namdrik that might inform a future Outer Islands electrification programme.

Copra oil is a natural resource widely available in the Pacific islands and elsewhere. Made by the milling and pressing of Copra (dried coconut flesh), it yields around 55% oil and the balance of copra cake, a by-product with a commercial value in its own right and suitable as an animal feed in outer atoll agribusinesses.

There are numerous ways to replace diesel by CNO or CNO derived products. Essentially, there are four options:

- Use of straight oil
- Use of diesel/CNO blends
- Chemical adaptation of CNO (Esterification into “Biodiesel”)
- Use of biodiesel/diesel blends

The first two options require the production of water free oil that is filtered to 5-micron mesh or better. The smaller the filter the better the fuel quality. As CNO and other vegetable oils readily mix with diesel filtered, water free CNO can be either used straight (neat) or in blends with diesel1. Numerous studies and tests involving the use of un-modified vegetable oils (including CNO) have been conducted since the early 1980s. From the considerable body of relevant scientific literature it must be concluded that while short-term operation of diesel engines on vegetable oils or vegetable oil/diesel fuel is possible, long-term use of vegetable oils in unmodified, standard engines results in operational problems, reduced engine life, increased maintenance, and possibly in catastrophic engine failure. There are a large number of parameters that influence performance and durability of engines fuelled by CNO. Engine type, speed, injection method, engine age, ambient temperature and loading all influence tolerance towards CNO. It is safe to assume that the characteristics of vegetable oils including CNO differ substantially from diesel oil and as a consequence the use of CNO will result in additional operation and maintenance cost2. The Marshall Islands is advantaged in respect of its high ambient temperatures, generally believed to always high enough to keep CNO liquid enough to use as a fuel (not lower than 22 deg C.)

4.1 Energy Resources – CNO

Review and assess the technical viability of CNO use

[1] CNO solidifies at around 25 C, and the use of neat CNO in Kiribati is only possible because of the high ambient temperatures that occur all year.
[2] The viscosity of CNO is approximately 10 times greater than that of diesel. The high viscosity with resulting poor atomisation prior to combustion is a major cause of engine problems such as nozzle coking and piston ring deposits

This section will not investigate the technical viability of using coconut oil (CNO) as a fuel, as this has been generally proven to be possible. It is however clear that there are operational and maintenance issues to be considered with the use of CNO as a fuel, and additional field testing is required before CNO can be put into a community setting with confidence. Majuro based copra oil processing company Tobolar are to be commended in their willingness to invest in research and Development of CNO as an atoll based fuel source. They have pointed out the need for additional input to additional R&D on the field use of the type and design of generators and community scale copra oil processing equipment such as the type they have purchased recently, shown below. It is also noted that Tobolar have operated two unmodified, factory standard 5 ton delivery trucks on pure un-esterified coconut oil filtered to 10 microns (now 1 micron) for the last 3 years and have not reported adverse mechanical effects or noted discernable efficiency changes. Tobolar have also indicated a willingness to share data on the technical and financial viability of the mini mill but this data is not available at the time of writing this report.

Additionally Tobolar are now ceasing exports of coconut oil, and report that the last export shipment went to Procter and Gamble in September 2005. From that point forward, Tobolar report that all oil will be used for domestic energy production. Government policy now requires that all government vehicles use CNO as a fuel.

So, the use of coconut oil as an atoll based fuel resource is assumed to be technically possible for the purposes of this study.

The team undertook studies of 5 separate weto on Namdrik to ascertain the present volume of copra production and potential for a) increasing production volumes, and b) ascertain if sufficient copra oil can be produced on the atoll to operate a generator to meet community needs.

Plot / Weto	**1**	**2**	**3**	**4**	**5**	**Av.**
Ha	6.2	6.3	2.2	4.0	9.9	5.7
Copra 3 months short tons	4.5	3.0	1.0	2.0	5.0	3.1
Total Metric tons per year	16.3	10.9	3.6	7.3	18.1	11.2
Metric tons copra per Ha pa	2.63	1.73	1.65	1.81	1.83	1.9
Metric tons copra oil per Ha pa	*1.50*	*0.98*	*0.94*	*1.03*	*1.04*	1.1
Income from this weto pa	$ 4,320	$ 2,880	$ 960	$1,920	$ 4,800	

** Weto #5 is located on the island to the west of Namdrik and is locally regarded as a good area for growing coconut with a high percentage of Marshalese coconut variety.*

Assuming the delivery of a 200 watt peak load to each of the 120 connection points on Namdrik via a centralised CNO generation plant, a total hypothetical load of 24 kW is presumed. Allowing 0.33 litres of CNO per kWhr produced, operating this genset for 6 hours per day will produce 144 kWhrs per day and consume approximately 47 litres (42 kg at 1.0 litres to 0.9091 kg) of CNO. Over a year, the total fuel consumption for this type of installation can be seen to be 17,100 litres (or 15.5 metric tons) of CNO per year.

Namdrik atoll has produced approximately 130 metric tons of copra per year, averaged over the last 5 years. At a recovery rate of 55%, this will yield around 71 metric tons of CNO. This considerably exceeds what is required to operate a centralised system using the hypothetical parameters suggested above.

Financially, this model must be evaluated in terms of its impact on the atoll community. Presently the solar home system model on Namdrik has the impact of creating a net negative cash movement out of the community of around $1,000 per month. This is the $12 per connection x total connections and then subtracting MEC staff salary, which is funds flowing into the community.

The CNO generation concept will see little cash moving from Namdrik to Majuro other than parts and technical support, and will directly reward community members for the copra that is used for fuel, and at the same rate that they would otherwise receive from Tobolar.

Effective per kWhr tariff for Namdrik Solar Home Systems

Array output	80	Watts
Average solar hours per day	6	hours
Estimated gross kWhr available per month	14.4	kWhrs
Monthly bill	$ 12.00	
Effective per kWhr charge	$ 0.83	

While this calculation is approximate and ignores efficiency losses etc, it nevertheless demonstrates the very high price of power produced by solar home systems when compared against more traditional sources of electricity production. Needless to say, solar home systems are better compared to kerosene lamps in terms of cost and the effective delivery of light, however experience shows that most homes equipped with solar home systems rapidly progress to using the electricity for other appliances, and at around 80 cents per kWhr, this is expensive.

Using the following assumptions, the financial viability of using solar home systems was compared with centralised diesel generation with a buried cable distribution line, centralised CNO generation with a buried cable distribution line and lastly decentralised CNO generation using 1 kW AC generation plant on a household basis.

Assumptions are:

- There is a 100% recovery of revenues from consumers
- That CNO generation is technically feasible with a 5 year replacement cycle on generation components
- That all scenarios offer approximately the same quantity of power per day

For the Namdrik situation, centralised CNO generation with a buried distribution line appears the most financially most attractive with an IRR of 3.3% and a NPV of USD 158,819

Solar home systems have the second most attractive financial status with an IRR of -0.4% and a NPV of USD -28,930

Centralised diesel generation appears not feasible. While the capital costs are very similar to centralised CNO generation plant, the high fuel costs on the atoll make this an unattractive option with a NPV of USD -229,919

Decentralised CNO generators operating on a domestic scale have also been modelled. Based on an estimated price of USD 1,000 for a Chinese made 1kw VAC Diesel/CNO genset from Tobolar, The financials are slightly better than for solar home systems, but allow users to connect larger AC loads as required. Households would also take responsibility for their own fuel consumption and would obtain CNO from an atoll based processing facility on a copra in-oil out basis. Allowing for a US$ 1,000 capital cost, and US$700 to rebuild the engine every 5 years, the project would provide an IRR of 0.33% and a NPV of US$ 9,554.

Copies of these calculation tables are provided in annex.

It can be seen that with the assumptions made, none of the scenarios trialled are financially robust, however it can be seen that the use of solar home systems can be challenged on financial grounds, in addition to the issues of service and user satisfaction as discussed earlier. Namdrik is somewhat unique in that it features tight clusters of households that may not be found in other atoll communities, but it does illustrate that solar home systems ought not to be taken as the optimal solution unquestioned. Donor agencies may need to approach the issue of electrification without a technology solution already pre-concluded and remain open to different technologies, or most likely for atoll communities, a mix of technologies being applied to service both the low demand requirements and higher demand AC power demands of all communities.

Preliminary design for a CNO generation plant.

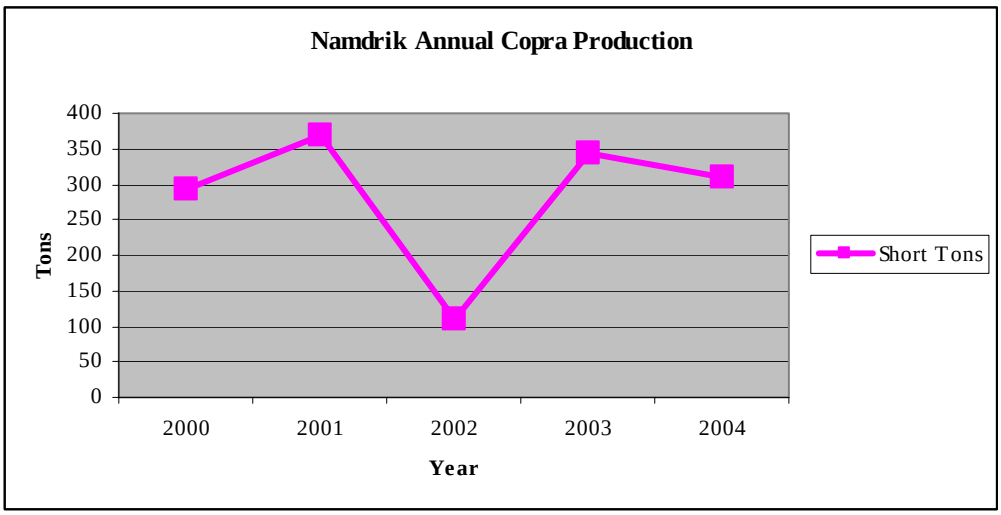
The deployment of small CNO based generation plants in outer atolls is technically feasible and financially viable, based on present costs and assumptions of mechanical sustainability. It is compatible for power generation either as a standalone generation resource, or as part of a hybrid power system. It is recommended that power planning for future outer atoll projects consider the use of centralised CNO plant for atolls where clusters of households allow buried, metered distribution systems.

The capital cost for centralised CNO generation systems is lower than for solar home systems, in the Namdrik situation. It is accepted that this may not be the case in other atolls, and a mix of SHS and CNO technologies may be necessary to adequately meet consumer needs.

The copra grinder, cooker and press, produce raw oil to be placed firstly into the settling tank to remove most water and particulate matter, and then into the filter, above. Oil is then able to used in a standard generation set, as this 30 kW Chinese made set below, running on pure CNO.

Additional data on the performance of the copra mini mill has been requested from Tobolar and will be reported on in the final report.

Copra production on Namdrik has varied significantly over the last 5 years, as shown in the graph below:



Local residents, and Tobolar staff recall that during the Japanese occupation Copra production was at one time up to 9 times higher than present production rates, leading to the conclusion that there is considerable potential for copra production to be dramatically increased should a viable market for copra be identified, or created through changes in end use applications for CNO, including fuel or other high value products suitable for manufacture and export from the atolls.

It is not the intention of this report to provide an analysis of world CNO prices or future trends, but certainly prices have declined consistently for many years and in a number of countries the copra industry itself is nearly defunct – a victim of low returns for high labour inputs. Recent surges in the international price for oil, and subsequent increases in diesel and petrol, particularly in the remote islands and atolls, means that the use of copra as an energy resource is rapidly gaining merit and may result in a renewed look at the rehabilitation of copra plantations.

4.2 Local Management

Local management appears efficient within the limitations imposed by the on-atoll role and responsibilities of MEC, and the shortage of spare parts.

Surveys of the community have found that in general most households are happy with the payment mechanism presently in place, this being the payment of monthly accounts directly to the MEC office on Namdrik.

Likewise the delicate issue of disconnection appears to be handled well and improvements to the system are not immediately apparent. Misconception within the community over exactly who has the authority and responsibility for disconnections has placed unnecessary stress on the MEC technician. The decision to disconnect resides in Majuro and it would be advantageous for the community to be well informed of this to deflect any feelings of responsibility away from the local staff.

The other strategic option presently under discussion is allowing households to pay the monthly bill in copra, rather than cash. The results of how this mechanism works in future, if trialled on Namdrik, may have application on other outer atoll projects.

Training requirements

The MEC technician has undertaken training on site and is familiar with the tasks related to the day to day maintenance and identification of problems with individual systems. There is interest in progressing further with this training and with other atolls likely to utilise solar technologies in the future it appears that scope exists for some form of Master Trainer role.

Payment mechanisms

Surveys of the community have found that in general most households are happy with the payment mechanism presently in place, this being the payment of monthly accounts directly to the MEC office on Namdrik. (This is covered more fully under Impacts)

Likewise the delicate issue of disconnection appears to be handled well and improvements to the system are not immediately apparent. Misconception within the community over exactly who has the authority and responsibility for disconnections has placed unnecessary stress on the MEC technician. The decision to disconnect resides in Majuro and it would be advantageous for the community to be well informed of this to deflect any feelings of responsibility away from the local staff.
The other strategic option presently under discussion is allowing households to pay the monthly bill in copra, rather than cash. The results of how this mechanism works in future, if trialled on Namdrik, may have application on other outer atoll projects.

