OPENING THE PV MARKET

THE DEVELOPMENT OF A RURAL PHOTOVOLTAIC ELECTRIFICATION MODEL IN THE PHILIPPINES

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Abstract–In the Philippines, the GTZ is demonstrating an innovative concept to integrate PV systems into a public rural electrification program. Power utilities assisted by the private sector utilize Solar Home Systems as an alternative to line electrification. PV electrification is identified as the most promising option to push the limits of rural electrification. As acceptance and economies are encouraging this concept provides the tools to open an emerging market for large-scale application.
A discussion of the specific rural electrification scenario is followed by a description of the strategy developed and the experience gained. In conclusion, recommendations are given on suitable financing options and focused Government policies.

1. Introduction

While we are heading for the year 2000 still one third of mankind cannot even switch on a light when the night falls. The amount of productivity lost because every day ends at sunset is hardly imaginable.
In order to provide citizens with a better chance to contribute to the economic development, most Governments commit to total electrification. Drawing from the current degree of electricity supply however, this would mean a 50% increase in the world's consumption of energy resources and consequently, in the world's environmental pollution. Both aspects would without doubt overdraw known limits.
Governments, particularly in Asia who have to fuel a two-digit economic growth also rather spend their financial resources on the productive infrastructure of the centers than to subsidize total electrification, which would mostly benefit the countryside. The striking consequence is that most of the world's rural population will never have electricity - at least not from conventional sources.
Unless we want to exclude 2 Billion people from development, new concepts of energization are requested. Many countries are creating incentives for indigenous energy technologies and have tried electrification with decentralized small solar systems both, under public service schemes and through private sector initiative. Most schemes met the barrier of affordability and required heavy subsidies. At the same time, scientists and researchers are achieving remarkable results in the improvement of efficiency, reliability, and reduction of manufacturing cost. All agree however that major cost reductions would require economies of scale. The rural electrification sector holds the potential to increase the current PV world production at least a 1000 times.

This enormous chance faces the challenge of making PV affordable to rural utilities and managing multiple projects in parallel, which calls for new managerial skills in the energy sector. A successful approach to PV-electrification would benefit the renewable energy sector all the way from science to manufacturing as much as it would serve large numbers of rural families, who continue to pressure their governments for access to highly valued lighting and electricity services.

2. The Rural Electrification Dilemma

A study presented by the World Bank [1] states that despite the rapid expansion of the power sector during the last two decades, only 800,000 of the more than 2.5 billion people living in rural areas have grid based electricity. Hopes of universal electrification through conventional grid services are dim, given the constraints of high capital, operational and maintenance cost.
The energy sector in the Philippines is making remarkable progress in catching up from the slow 3% power increase during the 80s by concentrating resources on making power available in the centers where it is needed for production. The rural areas in comparison, do not have enough load to justify a heavy investment in electrification where it would be socially desirable.
The *National Electrification Administration* NEA is mandated with the rural electrification, which serves 60% of the population but only 35% of the national load. NEA supervises and finances 119 *Rural Electric Cooperatives* (ECs) who buy electricity from the power producer *National Power Corporation* (NPC) and distribute it in their own grid. A new household connection costs at least 730$ [2] but may be far more depending on the topography and load density.

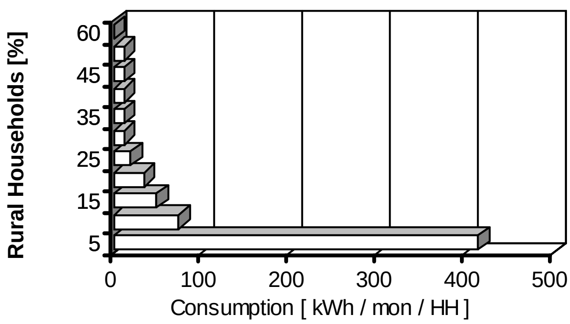

Fig.1 : Rural Load Pattern (NEA 1992)

NEA data show that of an approximately 8 Million rural households not more than 50% could be energized. While 91% of the total customers are residential they consume only 47% of the energy, an average of 37 kWh monthly. Of these some 40% are even minimum consumers with less than 15 kWh who pay only a flat rate of 50 P (2 $).

It is therefore safe to assume that those households to which the grid has not yet been extended will have a very low demand. As a rule of thumb, NEA considers only projects, which have at least 15 connections per km of grid. Most present projects are already below this value. In dispersedly settled regions the limits are reached. These data may explain the gloomy attitude in the rural electrification sector.

The convenience of conventional electrification in rural areas has become a costly luxury and earned a bad reputation with financing and aid institutions that tend to support electrification only where some 60% of the load can be used productively. The supply of basic electricity is ranking ever lower on the allocation agenda of social development plans. There is a risk that this dilemma of rural electrification is about to have alternative options discarded just the same.

3. The Renewable Energy Option

Lately the electric power markets are undergoing a rapid change. State-owned utilities are being privatized, the traditional utility monopolies are being unbundled, and the electric energy supply business is opening to competition at all levels. At the same time, public concerns over the environment are growing globally, and the government policies continue to increase restrictions on pollution and promote energy efficiency and renewable energy technologies [3].

These changes may open fresh opportunities for renewable energies with innovative project development and financing approaches that aggregate the market and allow customers to be served at affordable prices. In order to explore these approaches the *German Ministry for Technical Cooperation* commissioned the *Deutsche Gesellschaft für Technische Zusammenarbeit* (GTZ) in 1987 to develop and demonstrate dissemination models for solar electrification. Several approaches were to be tried and monitored in significant duration and quantity and evaluated regarding their ability to attain financial viability without subsidization.

The Philippines offered favorable conditions for the planning of a PV electrification concept:

- A fairly straight equatorial solar irradiation throughout the year of 1.9 $MWh/m^2/a$ resulting in energy outputs of 1500 MWh/ha/a
  (average values hydropower 500 MWh/ha/a, wind 160 MWh/ha/a, biomass 30 MWh/ha/a).
- A potential of 2 Million unelectrified dispersedly settled households with an initial energy demand below 120 kWh/a.
- Experience in joint bilateral cooperation on PV
- An organizational separation of power generation (NPC) and distribution (NEA) which would facilitate alternative distribution concepts.

The *Philippine-German Special Energy Programme* (SEP) identified NEA and the affiliated ECs as most attractive partners, since they provide:

- Access to long-term financing at prime conditions
- Tax-free privileges for energy commodities
- Capacity to buy bigger quantities
- Experienced electrification professionals
- Nationwide organizational network
- Familiarity with specific regional conditions

Notwithstanding these positive conditions, the SEP met many of the initial problems of PV projects:

- Faced with a new technology users invented ways to explore its limits.
- Users feared to preempt their chance for ”real” electricity once solar came in.
- Technicians had heard of breakdowns and that PV is too expensive.
- A little developed market offered a limited supply infrastructure and availability of standard quality components, some suppliers therefore considered the SEP a competition.
- Utilities offered at best polite interest in engaging in an alternative approach.

3.1 Strategy

The approach of preparing such a market was to focus on re-establishing confidence in the technology and to reduce the risk for the implementers before engaging them in an electrification scheme.

Confidence Building was addressed by demonstrating reliable technology with proven quality components. For this purpose an island site was selected which had served for PV demonstration before. Isla Verde was ideal because it represented a real, and beautiful, remote island setting yet was accessible from Manila in a day tour. With the support of the islanders it was converted into a showplace for various technology applications. A centralized plant, Battery Charging Stations, Solar Home Systems and streetlights were continuously improved, extended and streamlined and had info-panels to give boatloads of visitors an impression of how a solarized countryside would look like. Other places had different and interesting PV projects, but Isla Verde became in the Philippines the synonym for solar energy.

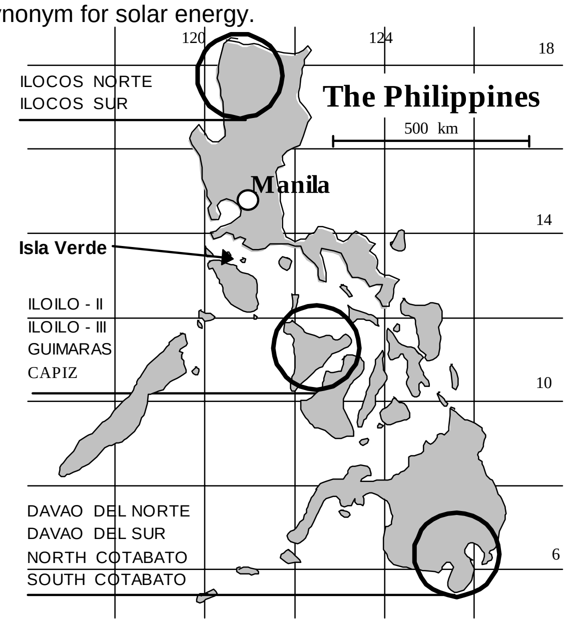

Fig.2 : Location of Pilot Areas

Risk Reduction meant to share the EC’s risk in introducing a new technology. Philippine utilities take a long-term risk when financing SHS. After all, it happened before that they were left alone with useless technology that would not recover the investment and would damage their reputation with the members and their political backers.