4.3 Ability to Pay

The question of non-payment on Namdrik threatens the viability of the project, and casts a shadow of doubt on the future programme, if there are insoluble problems with willingness and ability to pay. The team therefore took pains to understand what underlies this difficulty. It appears desirable to handle default with the co-operation of a local electrification committee. This would enable a local body to try to assist defaulters, and would remove the misplaced odium from the MEC operator.

Preparatory work was undertaken to determine ability to pay in the ADB's 1996 study, which concluded, based on expenditure on surrogates, that a monthly fee of $8 would be viable for the consumer, and with a critical mass of consumers, for a private sector utility. In the recently completed household survey, this aligns with the general rule that rural dwellers can spend about 5% of their income on energy. However, historically, the payments made for surrogates on Namdrik tended to be smaller and more regular, and therefore more acceptable and easier to manage than a single large monthly bill. This is discussed in the sections below. A discussion of willingness to pay follows the findings on impacts of the programme, since these are related.

4.3.1 Poverty in Namdrik

Pacific poverty has a character of its own, and is not generally distinguished by the hunger and disease of poverty elsewhere in the developing world. On Namdrik people found it hard to characterise. Indeed number concepts in general are of little relevance; for example, the team found that the LGC does not maintain any statistical records, and has no information even on the number of residents or households beyond the 1999 census.

People did not know the area of land of their *weto*, understandable since this is largely out of individual control. They did not know the number of trees on the land they

exploit, could not answer exactly how many bags of copra they produced in the last year or for the last field trip, knew only approximately what they spend on daily necessities, and in many cases could not remember the ages of their parents or siblings, their older children, or the last grade they had completed at school.

This is partly due to the relative irrelevance of enumerating things in a semi-subsistence society, which renders income groups difficult to distinguish. Most households believed that they produced from forty to sixty percent of their food, but answering this question took a good deal of probing, and also varies with circumstance; if there is no cash, people eat freely available local foods that they cultivate or gather, otherwise they will buy food.

It had been the intention to request the Local Government Council to divide households into upper, average and low income groups from which equal numbers would be selected at random for household survey. However, LGC members were unable to state even what would be a high and a low cash income on the island. It was clear from the discussion arising from our question that incomes other than a salary component are highly variable responsive to demands for cash, and the receipt of cash payments often dependent upon a number of circumstances beyond the control of the householder.
The MEC technician distinguished consumers who pay regularly without fail, those who are generally regular, and those who are generally in arrears or default, and these categories were used as a basis for random selection of a sample of some thirty per cent of households. As a cross-check, the team selected as a readily identifiable surrogate for wealth the ownership of an inverter, a piece of equipment that people must buy themselves at a cost between $75 and $200 depending on its capacity, and which presupposes that they intend to buy AC electrical equipment, itself an indicator of liquidity or creditworthiness. Eighty per cent of households have an inverter.

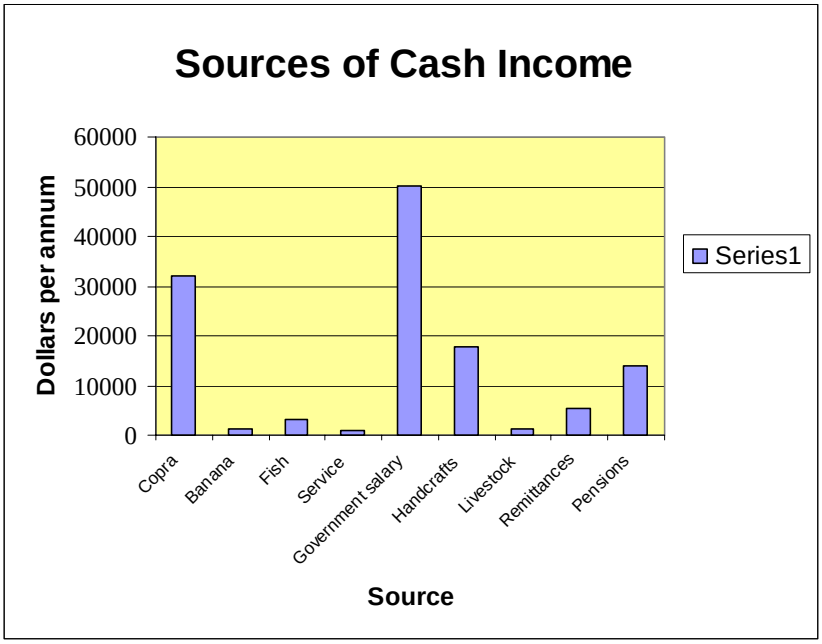
4.3.2 Survey results

The resultant survey of thirty-one households showed a quite weak correlation between the payment categories and wealth ranking, though there were no customarily poor payers in the top six cash income earners. Two respondents in the top ten earners do not have an inverter, while only two in the bottom ten do possess one. By the same token, there were only two customarily poor payers in the bottom six cash income earners. We shall return to this point, since in itself it indicates that ability may be less of an issue than willingness to pay.

4.3.3 Cash Incomes

Household cash incomes reported range from $577 to $21,702 per annum. The range per capita was $65 to $3,100 with an average of $660. This is influenced by the top four incomes. The fifth highest cash income is only one quarter of the fourth highest. The median in the sample is $478 per person. This is credible, compared with the 1999 census figure of $480 when copra prices were higher. Sources of cash income were

copra, fish, bananas, livestock, boat hire services, handicrafts, salaries, pensions and remittances. The relative contributions from these sources in the surveyed households is tabulated below. High cash incomes are strongly associated with salaries and pensions, sometimes two in one household.



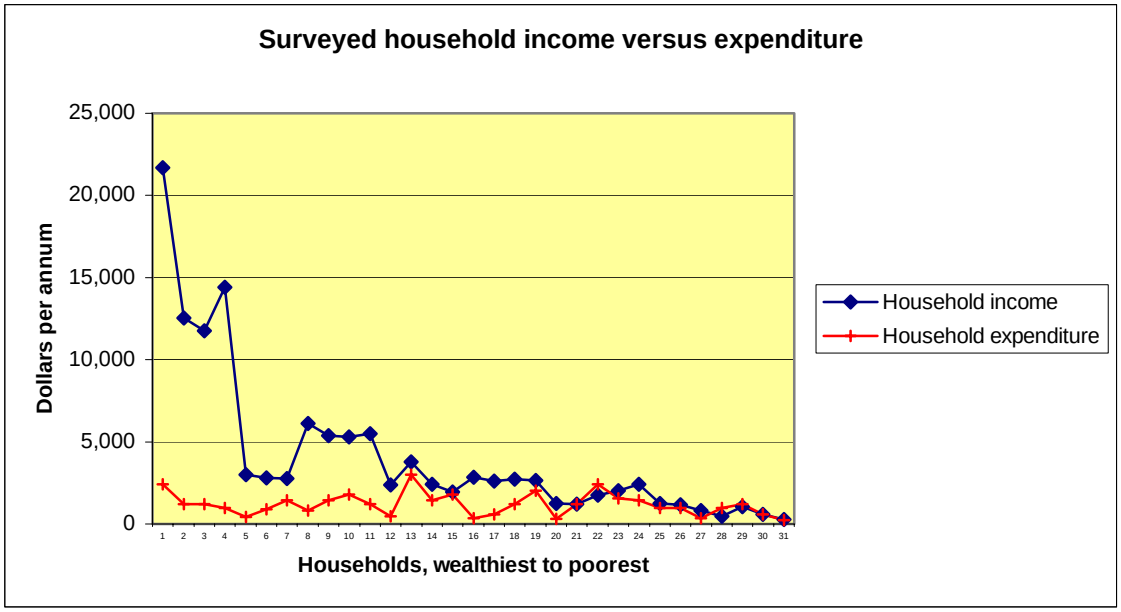
Data source: household surveys, Namdrik, July 2005

Notable is the relatively small contribution from copra, once the wealth of the islands, but in a four decade decline from around an adjusted 48 cents per pound in the mid 1960s to 12 cents per pound at present day prices, of which half is subsidy. In the mid 1970s, adjusted per capita copra incomes were at a high of $500; in the sample the highest per capita income from copra was $733, the second highest $411, and the median $142. Copra contributes one quarter of the total annual income of the surveyed households, while handcrafts represent 14% and government salaries together with pensions almost 51%. It has been estimated (Hart 2004) that it takes 19 person hours to produce a 100 lb bag of copra that fetches $12. On Namdrik, it may take a little longer if the *weto* is far distant. Women say it takes three or four days working about three hours a day, a total of about twelve person hours to produce a mat that they can sell at $50. Potentially productive resources such as fruit, fish and livestock make a very minor contribution to cash incomes.

In the household surveys, there is a correlation between diversification of livelihoods and higher incomes. There is no such thing as full time employment; even salary earners generally have other economic activities, and copra-making has never been a viable full-time occupation. Though the official statistics record the unemployment rate on Namdrik at 14.6% in 1999, every household member over the age of about ten contributes in some way to economic activities, all members preparing copra, boys catching or cleaning fish, girls starting to produce handicrafts. The eleven top income households have more than one, and up to two sources of cash income per household

member. With two exceptions, the bottom eleven have the same or fewer livelihoods strategies as members. Though availability of household labour is important in livelihoods, relative wealth is not related to family size; there are small richer families and large poorer families. Rather, households with a high percentage of dependents - small children or older people - and relatively poor access to coconut and other resources have the lowest incomes.

Comparing annualised stated expenditure on essentials at the local shops with annual incomes as given in the surveys shows that the lower the income, in general the higher the stated expenditure on essentials as a percentage of income. The graph of this relationship below shows that five respondents report expenditure as higher than income. This is explained in part by remittance income in cash, and partly probably by the general vagueness of respondents about numbers in any application, but the trend indicates the hand-to-mouth nature of earning and expenditure for those families on lower incomes.



Data source: Household surveys, Namdrik, July 2005

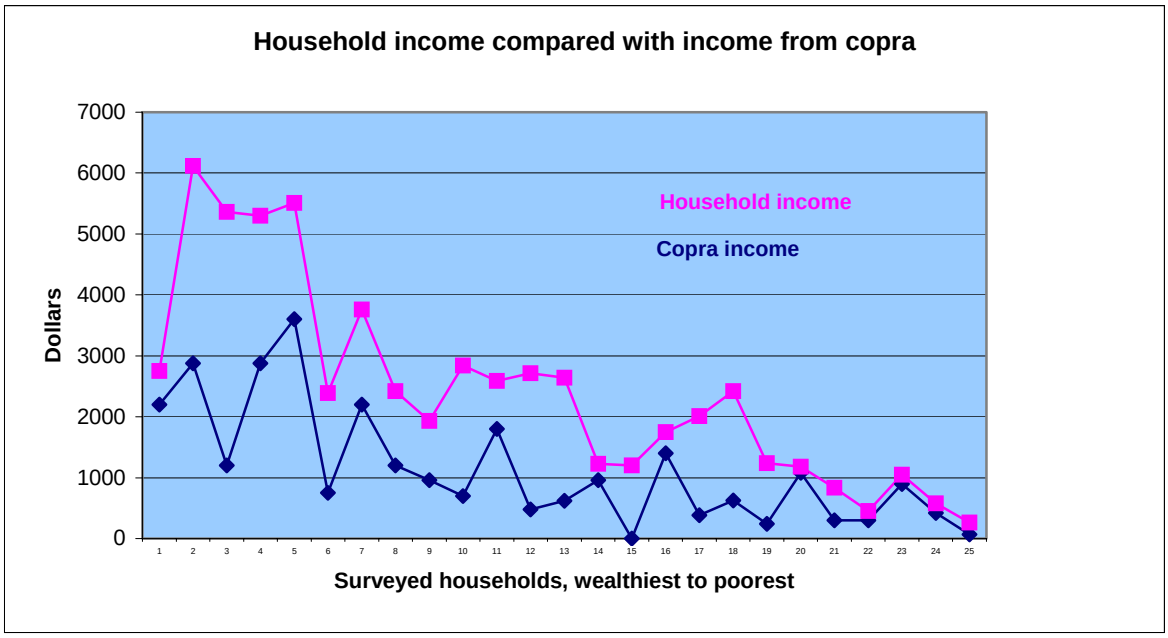
This annualised picture distorts the realities of cash flow that further complicate livelihoods. Producers have three options to sell their copra:

- Sell direct to the agent when a field trip or other ship comes at $12 per 100 lb bag. Most bags in fact weigh around 120 lbs, and the payment is adjusted according to weight when the ship comes
- Sell to the Copra Co-operative at $11 per 100 lb bag, or price adjusted according to weight. The Copra Co-op sells to the agent, using the extra dollar to offset losses in weight and quality that occur when field trips are delayed, and to pay workers to ferry the copra out to the ship, which cannot cross the reef.
- When the Copra Co-op has run out of funds, sell to one of the local stores for $10 per 100 lb bag, pro-rated by weight. The stores then on-sell the copra, and do not charge interest. Mark-ups on basics such as gasoline, flour, rice, sugar,

canned tuna and beef vary from 20% to 65% as compared with Majuro prices at the time of the survey. There is a proposal for a third store to open on the island, and to operate as agent for MEC, paying all dues a month in advance at the rate of $10, and recovering the cost in cash or kind to on-sell. This arrangement would have the benefit of reliability and simplicity for MEC, but could hypothetically be subject to abuse. If for example the store owner used uncalibrated scales, abused a position of power to extort goods of higher value than the electricity bill, or demanded other favours as the price of assistance. This risk is small, and at present is controlled by the fact that there are alternatives.