The SEP selected ECs with good financial and operational performance, in regions with high economic growth potential but different climate. Here, pilot projects were developed and SEP provided an incentive by sharing 50% of the solar generator's cost.

Users were not subsidized. In return, the ECs had to care for the installation, operation and monitoring. Initially, these costs accumulated for many to more than the granted amount. With time however, they learned to handle the technology and this learning curve allowed to gradually phase out the grant. All remaining proceeds went to a revolving fund for replacements and future procurements.

Rural Photovoltaic Electrification

With the experience from the demonstration projects the *RPE* concept was developed. Its main feature is that the ECs own the solar generators, finance them on long term loans and offer them to their consumers as an electricity service at low, yet cost covering fees [4].

As the sense of ownership is considered vital for a proper operation and it was found critical to win the utilities' support, ownership by the ECs is important for the RPE.

The individual user will not have to buy the generator, may return it when he cannot meet the financial obligations and retains the option of line electrification whenever it should become available. On the other hand his contribution is to properly operate and maintain his system.

Of all potential users, those in the more prosperous places were targeted initially as in the early stage payment problems should be avoided. They were expected to have more available resources to put this innovation to use. An appraisal scheme was developed by the SEP to help ECs choose the right PV site [5].

With the RPE the EC gains an additional instrument to perform her electrification mandate and report more members and electrified villages. SHS take little lead-time in planning and installation and may be relocated when the load reaches a level good for conventional electrification. ECs look at the RPE as a means of pre-electrification because in a limited way it would help to facilitate even a more viable conventional electrification. As an additional benefit, SHS users already learn to practice demand side management.

The ECs would have to assume additional tasks incurred with the logistics and supervision of many single and remote project sites. The SEP with NEA developed a series of training measures covering the institutional, technical, and monitoring instruments required to upgrade the specific knowledge of the ECs. In addition, competitions for site identification and awards for best performances spurred the motivation of the EC's staff.

The RPE should gradually develop and extend the domestic PV market, so all components for the RPE projects are bid out to local suppliers. The logistics are further strengthened by involving local enterprises in the supply, installation and maintenance of the systems.

3.2 Cost

Photovoltaic power supply systems are commonly considered expensive. For the individual Solar Home System this does not apply. Indeed, the cost is less than any other kind of electricity generator a household can buy: A 50 Wp panel will cost about $ 350 and come with an operational warranty of 10 years which again is more than offered for any other generator.

This exceptional lifetime allows the cost to be stretched over a long period so payment becomes acceptable for a wide range of consumers. The panel can also serve as collateral.

In the RPE, $ 480 for the solar panel, mounting, controller and house-connection financed over 10 years at 12% make $ 6.88 monthly payment. Including 10% for operation and maintenance a **household pays $ 7.60 monthly** and runs typically three lights, the radio and often a TV set. This service fee recovers all hardware cost and is not subsidized. It is mostly lower than the equivalent cost of kerosene for the commonly used pressure lamps.

For ECs such long term financing at low interest is usual and the individual user can enjoy these through the utilities. Specific economic conditions of the users such as seasonal income can be accommodated e.g. by offering one month's payment as discount for one-year advance payment.

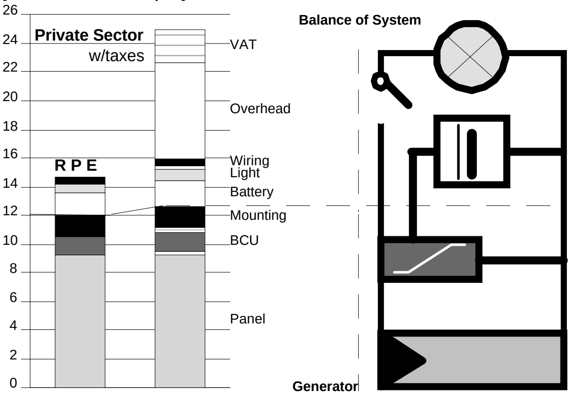

Fig.3 : System and Component Cost [Peso]

Commercial suppliers in comparison have to cover tax, a margin and overhead. While tax is less significant, substantial overhead cost occurs when a project is to be developed on a service level only remotely similar to the ECs. Also, they can only offer financing on short terms with higher interest rates [6].