The copra producer pays 0.2% to the *Iroij* or *Leroj* via the *Alap,* and 2% tax to the Local Government Council.

Clearly it is in the interests of the producer to maximise returns by preparing the copra as close as possible to the time of a field visit, and selling direct to the agent. However, sometimes the agent has already run out of cash. In this event, producers, the Co-op and the storekeepers may be waiting around six months from the time of copra production to receive their cash when the next field trip comes. At such times there is a general scarcity of cash on the atoll. This puts in context the ire of the LGC at cash leaving the atoll in payment of electricity bills. The table below shows copra income in relation to household income of the surveyed households. It indicates that for the poorest twenty per cent, there is high level of dependency on income from copra; almost all the household income comes from this source.



Data source: Household surveys on Namdrik, July 2005

It is clear that the narrower the gap between the lines, the greater the dependency on copra, and the higher the susceptability to cash-flow crisis, severe at the poorest end of

the lines. This demonstrates the need for a variety of economic coping mechanisms. Many of the livelihoods options suffer the same tyranny of distance as copra, though handicrafts, being lighter and higher value, are often transported by air and are therefore more readily convertible to cash. The market for fish, livestock and most vegetables is effectively confined to the atoll, and these items command decent but not high prices when sold to neighbours who may however suffer the same cash flow embarrassment as the vendor. So though alternatives are available, and people are not poor in the conventional sense, they may face real difficulties in participating in the cash economy. There are no banking or formal savings and credit facilities. People resort to the common strategy of using pigs as a form of rural bank. All bar three households interviewed keep pigs, with an average of 5.6 per household. One of the poorest households with limited income from copra has eighteen pigs. The animals are sometimes the cause of disputes when they root in neighbours' gardens, and there is an Ordinance requiring them to be penned. Unfortunately the pigs on the atoll are completely illiterate, and forage at will, restrained only when being fattened prior to slaughter. Pork fetches $1.50 per lb on the local market, while fish can be sold for $2 for a large fillet. There is no regular provision for transport of live animals to Majuro, and no chilled shipping facility.

Asked what makes people poor, responses were that people were poorer who have *weto* shared by numerous families, or have an adverse ratio of productive to non-productive household members, as may be the case of families with numerous young children. Otherwise, people may be poor if they have few relatives to perform as their *rijerbal*, or who are simply not very active. The health assistant states that there are no unsupported very elderly residents, and no disabled people on the island. A teacher stated that although a majority may graduate from eighth grade, levels of attainment are low, and ability to save and manage cash is not strong. He believes that anyone on the atoll can make money if they are determined. This viewpoint was reinforced by the leader of the largest religious group.

4.4 Impacts of electrification

There is limited baseline statistical data with which to compare before and after effects of the solar programmes on Namdrik. Focus groups, key informant interviews and the household survey probed impacts and attitudes to the programme.

4.4.1 Health

Health and education are the GoRMI's highest priorities, and the goal of improvements in these areas is the main justification for Outer Island electrification for lighting. The Key Informants' responses are somewhat discouraging, in view of this goal.

The Health Assistant states that electrification has not had any real impact on health. The Dispensary has just been refurbished, and has a solar installation inadequate for anything except lighting. The electricity bill has hitherto been met by charging patients 25 cents per visit, but in future it has been arranged that MEC may use the Dispensary

HF radio at no cost, and will waive the power bill payment. There is no vaccine refrigerator, steriliser, suction equipment or any other facility that would improve service delivery. Supplies of medications frequently run out between shipments. Human health is closely related to environmental health; the health assistant draws attention to the rats that infest the atoll, and the roaming dogs and pigs that contribute to pollution of the water. There has been only one test of catchment rainwater from Namdrik, and it was found to be contaminated. Acute Respiratory Infection and diarrhoea, including relatively high incidence of bloody diarrhoea, are the most prevalent complaints. Hypertension and diabetes are on the increase. There is no testing for cholesterol levels, but the Health Assistant suspects they are high. Diet is still dominated by starchy foods, rice and breadfruit, supplemented by fish, chicken, and occasionally pork. Aside from the local bananas which are also cooked and used as a starch substitute, there are few fruits, and almost no green vegetables on the atoll. Diet is therefore likely to be vitamin and mineral-deficient, though many adults suffer from over-nutrition in terms of calorie intake. Many people have observably poor dental health.

The midwife finds that better lighting is very helpful for night deliveries, though the solar programme has done nothing to improve hygiene for mothers and babies.

Householders on the other hand believed on the whole that their health had improved. No-one could state why, except some believe there are fewer mosquitoes than with kerosene lamps, but they feel brighter.

4.4.2 Education

Young people on the atoll do not yet exhibit the most serious indications of youth at risk identified in the EPPSO Policy Paper, 2005; teenage pregnancy, substance abuse, suicide, loss of identity and culture, and lack of community and family support, but they share with the national youth profile the tendency to drop out of school early. At present there are occupations for them on the island, though the viability of options is limited by the natural environment, world commodity prices and isolation.

The school principal finds that there has been no improvement in education as a result of the solar project. He is from Namdrik, but was not teaching at the school at the time of the first project. However, in his experience when electrification came to Ailinglaplap, students performed worse in examinations, due, he felt, to the greater distractions in the home. He observes the same trends on Namdrik. The school has a solar system that supplies power only to the staff room, and a VCR that can be used for audio-visual teaching, but this is limited by time and space to schedule sessions for the eight classes, lack of instructional materials and power. There is no television signal, and students watch inappropriate videos at home because their parents do not have the skills and experience to select or evaluate and screen what they watch. Children are quite often absent from classes because they are working on the *weto* or looking after younger siblings and there is generally little value placed on education. Computer and internet access would be likely to turn this around, especially as traditional livelihoods

become less viable. Instructional material delivered at the time of electrification would be valuable.

4.4.3 Economic activities

Solar home systems have not substantially enabled people to diversify their livelihoods. This is a source of frustration to many respondents, since they now have a perception of what is possible if one has electricity, and this vision is still unattainable. Incomes have improved slightly, mainly due to improved quality of light that permits women to work on handicrafts at night. Helping to counter the drop in the copra price, Namdrik handicrafts are prized on Majuro, though the Women's Groups say that sometimes the raw materials are in short supply. Like all other natural resources, they may gather only from their own *weto.* There are two main species of pandanus on the atoll; one valued for fruit, the other for fibre. When they cut a branch of pandanus for fibre, it takes six months to coppice and grow new fronds. Moreover, they are aware of the danger of flooding the Majuro market, and work only for firm orders, negotiated through kin or close friends, so as to maximise the return they themselves receive for their work. A significant proportion of their orders come from expatriates, often for traditional wedding gifts. It is therefore a fallacy to suppose that handicraft has inexhaustible potential for income generation. Other productive uses of power require reasonably substantial AC supply. This is discussed in Section 4.8, Development Priorities.

4.4.4 Social and cultural life

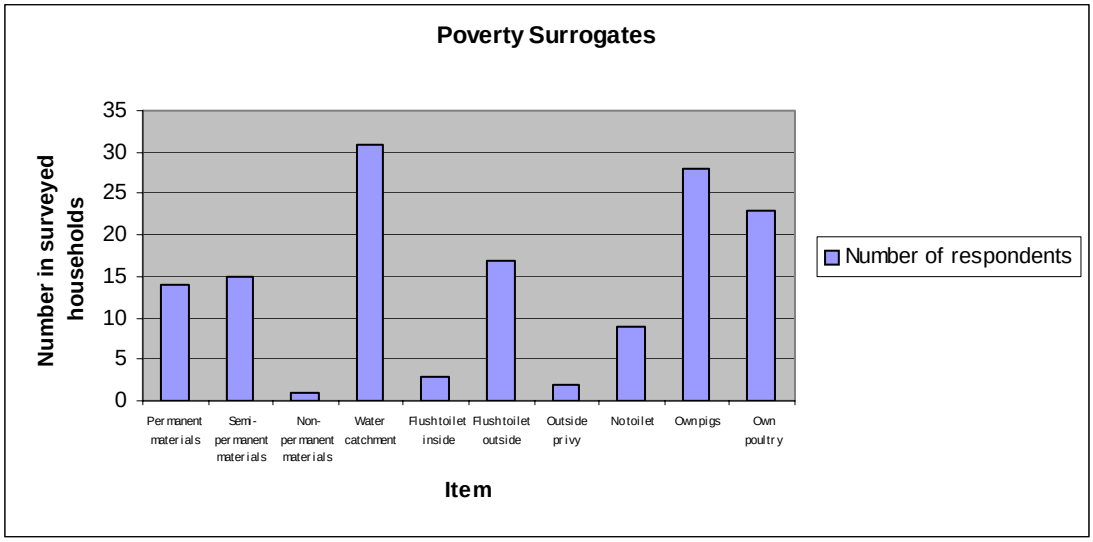
Residents have mixed feelings about the impacts of the solar programme on their social and cultural life. On the one hand, better light at night permits visiting and chatting with friends, sharing a video, reading the Bible or playing games together. On the other, the programme has been divisive because of the issues left over from the original 1996 programme, and there are still suspicions that there is some political skulduggery at play in the funds that were "missing" at the inception of the rehabilitation project, and rumours, unfounded as far as the team could determine, about the timing and targeting of disconnections. In the original project, six larger twelve-panel installations were provided complete with a refrigerator and washing machine intended for public amenity. In the absence of public land or facilities they were placed in the homes of the Chiefs and the then Health Assistant. The Health Assistant has since died, but the system remains with his surviving family, one of whom is a Councillor. Public access never eventuated; the systems were not located in public places. Today, these systems are still deployed, but MEC receives no payment at all for them. They are conspicuous daily irritants to those who smart at this injustice, and were explicitly mentioned by some who stated that they did not see why they should pay their bills, and that social life had deteriorated as a result of the project. On Namdrik, this inequity results from oversight or misjudgement at the time of the rehabilitation project. Resolving the issue will inevitably offend either the beneficiaries or those who are not. It is not a circumstance that should recur with future projects, though care needs to be exercised in project design that leakage or monopoly of project benefits is avoided.

The Principal comments that the children play video-influenced games such as Star Wars and Ninjas at play times, and that some of the content they see is far too adult, but thus far has not noted any loss of confidence in their own culture.

Religious leaders see the solar project as having had a positive effect on social life; people get out and interact with each other, families read the Bible together at night; young people are encouraged to be more active and aware.

4.4.5 The poor

For the reasons mentioned above, it is hard to identify "the poor;" there is apparently no family that is permanently doomed to disadvantaged economic status, though vulnerability is an omnipresent issue. According to the conventional surrogates for poverty, the people of Namdrik are relatively well off. The table below shows distribution of amenities and assets in the surveyed households. Findings from the survey are in line with these indicators in the 1999 census, suggesting that the solar programme has not made any impacts in these areas. Compared with the 1999 indicators, there has been no statistical change in access to water supply or sanitation, or in quality of homes and ownership of assets. This is consonant with the viewpoint of informants that the earlier projects have not really improved their incomes.



In the survey, individual home ownership is the norm. All respondents own their own home, except one who lives in her mother's house. Most houses are quite sturdy, those of permanent construction materials having concrete floors and walls, and galvanised iron roofs. Semi-permanent homes have concrete floor, wooden walls, often plywood, and tin roofs. Only one in the sample was of the traditional thatched roof and walls. The sample was quite representative; there are very few impermanent structures on the atoll, and quite a few permanent structures have been abandoned by departing families.

Water catchments in local parlance are tanks collecting rainwater from the roof. The water cannot be regarded as safe for drinking untreated, but it is relatively convenient, and obviates the necessity common in less developed countries of hauling water long distances.

Disposal of waste of any kind is problematic on coral atolls; even septic tanks are prone to pollute groundwater if any, and to seep into marine water systems. That said, toilets where they exist on the atoll are relatively salubrious and solid, usually with a concrete floor and a water seal toilet flushed with a bucket. Nine in the sample had no toilet. Six of these households are in the poorest ten in the sample; the remainder are in the twelfth to the twenty-second richest. There is thus some correlation between lack of a toilet and economic status.

Poorer households have quite high levels of ownership of domestic animals; the poorest ten households own on average five pigs and ten chickens each. Since livestock are left to forage freely, they are relatively cheap to run. People generally do not collect eggs; instead they allow the hens to brood, and use poultry for meat both for home consumption and for sale. Livestock are thus a useful form of storage of any surpluses, though the market is limited by poor transport to the atoll, and vulnerable to cash shortages as described above.