In addition to the long-lifetime generator component a complete solar system requires the balance of system (BOS). A minimum BOS with battery, house wiring and appliances will cost $ 108, which is similar to the house wiring cost for line connection. It has to be fully paid before installation and proves the user's ability and willingness to meet the financial obligations.

3.3 Economics

The economical advantage of PV over line extension depends on the load density, i.e. the distance, number and consumption of the households. In a conservative Philippine scenario 40 households with 160 Wh daily consumption are already favorable for solar when they are more than 2 km away from the next pole (3.2 kWh/km).

As PV systems using energy saving appliances give more service per Wh than conventional appliances, this limit is even pushed further. The load increase of individual users can be accommodated more economically, because with the modular concept of PV generators the supply can easily follow the demand.
This bottom-up supply is exactly the other way round than in conventional electrification. Here, a minimum load level would be required to justify line extension. As the real load rarely provided the income to pay the investment, a social benefit had to be applied - the load had to be productive. Photovoltaic Electrification as long as the investment is paid will not require the *sine qua non* of productive consumption.

4. Experiences

In the course of the Special Energy Programme some 1500 households were electrified which constitutes a sufficient database. Emphasis was less on the total quantity than on the demonstration and analysis of the RPE concept and several complementing dissemination models. From their monitoring and evaluation valuable data on the institutional and material performance and recommendations for future project developments could be retrieved.

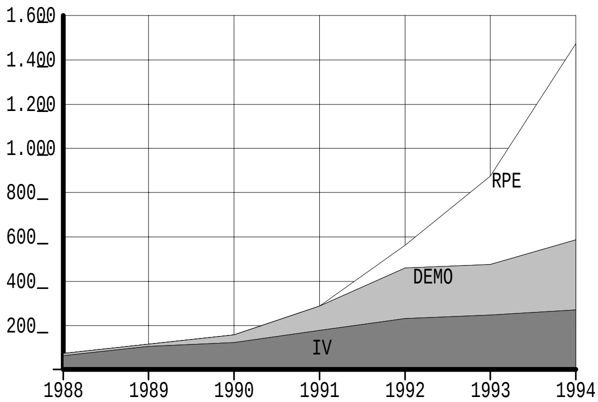

Fig.4: PV Electrified Households

4.1 Institutional

The input of SEP's technical assistance was to handle the project development in cooperation with the partner institutions. This task is generally found to draw considerable timely and financial resources and may be considered as main cost factor although there is a significant learning curve. For commercial suppliers (CS) and NGOs the project development cost is the main barrier. ECs are from their professional background more apt to the job but would initially need institutional coaching. Combining the advantages of the EC in development and financing with the independent CS service in supply and after sales operation offers a mutually beneficial solution. The cost of collection, operation and maintenance can be around $ 1per system and month for accessible sites but may reach more than $ 5 for scattered, remote installations.
The institutional setup and main financial parameters of the models observed are given in table 4.1 [7]: The RPE is column A; B is the cash sale of an SHS, C a commercial loan, and D a short-term soft loan. In order to accommodate user's payment patterns, E offers a soft loan including the BOS and F is based on a yearly advance payment with a one-month-off bonus. The RPE proved easiest to implement and counts for the majority of installations. Best collection efficiency was achieved however under the soft loans (D, F) which were particularly popular in areas where users would not realistically expect line electrification ever.

Function	*Actor*	*A*	*B*	*C*	*D*	*E*	*F*
Operation	EC	X					
	CS		X	X			
	NGO				X	X	X
Financing	NEA	X			X	X	X
	CS			X			
	User		X				
Owner	EC	X					
	User		X	X	X	X	X
Payment	***BOS***	4,100	4,100	4,100	4,100	-/-	4,100
	Loan	**190**	**14,000**	**535**	**420**	**535**	**4,620**
		120 m	COD	36 m	36 m	36 m	3 a
		12%		22%	12%	12%	16%
LCC	***S*:20**/m	27,688	28,360	31,523	27,122	27,426	**26,421**
10 a, 8%	**60**/m	**31,000**	33,160	36,323	31,766	32,226	31,109

Table 4.1: Institutional and Financial Dissemination Patterns
A=RPE, B+C=Commercial, D+E+F=Soft Loan
Amounts in Peso

Comparing the depreciated life cycle cost of the options at current prices shows that the RPE (A) which offers the lowest monthly rate burdens the user with the highest cost next to the commercial options (B, C). The most favorable costing comes with the short-term loan (D, F) as it is also offered by Development Banks. This applies however only as long as the monthly service cost is only 20 P ($0.80). Higher service cost clearly favors the RPE: At 60 P ($2.40) the RPE is already the least-cost option.

In determining the attractivity of a solution the supply side and the demand side apply different criteria. The power sector will judge the overall feasibility and studies [1],[2] show that for the consumer profile described the PV electrification is clearly the least-cost solution.
In order to assess the demand side several studies on user acceptance were conducted. Basic need surveys often did not rank electricity as a high priority among rural folks. It was found that users are clearly not looking for power as such, but that rather the service - light, information, entertainment etc. - is in demand. Once this service was experienced the prioritization would increase substantially.
Generally beneficiaries would like the service as cheap as from the subsidized grid. However, resource persons with and without SHS agree to prefer the PV service, as it offers a 24 h service, safety and reliable operation. They had experienced the comfort of PV electricity at home when elsewhere grid power was down after typhoons, flooding and technical failure.

This individual prioritization seems to be based less on economic evaluation as the price elasticity observed was low: Subsidies did not raise the initial acceptance of potential users.

4.2 Material

For the last three years, a nationwide monitoring scheme was introduced covering 746 installations, which were visited monthly. It should be noted that this monitoring not only gave a feedback on material quality but also significantly reduced the reported problems altogether, many of which seem to have been made only to defer payment.

As the RPE introduced materials with international quality standard, technical issues were the least problem [8].

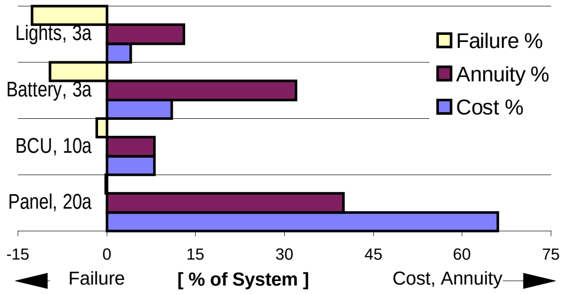

Fig.5: Component Cost and Performance

Solar panels are commonly subjected to rigid standards; so mass-produced crystalline solar panels perform fully to expectations. They account for 66% of the system's cost but only for 40% of the system's annuity. Some manufacturers seem to have a problem with the encapsulation, but in the majority of cases the degradation is within the specified 1%/a.

Battery controllers are lasting and reliable. Malfunctions were mostly due to tampering with the fuses, unauthorized load or reversed connections, which may be taken as a hint to more protected designs. Their annuity cost is low (8% of the system's annuity) so it is not economical to sacrifice battery life by saving on the controllers. Sophisticated overcharge protection is not required with household systems, as sadly most SHS batteries rarely reach the upper threshold. A clear indication of the battery state-of-charge helps users much with load management.

Lights show the highest failure rate of 12.6% after 20 months. Compared with an assumed lifetime of 36 months this is still only 45% of the pro-rated failure expectancy of 28%. Energy efficient lights come with tubes or compact lamps and can become expensive when users want to install several, yet the cost of an hour light is still below $0.05. Once exposed to efficient lights, users appreciate them, preferring white light. Only when lights were not readily available, tinkering with homemade solutions and bulbs started.

Batteries have the highest annuity next to the panels (11% of system's cost, 32% of the system's annuity). This cost varies more with the user's handling than with the manufacturing quality. As a consequence, the use of an expensive battery with a theoretically longer working life is not economical. A low cost quality battery will do, as long as replacements are available. Projects should take the proper disposal very seriously. In the Philippines, manufacturers recycle batteries and offer a $ 4 refund on return.

4.3 Market

With the SEP the supply situation in the Philippines has significantly improved in terms of availability, quality and cost. In 1993 SEP procured 600 SHS at $485. One year later, NEA bought 400 units at the equivalent of $458, which is an indication of a buyer's market. Buying larger quantities locally led to better prices for all and significantly stimulated the domestic market. Meanwhile some 14 companies contribute to the extended market. Panel prices dropped in the same period from $640 to $380 for 50 Wp. The project's public relation raises additional awareness and increases also the commercial demand. The initial suspicion of the private sector changed to cooperation.
ECs are no longer seen as competition but as viable clients as local enterprises do the supply, installation and maintenance of the systems. While the RPE provides only the basic system, individual upgrading with additional appliances like AC inverters, TV and even satellite receivers is entirely left to private suppliers. Today several projects are already commercially initiated and complement the EC's service in some areas. This underlines the potential of the cooperation of the public and the private sector.