- *Expenditure on Energy*

The household survey questioned expenditure on batteries and kerosene before and after the solar programme, as surrogates for ability to pay and to compare household expenditure on energy before and after the solar projects. The question was posed two ways, in terms of quantities used, and of money spent. People found it easier to recall quantities than costs.

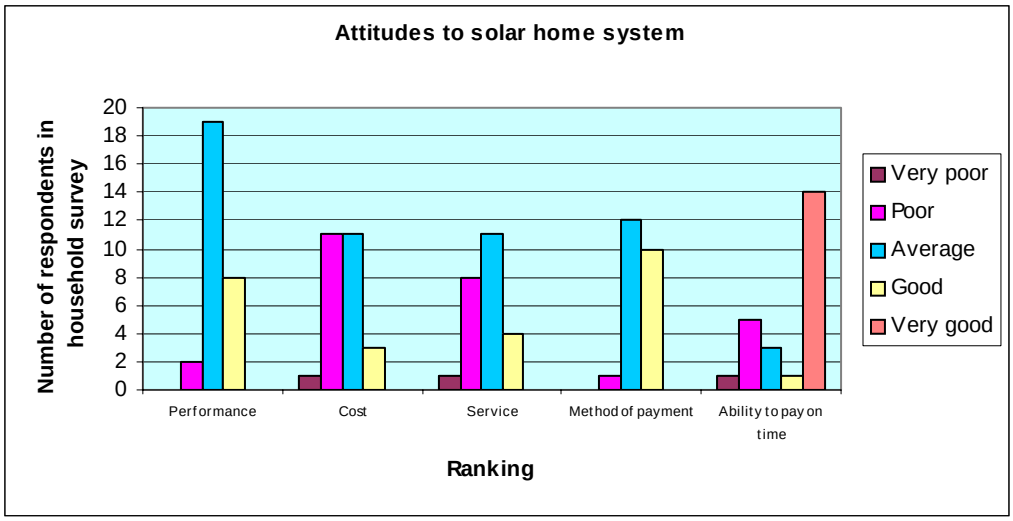
Use of batteries has declined; most respondents who could remember believe that they use half to two thirds the number of D-cells compared with the period before the solar project. On average, respondents reported using 15 D-cells before, against 9.5 per month after the projects. This has obvious favourable environmental impacts in reduction of a pollutant in the fragile terrestrial environment. The cost of batteries has increased; on average D-cell users are spending $9 per month for this requirement. No-one complained about this expenditure. Battery use is however a somewhat weak comparator of before and after effects because much of their use, moving around at night and fishing, is not substituted by a solar home system.

Kerosene use is a more reliable comparator. The passage of time may have rendered recall unreliable, but only 16% reported that they used enough kerosene to have cost more at the then reigning prices than the cost of electricity at the time of the first project in 1996. The cost of kerosene has risen sharply in the interim, with the greatest price hikes experienced since the rehabilitation project. The impacts on the poorer were therefore probably slightly negative in cash terms in the first phase when they paid $8

per month, and considerably more adverse when the monthly bill was raised to $12 in the rehabilitation phase, though very positive in terms of improvements in quality of light and life in general. Disconnected households who are currently using kerosene for lighting are paying on average less than 80% of an electricity bill. There is an obvious sacrifice in light quality.

- *Value for money*

Most informants have the feeling that the solar systems are not good value for money. This is born partly from frustration that they want more power, but if one calculates the effective tariff, they are not wrong to find that it is expensive. Assuming that Namdrik receives six hours of solar radiation per day on average, probably a generous estimate in the rainy Ralik chain, each system generates about 15 kWh of power per month. The effective tariff at a fixed price of $12 per month is thus $0.80 per unit. If consumers were buying their own system at $12 per month, it would take around 25 years to complete the purchase of each unit supplied under the rehabilitation project. This excludes the costs of battery replacement and system maintenance. While this indicates that the charge is realistic, it shows that solar electricity is not a cheap lighting option, especially for the poor in remote areas. The cost per unit on Majuro for lifeline consumption (500 kWhr per month) is $0.11. No-one, including the LGC members, had any recall of the cost of the solar home systems, and it was not well appreciated that the monthly fee is for maintenance and capital replacement; rather, the local assumption seems to be that when the systems decay, yet another donor will come to the rescue. No respondent did the maths to calculate the effective tariff rate, but the perception of poor value for money remains. This should be of concern to GoRMI in terms of its policy of least cost provision of electric light. The graph below shows the responses to the household survey questions directed at determining satisfaction with the solar systems.



The only feature of the systems that attracts a "very good" is the self assessment of almost half the respondents about their ability to pay regularly. Two thirds of the sample rate performance and cost as average at best. Service is also perceived to be poor, though much of this is due to the misconception that MEC is responsible for

replacing light bulbs and burned out holders. This is not a contractual duty, though the technician tries to oblige consumers whose lights fail. There are insufficient replacement bulbs and holders both in Majuro and on the atoll; the local shops do not stock this item. The upshot, whatever the cause, is long delays and unhappy customers.

- *Help for the poor*

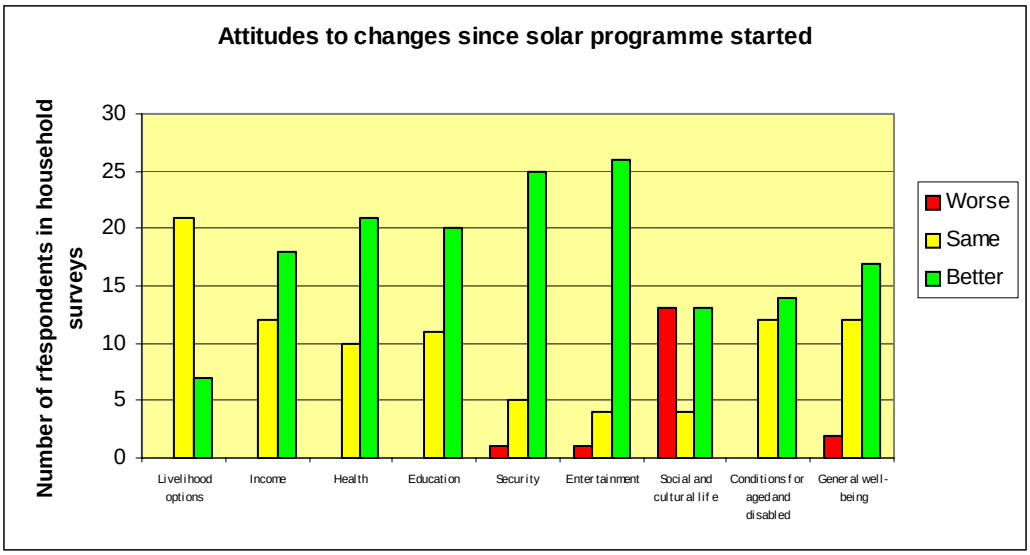
The leader of the largest church on the atoll tries to assist families who find it difficult to pay their bills by helping to find buyers for their handicrafts, or finding labouring work for them that will inject cash into the household. Local Government Council members state that if they are aware of household hardship, they too will try to manoeuvre family members into some form of work. The consensus is that the bill is manageable given assistance to acquire cash. The mechanisms for using copra as currency are discussed above. The proposed agency arrangement relationship between MEC and a new shop owner will create a direct linkage between receipts for copra and bill payment to MEC.

4.4.6 Women

Women are almost invariably the biggest winners from electrification. Better light alone greatly facilitates household chores, and enables women to spread their work load over longer hours; "Now we don't have to rush." The solar programme has lengthened their working day by two or three hours, but they are happy about this. Their ability to work on handicrafts at night has been the only positive economic impact of the solar programme mentioned, limited though it is by the market, transport, and sometimes shortage of raw materials.

4.4.7 Overall Assessment of Impacts

Though consumers are somewhat disgruntled with the solar programme, their overall assessment of its impacts is much more positive. They were asked to rank facets of their lives as worse, the same, or better than before the programme. Improvement in entertainment gained the highest approval rating, followed by improved security. One respondent remarked "Now I can see who is stealing my chickens." As noted above, consumer perceptions about impacts on health and education are more positive than those of the professionals, though householders were generally unable to point to measurable improvements such as reductions in sickness or improvements in examination results. As noted above, there has been limited but welcome impact on livelihood options or incomes, and feelings are mixed about impacts on social and cultural life. The graph below summarises feedback from the household surveys.



Data source: Household surveys, Namdrik, July 2005

For most respondents, the best thing about the programme is improved quality of light. The worst is paying the bill. Many of the reservations expressed relate to frustrated energy demand and development aspirations.

4.5 Willingness to pay

The difficulties with ability to pay the monthly electricity bill were found to be linked to cashflow, and to high levels of household dependency and limited livelihoods strategies. None of these is insuperable, and in fact non-payment is only weakly linked to relative poverty. The evidence suggests that when people strongly desire a material good, they can quite rapidly find a way to pay for it, as noted below in the discussion on energy demand. There are however clearly articulated grounds for unwillingness to pay.

1. First, there is residual resentment that the large systems gifted under the 1996 project were not dismantled, as were the smaller systems, were never made available for the public good as intended, and are now operating at no capital contribution or running cost to the beneficiaries, who are former mayors, and a former Health Assistant's family.
2. It is now known on the atoll that Mejit, the next atoll planned for electrification, will receive 160 Wp systems, twice the capacity of the Namdrik rehabilitated systems, for the same monthly charge. This is perceived as unjust.
3. A former teacher, respected by the community, told consumers that the systems were donated; as the fuel is free, why should they pay anything? There is complete lack of understanding about the original capital cost, and the need to build a capital replacement reserve.
4. The rehabilitated systems are 12 volt instead of the 24 volt systems they replaced. This is seen as a step backward; people considered that they lost functionality after the rehabilitation

5. There is misunderstanding about responsibilities for replacing bulbs and holders, anger and frustration that even when consumers can pay for them, service and spares are not available. Some consumers believe that they are paying for three indoor lights; when two are non-operational, why should they pay?
6. The batteries in some systems are beginning to fail, especially where regular use of a VCR is speeding up the cycling and their ultimate demise. That they are replaced as part of the $12 charge seems to reward careless or profligate use, and is causing some indignation
7. Because there is no local involvement in the management of the project, there is suspicion that somehow fees are being collected but not returned to MEC; that disconnection of some consumers has been directed, but not carried out because the fees were expropriated. The payment mechanism requires numbered receipts to be issued, and people are aware that this is the case, but the rumours persist that money is going astray
8. Consumers want much more power. This compounds their reluctance to pay what they see as being high charges for limited supply. EPPSO draws a distinction in its statistical analysis between those who have "solar" light and those who have "electricity." This is a meaningful distinction. The Namdrik experience teaches us that solar light is perceived at best as a form of pre-electrification, for which willingness to pay has financial and temporal limits.

Ways to address this unwillingness to pay will be discussed in conclusions and recommendations, after revisiting energy use and demand.

4.6 Energy use update

Energy use has changed little since the PREFACE rehabilitation project. For lighting, every household has at least an 80 Wp solar home system. Forty-five per cent of consumers, and eight in the household survey, are currently disconnected due to long-term non-payment. These households use kerosene as their main source of lighting. Almost all households still use D-cells for flashlights to move around after dark, and for fishing.

Most households cook over a wood fire in an aluminium bowl about 60 cms wide and 15 cms deep. They set a fire using kindling, then use slow steady-burning coconut shells to keep the fire going. Most households, large or small, spend two to three hours cooking daily. Cooking vessels are placed on two or three steel rods that straddle the bowl. Some families use the cut off bottom of a 44-gallon drum for their cooking fire. Drums are also adapted as baking ovens by cutting out an aperture at the bottom for a fire, and inserting rods through the walls of the drum to form shelves on which baking dishes are placed. Skilled cooks thus produce breads and cakes for special occasions. A few households also have a kerosene stove and one or two use propane canisters with camping stoves for quick cooking. At the time the team was on the atoll, the stores had run out of both these fuels, and supplies of kerosene on Majuro were also critically short, illustrating that even relative financial ease cannot buy immunity from the transport and supply difficulties that all in the country share to a greater or lesser extent.

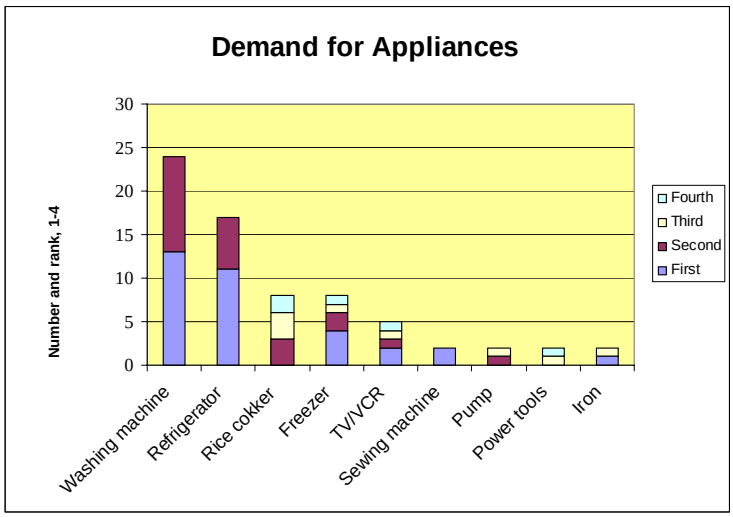
Use of other fuels is very limited. In addition to the truck, there are five gasoline generators, and one weedeater on the island. The generators are privately owned, and are operated when their owners want AC power, for example to run a washing machine. People are sparing in their use because of unreliability of fuels supply as much as out of thrift. They perform their own maintenance. The same is true of the twenty or so outboard motors that power small usually open fishing craft. Engine failure is said to be rare, though usually for security, fishers usually travel beyond the reef in a small fleet.

Left: one of the atoll's gensets is utilised to operate a washing machine, the most desirable consumer durable in the survey.

4.7 Energy Demand Update

The 1996 ADB Outer Islands Electrification Study Report observed "Where supply of photovoltaics is restricted below demand, dissatisfaction can become serious in small communities (ADB 1996:19). This was prophetic. The solar programme has made consumers more aware of what could be accomplished with a robust AC power supply. The more entrepreneurial have taken their own steps to access power. One shopkeeper has purchased his own solar system comprising four 100Wp panels, two batteries, a 150 W and a 400W inverter. He will have to replace his own batteries eventually. Given his utilisation, he reckons the system will have paid for itself in two to three years as compared with the amount of energy received from a solar home system for $12 monthly. Four others have purchased gasoline generators so as to be able to use washing machines or power tools.

The constrained demand is indicated in the responses in the household survey to the question asking what appliances they would buy, and in what order, if they had AC power for a notional six hours per day. The first four responses of each respondent are tabulated and ranked in the table below.



Data source: Household surveys, Namdrik, July 2005

The patterns of response are in line with the findings about demand in the 1996 ADB report. Expression of demand for TVs and VCRs is lower than might be anticipated because many households already possess these appliances. The overwhelming popularity of washing machines indicates concern for hygiene and presentability. While the high demand for refrigerators and freezers is indicative of a desire for convenience, there is a strong demand for these appliances for productive purposes, to store meat and fish until it can be marketed, and to prevent the wastage of leftover food, whose shelf life in the climate of the Marshalls is very short. True, leftovers are generally consumed and thus stored by pigs and chickens, but the labour and energy content is regarded as wasteful.

Sewing machines and power tools were also specifically articulated as having both family utility and productive potential.

This demand profile must however be interpreted as a wish-list. Respondents had very poor perceptions of what service was worth, or they would be willing to pay were their demands satisfied. Applying the rule of thumb that rural people in developing countries usually spend about 5% of their cash income on energy, the surveyed households could afford an average of USD 200 per annum, distorted by the significant highest household income, but a median of only $125, less than $10 per month. However, as discussed in the analysis of ability to pay, most people have the means to generate income to order, when highly motivated.

4.8 Development priorities and resources

Asked “What’s wrong with life on this atoll?” one respondent looked surprised, thought a minute or two and responded “Nothing, really.” Indeed the basic necessities are free from nature, and a constrained subsistence existence would still be viable.

Asked to nominate their five top development objectives, it was accordingly quite difficult for LGC members to formulate very strong development aspirations. The main natural resources that can be elaborated or developed are coconuts, marine products, pandanus and other craft materials; wood, fibre, shells and seeds, sunshine and rainfall. Livestock development also has potential with other inputs. The constraints imposed by transport limitations are so obvious that LGC members did not bother to articulate them.

The Department of Social Welfare is currently implementing a highly popular programme under which the elderly may be granted $7,500 for home improvements. A new school is to be built by the Ministry of Education. The Principal would like electricity in the classrooms to enable use of educational electronic media, and to run night classes for adults whose school achievements were more modest than they would like, but there is no operating budget provision for this. The LGC would like to build a Council office and public meeting facility.

The Women's Unions had clear ideas about development potential. They cited as income generating possibilities various activities based on local resources:

- Preserving giant clam
- Handicrafts
- Producing coconut oil for cooking and cosmetic use
- Selling surplus raw materials for handicrafts when available
- Making charcoal from coconut shells
- Making ornaments and jewellery from pearl shell
- Sewing
- Making tuna jerky
- Making dried banana chips.

The difficulties they encounter in implementing these ideas are spoilage, poor transportation, and cashflow difficulties. If they had AC power, they could overcome some of their problems, and would have more time to pursue enterprises because of availability of labour saving devices. Food preservation projects would require external inputs to advise on techniques, food hygiene, presentation and marketing.

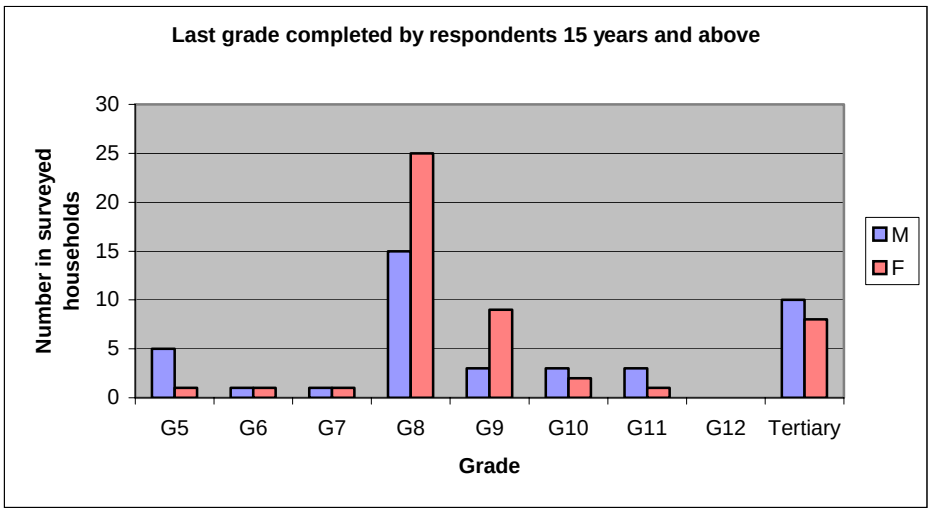
Residents commenting on development aspirations would like street lighting to be restored, provided under the first solar project but currently non-operational.

They would like more effective, cheaper communications of all kinds, but in particular telecommunications; at present they pay 50 cents per minute to use one of the HF radio telephones, from which they can be patched through to any subscriber in Majuro.

4.9 Human Resources on Namdrik

Namdrik residents are resourceful and have skills and competencies that equip them to subsist in their environment, but few formal educational qualifications and skills. LGC members told the team that the atoll would benefit from the presence of an electrician, a

mechanic, nurse, builder and carpenter. Teachers say that formal education is not greatly valued, and indeed, given the limited occupational options may seem irrelevant. The graph below shows the last grade completed by family members in the household surveys over the age of fifteen, at which people may be assumed to be economically active if not still in formal education. The relatively low valuation people place on formal education is evidenced by the fact the some could not remember the academic history of members of their households. This sample is therefore considerably fewer than the number of household members of economically active age group, and includes those over the age of 60, who constitute 11 in the sample of 89.



Data source: Household surveys, Namdrik, July 2005

The graph shows the strong tendency of residents of both sexes to leave school after Grade 8, the last class available on the atoll. Aside from the MEC technician, there are no residents with any formal engineering or mechanical training. Though individuals are quite expert at maintaining their generators and outboard motors, this indicates that any further electrification initiatives should be supported by capacity building, and if necessary bonding of two or three trainees to ensure sustainability of a pool of relevant maintenance skills on the atoll. The tertiary graduates include one individual with management skills, while the rest are professionals. If Namdrik is typical, specific training in small utility management will be an important component of delivery of electrification.

5 Role of MEC in responding to Namdrik Needs and Wants

The role of MEC is to implement government policy and to provide a quality sustainable service. Within the limitations of the project design they have performed well, the failings in sustainability relating not to the service that they provide, but rather to policy and planning which with hindsight can be improved.

5.1 Revenue requirements for sustainability

MEC's aim is to cover its operating budget and the eventual replacement costs of the equipment from revenue. Their revenue requirements to provide sustainable service are therefore their annual costs for salary, travel and incidentals, and an annual contribution to a capital replacement reserve. To date MEC have been covering their operating costs but not without some subsidy on office overheads and management time at the Majuro end. MEC have board authority to manage the project but with the strict proviso that revenues not be taken from Majuro operations to prop up the Namdrik project. The ability of the Namdrik end to operate financially independently appears poor at this stage, unless consumer payments in arrears are recovered. This issue will become most apparent when capital expenditure items such as batteries or replacement charge controllers are required.

5.2 Installations

Government policy is to avail itself of donor funding for Outer Islands electrification. The cost of installations is therefore to be met from this source, rather than by MEC, unless MEC is contracted by the supplier to perform installation service under normal commercial conditions. Since MEC has assumed ultimate responsibility for operation and management of the systems, MEC should develop a cadre of Master Trainers. All donor projects should automatically provide for MEC to participate in operator training for each installation, and in establishing the lines of management communication.

5.3 Fees

While each installation will have different costs, it should be a matter of government policy as to whether some attempt is made to standardise fees, as it tries to standardise equipment, service and spares. MEC's role in this process will be to advise on financial feasibility.

5.4 Disconnections

If the recommendations below regarding flexibility in consumer electrification options, and insisting on consumer contracts are adopted, there is no reason to tolerate fraud or default beyond a reasonable period. The policy regarding disconnection serves social equity, since with small communities and systems, the burden on other consumers of non-performance is proportionally much higher than for large populations and installations, where the burden is wider spread and smaller. Inclusion of local representation in management should ensure that help to ensure that disconnection is not unjust or oppressive. Disconnection always appears punitive, since where there is clearly no operating cost, it creates a "no-win" situation; the consumer receives no service, and the supplier receives no payment, thus impacting the financial viability of

the operation. On Namdrik, since every household was supplied with the same package, there is also little opportunity value to systems, though it is possible that relocation to another household willing and able to pay for more electricity could resolve the supplier's economic problem. However, some systems have been effectively abandoned at houses that are no longer occupied, indicating that the market may be saturated. It would be desirable to include provision for MEC to relocate systems that are not used, and for which no stand-down arrangement has been made with the consumer.

5.5 Repairs & Maintenance

The present upkeep of the systems is adequate and there is little more than Atoll operators can do other than clearance of vines and creepers, and where possible try to avoid shading of the panels from growing vegetation. There is no maintenance possible on the sealed batteries other than watching for corrosion on the terminals, and the charge controllers are generally not an atoll technician serviceable component.

The primary maintenance and repair issue at present is the light and ballasts for the internal light fixtures. The lack of parts, compounded with the contractural confusion has resulted in this issue being a major factor in consumer dissatisfaction.

5.6 Tariff for the poor

Poverty alleviation is a function of broader government policy. This is not a function of MEC, though it should be included as a stakeholder in any discussions about subsidy for electricity. The fee on Namdrik, in light of the plans to electrify Mejit, is unfair, and too high. Solar PV prices have continued to fall over the last decade, and future communities appear likely to enjoy lower component prices than those in the past. Pricing will also be influenced by the size of the projects undertaken so direct comparisons will not always be possible. It is important before any further atoll electrification is contemplated to establish a coherent pricing policy that will take the programme in to the future without causing problems of inequity on the one hand, or sustainability on the other.

In the Marshalls Outer Islands, limited affordability of power does not result in the threats to human life health that have emerged for example in Europe in heat-waves, or in long power cuts in the cold of winter. Provision of public services such as laundries, freezers, livelihoods and entertainment centres would be a better pro-poor alternative than giving a tariff subsidy that may stigmatise poorer community members, and places the burden of cross-subsidy on their friends and neighbours.

While undertaken with the best of intentions, the provision of the same sized system for all households promotes inequity rather than fairness. A solution to the cash difficulties experienced by the poorer or smaller households is to let them find their own level of budgetary comfort by offering options in the level of service. People will still doubtless

make mistakes in contracting for more or less than they need and can afford, but this mechanism encourages responsibility, and should allow people to move up or down the service scale without loss of dignity.

6 Role of the Local Government Council

MEC has tried to engage with the Local Government Council, and has put forward some positive suggestions about how they might participate in the electrification project, but nothing has yet eventuated from these initiatives. There may be political forces at play in this stand-off. The LGC Cabinet comprises mainly members with allegiance to the opposition Ailin Kein Ad Party, while MEC is associated with the government through the Minister and the Energy Office. Against this background, the attitude to the LGC to the project is somewhat ambivalent. They recognise that it is a positive presence in their community. They acknowledge that they were consulted in the planning phases of both the original project and its rehabilitation, but feel that they have since been marginalised. They would like to participate in local management, especially as regards default and disconnections. They believe that if they were included in the information loop, they would be able to assist the genuinely needy to find ways to pay their bills, and to put pressure on those who are able to pay but lack financial organisational skills or nurse some residual grudge. They are not happy about dissent within the community and hope to participate in its alleviation.

It is probable, though was not stated, that the LGC would like to be able to divert some of the revenue from electricity bills to local purposes. However, this possibility emerged in the discussions about ways in which CNO-based generation might be handled on an atoll, discussed below.