The Department of Energy started the initiative **ProSolar** that aims at supporting rural project development by commercial suppliers. It prescribes system standards and includes type approval for PV components by the National Appliance Test Lab. In turn, all import tax on PV systems is waived. This will facilitate the wider application of international quality standards.

At the end of the pilot phase the cooperation endeavor can be considered to have established confidence in the PV concept. As a result, an additional 22 EC's have proposed RPE projects to be replicated by NEA and pave the way for a full-scale Rural Photovoltaic Electrification program.

5. Conclusion

The projects demonstrated under the Special Energy Programme in cooperation with the National Electrification Administration have opened and stimulated the domestic market in the Philippines. They showed that the main technical, institutional, and financial barriers could be removed. The barrier of high project development cost will be further pushed when photovoltaic electrification is implemented in large quantity as part of the professional electrification mainstream:

- RELIABLE
  A serviced project operates SHS above 98% availability. The failure rate of quality components is better than relative lifetime expectation.
- AFFORDABLE
  The demand for SHS under current terms within the next five years ranges to 50.000 remote rural households with small residential consumption who afford the system [5]. Financing of a properly developed project is not a problem. Projects with low service requirements will prefer short-term soft loans, which can be obtained from development banks and managed by NGOs or commercial suppliers. All projects in difficult areas with high service cost will prefer a rental scheme financed by the utility.
- MANAGEABLE
  Utilities and specialized NGOs have shown their ability to manage the operation and payment collection of SHS projects. The implementation of PV electrification schemes is economically superior to line extension. The project development and service cost proved higher than expected but can be covered with local labor content.

The economical advantages translate into even more benefits on the macro economical level: The cost to reach the 80% electrification goal in the Philippines is estimated by the DoE to cost $1,500 Million. The same goal could be attained with SHS for $ 72 Million. This much lower material investment requires however extensive management with higher input of local labor.
The unrestricted inclusion of PV in the rural electrification program would open a market of 20 MW. However, as of today renewable sources of energy are not competing in a free market for electrification because existing institutions are tailored to support conventional generation and distribution options and hidden support exists for conventional sources [9]. It would therefore not be sufficient and realistic to rely on market forces or call on private sector initiative alone. In fact, government programs have clearly been the driving force for the current renewable's market development, often supported by aid agencies. However, financial resources are limited and will not allow supporting both, the conventional and the renewable options.

Lest billions of people shall remain excluded from the benefits of electricity, it becomes imperative to call on focused Government policy:

- Subsidies to conventional energy sources should be gradually reduced to a socially affordable level
- Incentives should be shifted to renewable sources, until a fair competition is possible
- Subsidies should support the local labor content of project development and operation. The learning curves experienced will allow the subsidy to be phased out in time.

In order to be effective this policy must be consistent and predictable so the actors can plan and adjust to the rules. The expected results may be endangered when policy fluctuates with political interest. Also the availability of foreign assistance will be enhanced by a consistent policy. It is understood that this requires responsible political prioritization as the allocation of limited funds always compete with other important fields as poverty alleviation, health care, water, peace&order, industrialization, infrastructure, to name only a few.
The Rural Photovoltaic Electrification concept in the Philippines has demonstrated a viable improvement to the living conditions of rural families and opened a market for large-scale application. This was achieved with the cooperation of public utilities and private sector in a carefully tuned combination of technical support, supply and financing.
As we approach the next millennium the gap between those who have and who have no access to simple electricity services is widening and cannot be ignored. Solutions have been shown and focused actions of Governments, aid agencies, and financing institutions are required to address people's needs in time.

6. Acknowledgment

It must be considered a rare privilege that an activity like the Special Energy Programme has the opportunity to explore the different approaches of sustainable PV dissemination in depth and over a length of time. This work, the results of which can change the lives of millions of people, is the result of the consistent support by the Federal Ministry for Cooperation of the Federal Republic of Germany.

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Exchange rate Philippine Peso in 8/95:
1 DM = 17 Peso
1 US$ = 25 Peso