6.1 Role in CNO-based generation

The team outlined the objectives of the visit both to LGC members and at the public meeting. It was clearly articulated that the enquiry into CNO was still at the pre-feasibility stage, and that this investigation in no way implied that a project would result. However, the enthusiasm for it was such that there is some danger wishful thinking will result in disappointment. It was clearly pointed out that as long as the shadow of non-payment for electricity hangs over Namdrik, official enthusiasm for another project can be expected to be limited. Nonetheless the LGC asked the team formally to convey its interest in CNO generation. To calculate the relative benefits to the producer of selling subsidised copra versus unsubsidised coconut oil was premature, since pricing policies are yet to be established, but the LGC was disposed to feel that they could easily manage oil production and CNO-based generation as a community enterprise.

6.2 Community awareness

There is definite community interest in achieving quality AC power supply. The team directed discussion principally to discussion of how, in theory, a community on an outer island could use CNO-generated power productively, so as to be able to meet the costs of repairs, maintenance and replacement of components.

In general, the strategy was to identify local products to which value could be added using power. Obvious candidates are freezing and drying fish and fruits. Drying has greater immediate appeal because it overcomes the transport difficulties inherent in the absence of refrigerated shipping, reduces weight and volume.

Other potential income generating activities were identified by the women's groups and are discussed above; attractive amongst them for CNO-based generation support are sewing and both men's and women's handicraft activities. One of the lowest income men is teaching himself to make traditional carved canoes as ornaments, since they attract very good prices on the Majuro market. It takes him two months to produce one piece. The women would make high value pearl shell jewellery, assisted by availability of power tools, as well as the traditional woven items.

Other possibilities include pearl culture and possibly hydroponic vegetable production of high value crops such as tomatoes, but these would require external inputs.

7 Lessons learned

To move the Namdrik project forward involves reducing consumer dissatisfaction while improving willingness to pay for the service provided. The Namdrik experience is a particularly instructive experience, as it raises many of the classic problems of rural electrification. Generally the consumers are willing to pay, but not if they feel they are not being serviced, and are less likely to pay if they feel they are not being charged in a manner equal to what others are paying.

Technically the project seemed to start without serious consideration of other technical options, most likely due to donor predisposition, but compounded with a lack of willingness to recognise the rapid growth in consumer demand and formulation of a plan to provide for it.

Other comments on technical and social impediments are as below:

7.1 Technical

The residual inequities felt by the community over the allocation of systems and willingness to pay need to be addressed, and there needs to be a plan in place to meet the growing demand for AC power in the community. Access to household CNO generation plants is one option, as could be a community hall concept with a single

generator allowing access to refrigeration and washing machines for the long term, for all residents. While it would seem fair to take the large 12 panel systems remaining on Namdrik and centralise them to provide an AC power source capable of meeting these needs, this is likely to be met with political resistance. The beneficiaries should be given the option of paying for their service, or having the systems removed in whole or in part. It is hoped that successful CNO generation trials may offer an opportunity to use local resources to meet the growing demand for energy in a viable and sustainable manner.

7.1.1 Improvement of the Namdrik project

From a technical perspective the Namdrik project can be improved by more adequately meeting the needs of the community. There is a clear need for AC power for high demand appliances such as washing machines, entertainment and refrigeration. Consumer dissatisfaction will remain while these needs remain unserviced. Similarly the reliability of the lighting fixtures requires improvement, either through identifying a more reliable brand, or improving the supply of spares, once the actual cause of failure is identified.

7.1.2 Revenue requirements

The operational revenue requirements for Namdrik are low. The MEC operator draws a salary of around $50 per week, or $2,600 per annum. Rent and communications are offset by bartering access to power and thus do not have a cashflow implication. Other inputs required but not accounted for include Majuro management and office overhead.

But as shown in the spreadsheet attached the solar home system on Namdrik needs annual revenues of around $28,000 per year to meet operating expenses and fully depreciate the capital assets. With maximum revenues of 120 connections x $12 x 12 months being $17,280, (and also assuming 100% of revenues are collected) it can be seen that the project has no chance of full financial sustainability, unless the depreciation of long life components such as panels is ignored.

7.1.3 Lessons learned for future RE projects

The power demands for atoll communities are real and predictable. Solar home systems can meet initial requirements for higher quality and safer lighting, but will soon be followed with demands for higher demand appliances. A follow up plan is needed to meet the predicted demand.

Contracts need to be clear and unambiguous.

Within 2 or 3 years of installation of SHS systems, consumers will want AC power sources to drive higher demand appliances.

Funding agencies need to be realistic in understanding community power demand patterns and expectations. Consumer electronics and entertainment are a part of normal everyday life in 2005 and the utilisation of solar power to drive these appliances should not be feared or need to be disguised.

Solar home systems are an appropriate technology for some locations, but not all. CNO does have a role to play and should be investigated as an alternative to solar home systems. This may require some education of funders as widespread publicity of SHS technologies may lead to a predisposition in that particular technical direction, whereas the use of CNO may not be well understood and not be viewed as the carbon neutral renewable fuel that it is.

Pre-pay meters are an attractive concept but in practice suffer badly and need close management to operate. Consumers struggle with large monthly bills and tend to prefer smaller more regular payments.

7.2 Social

The Namdrik experience illustrates the importance of social mobilisation prior to final selection of technologies and management frameworks for Outer Island electrification. Though it is desirable to standardise technologies and equipment in the interests of economies of scale in both service and spare parts, this should not be accomplished to the detriment of considerations of cost and appropriateness.

The management structure may vary a little from atoll to atoll, but the wisdom of active involvement of local government in management decisions seems inescapable. While this may carry some risk of interference, the risks of creating disownership and lack of responsibility are probably greater. These pitfalls result in social unease, which translates quickly into commercial risk.

7.3 Cultural

Impacts on cultural life in Namdrik have been both positive and negative. The experience shows that well planned, electrification can act as social glue, bringing communities together in leisure time to socialise, study, or enjoy entertainment together. Future programmes should strive to accentuate these positive impacts and avoid the pitfalls of the Namdrik projects.

7.4 Economic

Electrification for lighting alone generally merely results in better illuminated poverty. The lessons from Namdrik are clear; unless there is a conscious focus on productive uses of power, solar home systems tend not to have a positive economic impact; to the contrary, as a very expensive way of achieving better lighting, they drain cash from the Outer Islands economies. It is true that working hours can be extended and manual cash

generating activities such as handicraft can be undertaken at night. Policy makers need however to be very clear about the extent and elasticity of the market for such goods, and to ensure that other critical inputs, such as quality control, manufacturing and marketing skills and network development are delivered simultaneously if the sustainability of an electrification project is critically dependent on household income from such sources. Namdrik also teaches us that cash on the Outer Islands can at times be in generally short supply. The solution to this lies in improving the performance of the shipping service, but mitigation measures that involve payment in kind are clearly welcome.

7.5 Participation

Outer Island electrification is a wonderful vehicle for delivery or many messages, about health, education, production and prices, weather forecasts, new livelihoods activities. Experience shows that impacts are fastest and most favourable when a co-ordinated and multi-sectoral approach is taken, so that all government agencies' programme delivery is enhanced by electrification, and the whole community is engaged through various interest avenues, as householders, fishers, farmers, professionals or craftspeople in maximising benefits. On Namdrik, opportunities were lost to enhance the impacts of the projects by failing to integrate socially and economically productive applications at the time of installation.

7.6 Technical

Namdrik teaches us that one size does not fit all. Some eight consumers have got around the inadequacy of supply by taking two systems, and a further five have purchased small, inexpensive AC 2 stroke generators, a clear indication that flexibility is needed. Others struggle with the power bill, and might have been better off with a couple of much cheaper and more flexible solar lanterns for around $100 each, very much less than the cost of a solar home system for which they are not very grateful.

Consumer demand will grow rapidly, and will follow patterns that correspond to community needs rather than donor plans. For this reason it is essential to plan for rapid growth in initial technical design, and also plan, where possible, to consider significant upgrading of simple DC lighting systems to more comprehensive AC capable systems within the medium term (5 to 7 years). Taking the growth into account, there is a strong argument for accepting a higher initial capital cost to install buried distribution cables and power meters in atoll areas where sufficient housing density is present.

The selection of a technical option needs to be preceded a systematic survey of resources, needs and wants, ability and willingness to pay, and careful participatory planning and training for operation, management and maintenance. While it is recognised that the primary focus is on provision of light with an aim of improving education and health, delivery of infrastructure alone does not accomplish these wider aims. It is hoped that the lessons learned from Namdrik will enable GoRMI to

influence donors to allow for local inputs in the selection of appropriate technology and management mixes, and of other inputs that will enhance effectiveness.

8 Recommendations for Improvements

8.1 Technical Options

1. Approach outer atoll electrification with a view to exploring technical solutions other than only solar home systems, in particular where clusters of houses exist.
2. Where possible, try not to allow donor agency technology bias to influence the engineering design or constrain the technical options explored.
3. Coconut oil is a viable option for outer atoll electrification but field testing on the types of diesel generators to be installed is recommended to explore possible mechanical problems through the use of oil of a quality produced in an atoll environment.
4. The use of solar home systems will be inevitable in most atolls, as some, or perhaps most houses will be too dispersed for other options. In these cases education must be provided with the systems to understand the power limitations of the systems. A follow-up strategy to supply at least some AC power for livelihoods activities is desirable.
5. Contracts must be clearly explained to ensure clarity and understanding of who is responsible for what.
6. Stocks of spare parts, such as light fittings, must be ordered well in advance to ensure consumer satisfaction.

A variety of options can be explored when electrifying outer atolls, and recognising that the demand for power will inevitably grow. Options that could be explored include:

a. Using a standard, metered distribution system with an underground cable to service viable clusters of houses. Generation from CNO, diesel or solar hybrid.
b. Solar home systems for households too remote to connect to a cable supply, but with education to users to better understand supply constraints.
c. Small CNO or diesel gensets for households or community centres to provide access to AC power needed for communal facilities, and complimenting solar home systems used to meet basic domestic lighting needs.

8.2 Management and Planning Options

1. Coherent and consistent Outer Islands electrification **policy and procedures** need to be promulgated to provide predictability and stability to consumers and donors. Government should feel free to discuss with donors adaptation of offers of assistance to the internal policy and institutional context, which is sometimes imperfectly understood.

2. Each atoll electrification project should be **conceptualised as a mini-utility** or separate cost centre within MEC as done with Namdrik, required normally to meet the costs of operation, maintenance, depreciation and capital replacement, as well as facilitating GoRMI's policy objectives of social and economic development.

3. To ensure that GoRMI's Outer Islands electrification policy objectives are met, **community mobilisation should be part of the donor package**, and commence at least six months prior to any planned installation using a team that combines hardware and software skills. The mobilisation team should ascertain what is technically feasible and socially and economically desirable, assist with productive power use planning, ensure that all community members understand what their system will and will not do, and establish whether consumers are willing and able to meet the costs of a financially sustainable project. This lead time enables households to start saving for connection, and to purchase appliances.

4. **Objective criteria for site selection** should be promulgated in the interests of transparency, and to encourage LGCs to organise so as to qualify for consideration.

5. To prepare for electrification, each Local Government Council should be asked to prepare an **energy demand profile** for the Energy Office, including at a minimum:

    a. Number of households
    b. Distribution of households
    c. Range of household cash incomes
    d. Current energy expenditure, willingness and ability to pay for electricity service
    e. Resource potential; energy, natural and human
    f. Development priorities and constraints.

    This would enable the Energy Office to a first approximation to match donor resources to appropriate locations, recognising that one size does not fit all.

6. Community mobilisation needs to set **the proposed programme in its policy and institutional context**, so that beneficiaries understand what the government is trying to achieve, what donor contributions are available and any conditions that these impose on the outcome. This may limit power availability. In the event that this limitation seems likely to doom consumers to disappointment, a follow-up strategy, perhaps centralised provision of services based on CNO generation, will be desirable.

7. **Beneficiaries need to understand as part of this mobilisation the full cost of the systems and the project**. The method of calculating the monthly fee, and what it covers should be explained in public meetings. Simple flip-chart

graphics should be produced in Marshallese to show graphically and verbally where the money goes. These should be displayed in a public place for the duration of the planning and thereafter at the point of payment.

8. **A range of household consumer supply options** needs to be available. This could start from a simple robust solar lantern to a system that will support some use of AC power. Consumers could be offered modules that suit their household configuration and budget, and are charged accordingly. If planned at the outset, this could be accommodated without loss to the benefits of standardisation of equipment, service and spares. Consumers need the flexibility to move up or down the scale as their needs and budgets change. It is recognised that the GoRMI has a primary imperative to ensure that lighting is available to all, and that this policy objective must not be compromised by allowing the richer to capture all the benefits. On the other hand, a flexible arrangement will better serve the policy goals of financial sustainability of electrification projects and improving livelihoods options on the Outer Islands.

9. **Willingness to pay** is sensitive to the procedures followed in introducing and managing the project. Difficulties with **ability to pay** are more related to cash flow problems than to absolute poverty in the conventional sense, though cases of genuine need exist. These should be identified in the mobilisation phase prior to installation. Local authorities should be involved in management of the project and tasked with ensuring that consumers in genuine financial difficulty with paying their bill are given the opportunity to contribute community labour or services in lieu, or receive support through traditional local channels to avoid as far as possible default, humiliation or social exclusion.

   In the mobilisation phase, the LGC should be encouraged to set up a co-operative or other such mechanism under the electrification committee for trading local goods that can act effectively as a credit agency to help consumers meet their payment obligations.

10. **Installation planning should be co-ordinated with all government agencies** whose portfolios are dependent upon, or enhanced by power provision, so that the school, dispensary, communications centre and any other essential services are supplied and supported through the same mechanism as household supply. The community mobilisation team could be tasked with ensuring this occurs. The ADB 2005 paper on Issues and Options for Improving Education in the RMI depicts educational achievement in crisis, with teaching capacity weak in crucial areas, and low levels of achievement by students. Distance education packages supported by simple IT could make a quantum difference in this key area of Government policy.

    The Ministry of Health states that when health teams visit the Outer Islands, they try to target the whole population on all programme areas, e.g. pre-natal care, immunisation, diabetic and hypertensive services, dental services. Vaccine

storage, blood screening for communicable diseases and dental services in particular require electricity supply, and would enable provision of more services on-island. The see definite value in co-ordination of services at the time of installations, and suggest that a meeting to clarify the roles of agencies would be a useful precursor. Maintenance should be included in these discussions. An RMI Government MOU could be developed to guide the process.

11. **The utilisation of CNO as a diesel substitute** offers the hope that frustrated demand for AC power may be satisfied using this local biofuel option. To meet the various government objectives of provision of lighting, sustainability and economic development that might arrest the urban drift from the Outer Islands, a two-stage approach to electrification could be planned. In the first stage, consumers could be offered an appropriately sized solar home system. Follow up after a year or two could offer local **CNO production and generation to support larger load demands. A number of standardised service packages could be developed and included according to need**, for example:

    a. A **school electrification** package with lighting for classrooms and staff facilities, a radio and VCR and some instructional videos on electrical safety, consumer durables, power demand and warranties, human health, environmental health, adult education videos, etc, and ideally a computer
    b. A **Dispensary** package, including lighting, a small vaccine refrigerator and other medical equipment according to the size of the population and the appropriate level of service
    c. A **safe drinking water treatment** plant. This can be provided by ozonation or UV treatment with very low power demand. Ozonation equipment is a little more expensive initially, but has the advantage of requiring very few consumables and minimal maintenance. A station that can treat 2,000 litres of water per day costs about USD 5,000 delivered.
    d. A **satellite telephone** package with a computer and internet connectivity
    e. A small **community hall** with lighting and a large screen facility that could serve as a mini-cinema
    f. A **workshop** with rentable power tools and sewing machine
    g. A pay-by-the-kilo community **freezer**
    h. A pay-as-you-go **washing machine**
    i. Provision for power for **other income generating activities** identified by the community in the planning phase.

    Depending on the configuration of the atoll, these facilities might be centralised or scattered, with one larger or a number of smaller CNO diesel generators supplying clusters of households with partially centralised services. Ideally, consumers want centrally generated and distributed mains power. This option should not be discounted, though the realities of geography and cost may prove insurmountable in most atolls. In any of these cases, the issue of land ownership and access for the processing, generating and any public facilities would need

careful consideration and prior agreement to avoid the Namdrik trap of locating what were intended to be public facilities in private premises.

At time of writing, the cost of the equipment package required to decentralise oil production on the Outer Islands is around $15,000. If tests confirm viability in an Outer Island environment, it could be proposed that Local Government Councils purchase the equipment out of their annual operating budgets, allocate land according to local tradition, and run second stage electrification with CNO-based generation as a local business. Maintenance contracts for technical support could be negotiated with Tobolar. Though CNO has been tested in a number of engines, it is suggested that regional universities and technical training facilities be approached with a view to locating test facilities and possibly identify graduate students who might be interested in testing the models proposed for the Outer Islands as a research project. This could be a cost-effective way of providing OEMs with the data required to avoid invalidation of warranties, and perhaps to make modifications and improvements to the generators.

12. Though it is operationally easier for MEC to have a straightforward commercial relationship with a local atoll agent for collection of bills, the Namdrik experience suggests that it is desirable to have some **local government involvement in project management**. This does not preclude an agency arrangement, but renders it more transparent, and less liable to potential accusations of cheating or oppression.

13. The beneficiaries of each island electrification project should be required to establish with MEC **an agreed management structure,** preferably formally registered with a constitution and operational rules and guidelines. This should be a pre-condition of commencement of any installation work.

14. Ideally, the LGC should be included in local management under a **clear agreement with MEC** that spells out rules, roles and responsibilities. On Namdrik, the suggestion was made that an atoll Electrification Committee could be formed, comprising ex officio the MEC technician and an LGC member, and including two or three more respected community members, such as a teacher, policeman or pastor.

15. The local mangers/agent should **collect an agreed percentage of connection fees as a precondition before installation commences**; not less than 50% of households is suggested, but in any case, to satisfy policy requirements, the number of consumers needed for the project to break even financially. This will ensure that the project has at least some operating capital, and will be testimony to some level of local buy-in and support. No household should have an installation or connection made until its connection fee is paid. This may impose some technical inconvenience; it is easier for technicians to make all installations simultaneously, but care must be taken not to deliver meta-messages that the connection fee is avoidable. If simple, cheap alternatives such as solar lanterns are offered, there is no risk of social exclusion.

16. There needs to be prior exhaustive public discussion about **how monthly bills will be paid**. If necessary, a mechanism for payment in kind that does not involve MEC in becoming a copra or handicrafts merchant may need to be devised. For example, the electrification committee or local agent could set up a trading mechanism to enable consumers to convert product into cash at agreed rates for given categories, sizes, weights and quality of goods. Transparency in this process will be crucial to success.

17. Disconnection of solar home systems serves no-one's interests. Contractual arrangements should allow MEC to relocate systems that are not being utilised or paid for, so that financial viability is not compromised by **unproductive assets.**

18. Electrification planning should identify with community participation some **productive uses of power**. Agreement of livelihoods activities, preferably involving productive use of power, should be planned prior to installation so that appropriate provision can be made, e.g. for electricity supply for a handicraft centre, small community-run laundrette, mini-cinema, hydroponics business – ideally applications that have low capital cost and power demand but have potential to add high social or economic value. These could be run as small enterprises, and would assist especially poorer members of communities with access to desirable services such as laundry or videos on a pay-as-you-go basis, so that all households need not invest in the desired appliances, and bills can be kept under control. Limiting the number of large appliances on Outer Islands is also desirable in environmental terms because of the high probability that aged or failed appliances will be dumped, contributing to either terrestrial or marine pollution.

    Options for productive uses based on available natural resources were discussed under Section 4.10, Development Priorities.

    The ideal income generating options are low volume, high value non-perishable goods that can be produced with little capital investment and do not rely on highly skilled labour. Coconut oil production, handicrafts, sewing, shell jewellery and charcoal making are all easily managed without external resources or support other than transport. AC power availability would add value where mechanised tools and equipment improves productivity and quality.

    Though the community itself did not articulate development priorities that are inhibited by the obvious inhibitors of distance and transportation, a clear candidate is **cool storage**. Given refrigerated shipping, or the means to keep the product chilled for the 24-hour journey to Majuro, this could open a metropolitan market for fish and pork. Facilities for hygienic slaughter and preparation for freezing would be necessary.
    Vacuum packing of fish and meat, smoked or fresh, could also bear investigation. The equipment is cheap and simple. Power demand is low, but

there is a clear need for capacity building in hygienic food handling, and for quality control. Vacuum packing equipment can be simple and low cost, with basic units for less than $500.

Hydroponic high value fruit and vegetable production is another possibility that obviates the problems of scarcity and poverty of soil, and can easily be planned to limit potential damage from predators such as pigs and rats. Power demand is low, and simple household-scale kitsets cost less than $500. Tomatoes, beans, peas and other crops that are imported for the Majuro market would be good candidates since their value-to-volume ratio is quite high, and they can be packed to travel well. The cost and logistics of plant nutrient supply would require investigation.

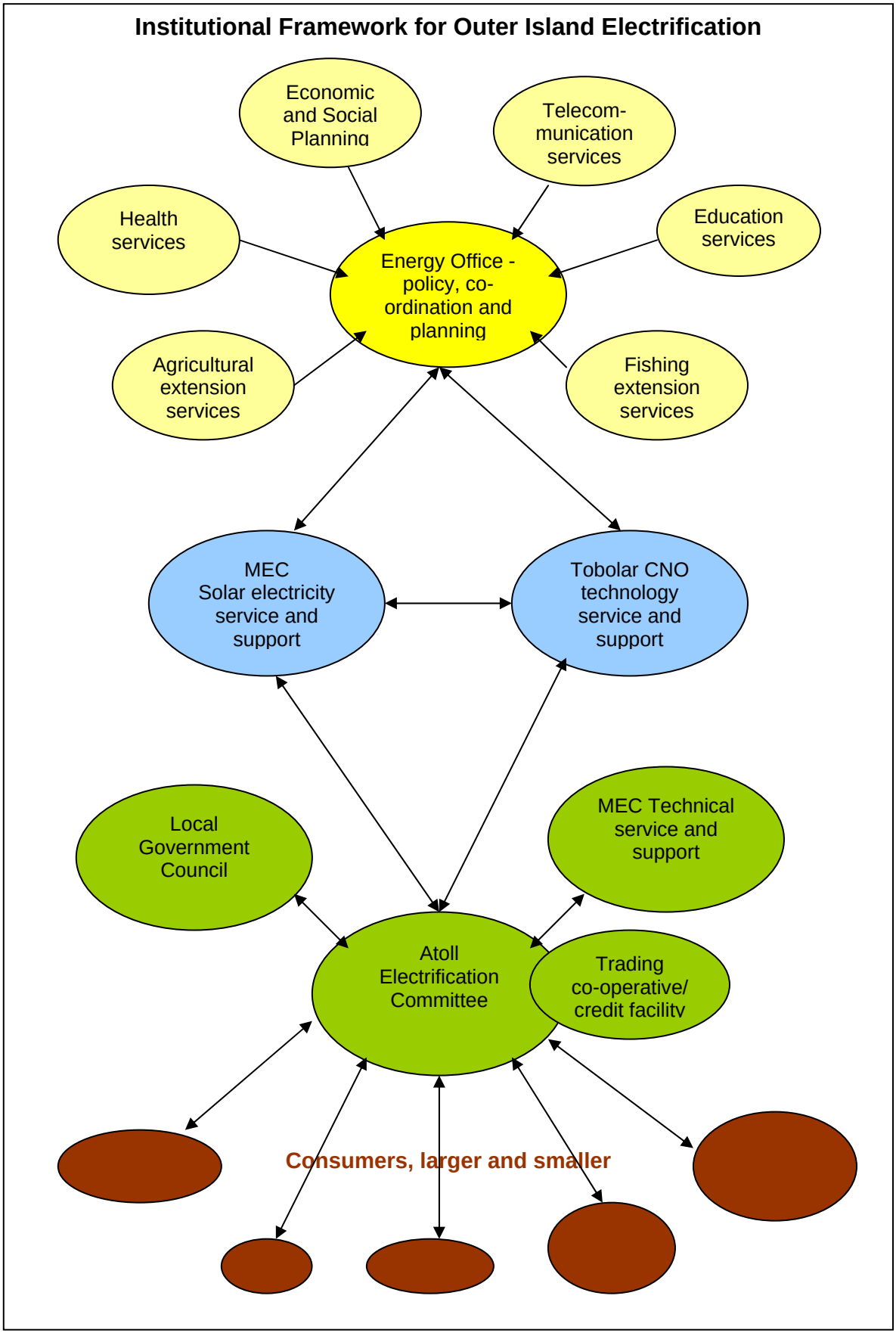
Chicken raising could have considerable value added by incubating eggs, penning and hand feeding the chickens for live or chilled transport to the Majuro market. Free-ranging chicken is quite widely eaten, but is tough. A quality table product could be produced with simple materials, readily available feed based on copra supplemented with other nutrients, a little power, and not excessive labour or risk of disease.

Medicinal plants are available on Namdrik, and may have potential for development, but to the knowledge of the Health Assistant have not been clinically tested, and are of unknown properties and efficacy.

19. A **public information campaign** could be launched through the local Electrification Committee as the project rolls out to cover:

    a. Electrical safety
    b. Power demand of common appliances
    c. Public health issues and messages
    d. Environmental messages
    e. Educational messages – guidelines for parents about video materials that are appropriate for children, appropriate limits to viewing hours, how to manage homework, housework and sleep for their children
    f. Adult education materials
    g. Instructional videos on crop or fisheries management.

    Most of these subjects are well covered with off-the-shelf public good information materials. Their provision to the local management adds a fraction to the cost of the project, but greatly enhances its effectiveness. The graphic below illustrates the suggested institutional relationships. This structure is viable irrespective of whether the energy source is solar, hybrid or CNO-based. The interlocking Board membership of MEC and Tobolar facilitates co-operation between the two organisations where a dual source or two-tiered approach to meeting atoll energy needs is indicated.


Institutional Framework for Outer Island Electrification
Economic and Social Planning
Telecom-munication services
Health services
Education services
Energy Office - policy, co-ordination and planning
Agricultural extension services
Fishing extension services
MEC Solar electricity service and support
Tobolar CNO technology service and support
Local Government Council
MEC Technical service and support
Atoll Electrification Committee
Trading co-operative/ credit facility
Consumers, larger and smaller

8.3 Government Programmes and Resources

The GoRMI has no funding for Outer Islands electrification; its policy is to access donor funding for the initial provision of hardware. Thereafter, the aim is for each sub-project to be financially sustainable, including eventual replacement of equipment.

The Energy Office develops policy, but currently has only one officer, who cannot absent herself from the office to participate in delivery of the programme. It is therefore desirable to ensure that donor packages have the flexibility to accommodate GoRMI policy and development objectives.

In future, this could include:

- Allowing for community preparation and mobilisation
- Allowing for integrated development taking account of the energy needs for health, education, communications and livelihoods
- Allowing a range of size and service options to avoid inequity and dissent in communities
- Allowing GoRMI rather than donor selection of equipment to standardise and avoid creation of "orphan" installations that cannot be supported with service and spare parts.

8.4 External Resources

The Marshall Islands enjoy good relations with a number of multilateral, regional and bilateral assistance organisations. It is suggested that the Energy Office maintain liaison with these organisations to leverage all available funding for Outer Island electrification. The proposed statement of Outer Island electrification policy and procedures could usefully identify community of interest between GoRMI, social development and environmental protection organisations which might provide funding.

While co-ordination of donor programmes is a load on local resources, the creation of a critical mass of well-designed projects leads ultimately to economies of scale in administration, and helps to develop local pools of skills and support that ultimately make the task easier.

Annex A Informants and Workshop Participants

Grateful thanks for their time and co-operation are due to:

Hon John Silk, Minister, Resources and Development

Hon Mattlan Zackhras, Minister of Public Works/ Chairman of the Board, Marshalls Energy Company

Frederick Muller, Secretary, Ministry of Resources and Development

Rebecca Lorennij, Deputy Secretary, Ministry of Resources and Development

Atina Myazoe, Energy Office, Ministry of Resources and Development

Anel Philimon, Small Business Development Centre, Ministry of Resources and Development

Henry Capelle, Director Agriculture, Ministry of Resources and Development

Glen Joseph, Director, Marshall Islands Marine Resources Authority

Carl Hacker, Economic Policy, Planning and Statistics Office

Korent Joel, Ministry of Transport and Communications

Tommy De Brum, National Telecommunications Authority

Mayor Amos McQuinn, Namdrik Atoll Local Government

Acting Mayor Eknar, Namdrik Atoll Local Government

Jerry Kramer, Chief Executive, Pacific International Inc

Steve Wakefield, Marshalls Energy Company

Billy Schutz, Marshalls Energy Company

Billy Roberts, Marshalls Energy Company

Wilfredo Candilas, Tobolar Copra Processing Authority

Marie Maddison, Women United Together Marshall Islands (WUTMI)

Osi Jitiam, MEC solar technician, Namdrik Atoll

Aisa Peter, Health Assistant, Namdrik Atoll

Councillors, Members of the Copra Co-operative, Members of the Women's Union, householders and residents of Namdrik Atoll

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Marshall Islands Visitors Authority	Nd	Guidebook
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Annex C Financial Comparisons

Solar Home Systems

	US$			
Individual systems	3000			
Total systems installed	120		**Panels assumed to last 20 years**	
Total equipment cost	**360000**		**Batteries replaced after 4 years**	
Grant funding			**Controllers replaced after 10 years**	
Total capital cost	360000			
			Replacement panels every 25 years	**120,000**
			Replacement controllers every 7 years	**24,000**
Fuel Consumption			**Replacement batteries every 4 years**	**60,000**
Weekly consumption	28	litres	**Operators salary @ 150 per month**	**1,800**
Cost per litre	0	USD	**Annual spare parts allowance**	**3,000**
Fuel cost per annum	**0**			

Growth in demand per annum **0.0%**

Net Cash Flow **Discount rate applied** **5%**

Year	Investment (M)	Fuel Costs	Operating Costs (M)	Revenues (M)	Net Cash Flows	Discounted Cash Flow
0	360,000	0	4,800	17,280	-347,520	-347,520
1		0	5,040	7,665	2,625	2,500
2		0	5,292	8,815	3,523	3,195
3		0	5,557	10,137	4,580	3,957
4	60,000	0	5,834	11,658	-54,177	-44,571
5		0	6,126	13,406	7,280	5,704
6		0	6,432	15,417	8,985	6,704
7	24,000	0	6,754	17,730	-13,024	-9,256
8	60,000	0	7,092	20,389	-46,703	-31,610
9		0	7,446	23,447	16,001	10,314
10		0	7,819	26,965	19,146	11,754
11		0	8,210	31,009	22,800	13,330
12	60,000	0	8,620	35,661	-32,960	-18,353
13		0	9,051	41,010	31,959	16,948
14	24,000	0	9,504	47,161	13,657	6,898
15		0	9,979	54,235	44,256	21,288
16	60,000	0	10,478	62,371	-8,107	-3,714
17		0	11,002	71,726	60,724	26,494
18		0	11,552	82,485	70,933	29,474
19		0	12,129	94,858	82,728	32,738
20	60,000	0	12,736	109,087	36,351	13,700
21	24,000	0	13,373	125,450	88,077	31,615
22		0	14,041	144,267	130,226	44,518
23		0	14,743	165,907	151,164	49,215
24	60,000	0	15,480	190,793	115,313	35,755
25		0	16,255	219,412	203,157	59,993
				NPV	**-28,930**	-$28,930
				IRR	**-0.4%**	

CNDC Scheme (2005) Diesel Only (2005) Distribution Line

	US$			
Generator and Copra oil mill	20,000	US$	Salvage after 5 years	5000
Distribution line	180000	15000	Diesel salvage after every 5 years	1500
Diesel Generator	15000			
Total Grant Required	200000	200000		
Distribution line	180000			
Total equipment cost	**195000**			
Fuel Consumption		200000	Lubricants, filters and small consumables	200
Weekly consumption	140	litres	Operators salary @ 150 per month	1800
Cost per litre	0.4	USD	Annual spare parts allowance	1000
Fuel cost per annum in year zero	**2,912**			

Fuel Consumption			Lubricants, filters and small consumables	200
Weekly consumption	140	litres	Growth in demand per annum	15.0%
Cost per litre	0.94	USD	Operators salary @ 150 per month	1800
Fuel cost per annum in year zero	**6843**		Discount rate applied	5%
			Annual spare parts allowance	1000

Net Cash Flow

Year	Investment (M)	Fuel Costs	Operating Costs (M)	Revenues (M)	Net Cash Flows	Discounted Cash Flow
0	200,000	2,912	3,000	7,665	-198,247	-198,247
1		3,349	3,150	8,815	2,316	2,206
2		3,851	3,308	10,137	2,978	2,701
3		4,429	3,473	11,658	3,756	3,244
4		5,093	3,647	13,406	4,667	3,839
5	15,000	5,857	3,829	15,417	-9,269	-7,262
6		6,736	4,020	17,730	6,974	5,204
7		7,746	4,221	20,389	8,422	5,985
8		8,908	4,432	23,447	10,107	6,841
9		10,244	4,654	26,965	12,066	7,778
10	16,500	11,781	4,887	31,009	-2,158	-1,325
11		13,548	5,131	35,661	16,982	9,929
12	13500	15,580	5,388	41,010	20,042	11,160
13		17,917	5,657	47,161	23,587	12,509
14		20,604	5,940	54,235	27,691	13,986
15	18,150	23,695	6,237	62,371	14,289	6,873
16		27,249	6,549	71,726	37,928	17,375
17	14850	31,337	6,876	82,485	44,272	19,316
18		36,037	7,220	94,858	51,601	21,441
19		41,443	7,581	109,087	60,063	23,769
20	19,965	47,659	7,960	125,450	49,865	18,794
21		54,808	8,358	144,267	81,101	29,111
22	16335	63,029	8,776	165,907	94,102	32,169
23		72,484	9,215	190,793	109,095	35,518
24		83,357	9,675	219,412	126,380	39,186
25	21,962	95,860	10,159	252,324	124,343	36,719
	19	97,391	7,581	109,087	4,115	1,628
	20 17,969	111,999	7,960	125,450	1,478	158,819 -4,703
	21	128,799	8,358	144,267	7,110	2,552
	22	148,119	8,776	165,907	9,012	3,081
	23	170,337	9,215	190,793	11,241	3,660
	24	195,888	9,675	219,412	13,849	4,294
	25 19,765	225,271	10,159	252,324	-2,872	-848

NPV **-229,919** -$229,919
IRR **#DIV/0!**

Income	
Assume 100 kWhrs sold per day @ $0.35 per kWhr	
Daily kWhrs	60
Price per kWhr	0.35
Recovery rate	100%
Annual income	**7665**

Individual Domestic CNO generators

	US$		
Household scale CNO generator	1,200	**Full mechanical overall every 5 years, per system**	**700**
Number of consumers	120		
Total capital cost	**144000**		
Fuel Consumption		**Lubricants, filters and small consumables pa**	**200**
Weekly consumption	120 litres	**Local maintenance staff salary @ 150 per month**	**1800**
Cost per litre	0.4 USD	**Annual spare parts allowance**	**1000**
Fuel cost per annum in year zero	**2,496**		

Growth in demand per annum **15.0%**
Discount rate applied **5%**

Net Cash Flow

Year	Investment (M)	Fuel Costs	Operating Costs (M)	Revenues (M)	Net Cash Flows	Discounted Cash Flow
0	144,000	2,912	3,000	7,665	-142,247	-142,247
1		3,349	3,150	8,815	2,316	2,206
2		3,851	3,308	10,137	2,978	2,701
3		4,429	3,473	11,658	3,756	3,244
4		5,093	3,647	13,406	4,667	3,839
5	84,000	5,857	3,829	15,417	-78,269	-61,326
6		6,736	4,020	17,730	6,974	5,204
7		7,746	4,221	20,389	8,422	5,985
8		8,908	4,432	23,447	10,107	6,841
9		10,244	4,654	26,965	12,066	7,778
10	92,400	11,781	4,887	31,009	-78,058	-47,921
11		13,548	5,131	35,661	16,982	9,929
12		15,580	5,388	41,010	20,042	11,160
13		17,917	5,657	47,161	23,587	12,509
14		20,604	5,940	54,235	27,691	13,986
15	101,640	23,695	6,237	62,371	-69,201	-33,287
16		27,249	6,549	71,726	37,928	17,375
17		31,337	6,876	82,485	44,272	19,316
18		36,037	7,220	94,858	51,601	21,441
19		41,443	7,581	109,087	60,063	23,769
20	111,804	47,659	7,960	125,450	-41,974	-15,819
21		54,808	8,358	144,267	81,101	29,111
22		63,029	8,776	165,907	94,102	32,169
23		72,484	9,215	190,793	109,095	35,518
24		83,357	9,675	219,412	126,380	39,186
25	122,984	95,860	10,159	252,324	23,320	6,887

NPV **9,554** $ 9,554
IRR **0.3%**

Income	
Assume 100 kWhrs sold per day @ $0.35 per kWhr	
Daily kWhrs	60
Price per kWhr	0.35
Recovery rate	100%
Annual income	**7665**

Annex D A Cautionary Tale

A consultant goes to a Pacific Island to assist to identify income generating opportunities. Noticing a group of men parked up under a coconut palm on the shore, he ambles up to join them. A couple of fishing canoes come ashore. Everyone helps to pull them up on to the beach, and unload their catch.

"You know" observes the consultant gesturing at the bunch of nuts above them "you can use coconut oil as an outboard fuel?"

"No kidding!"
5 Revenue requirements for sustainability

"Yes, and with a cheap locally available fuel like that, you guys could operate a little transport service to the town across the lagoon."

"Uh-huh; that'd be good," the group agrees. "We have a real problem with transport here."

"And it would return a good income," enthuses the consultant. "With the profits, you could build little cabanas here, bring tourists over for day trips and barbecues."

"Uh-huh, yes, I suppose we could catch some fish, bake some breadfruit…"

"And then you could invest the profits in a hotel in town. Control the day trip market. Have a base for when you have to go shopping, see the doctor, or put the kids in secondary school."

"That'd be good," agrees the group. "It's expensive to go to town if you haven't got family members to stay with."

"And why stop there?" continues the consultant. "With the profits from the hotel, you could invest offshore. Where do most of the tourists come from? Germany? Well, you could open an office in Germany, say Frankfurt. Big air travel hub. Promote your destination. Sell tour packages at source!"

"Uh-huh…… maybe… it's cold there, right? What then?"

"Well, then," the consultant asserts, "you guys would be making so much money you'd never need to work again. You could just park up under a coconut palm, and go fishing!"