第７章　今後の計画策定のための教訓及び提言

１．PVシステムの有効性

PVシステムは、電気という高品位で貴重なエネルギーの供給を目的としている。メカニカル部分が無く、シンプルな構造なため扱いが容易で、メインテナンスフリーで長期運転が可能、かつ燃料が不要なこと等より、途上国の電化に最適な発電システムである。特に分散型などは、将来近くにグリッドが連系された場合、既存の太陽光発電設備を別の無電化地域に比較的容易に移設・再利用できる利点もある。

電池は、一般的にスケールメリットがないと言われている。太陽電池も例外でなく、電卓や時計などの小規模で利用する方が、電力用の大規模発電より競争力がある。日本においては、その中間型として住宅の屋根に設置する３～４kW規模のシステムがある。このシステムは、電力会社に余剰電力分を逆潮する事により、年間を通じて家庭での消費電力分をほぼ自前で発電することが出来るとされる。しかし、このシステムによる発電単価においても100円／kWhになり配電網からのみの電力供給に比べても高い。このことからもPVによる地方電化を実施する際、規模が大きくなる集中型システムは、不利となる傾向がある。この様なことからも、消費量の多い我が国で太陽光発電システムを導入するより、電灯用などのわずかな消費へ途上国での電化などに使用する方が理にかなっていると言える。

今回の調査は、３ヶ国の太陽光発電設備の視察を行った。その結果、長期間運転しているにも拘わらず（鉛電池の電極は腐食し容量低下が見られたが）順調に機能していることが確認された。特にタイDen Mai Sungの集中型電化システムは、設置後11年経過した設備を経ているが、現在も発電設備は機能しており、その電力による恩恵を享受している人々（82軒）がいたことに大いに驚嘆した。また、キリバスにおける戸別型電化システムは、わずか10数Wの蛍光灯であっても従来のケロシンランプと比較すると非常に明るく、夜間読書・手工芸が可能となり地元の人々にとっては大いに恩恵を与えている。

これらのことからも太陽光発電システムが、無電化地域の電化方策には大変有効な手段であることが確認された。

それぞれのシステムの設計は、消耗品交換の際、最も経費を必要とする鉛電池の寿命を延伸させるため、分散型の場合、放電深度を深くせず、蓄充電を制御装置で行い利用者は一切手をふれない様なシステムが有効である。集中型の場合、放電深度の設計等を工夫することにより10年間程度は設備の取り替えが不要となるシステム設計とすることが望ましい。

２．途上国における電力ニーズと太陽光発電（PV）協力の拡充

本調査の対象国となったキリバス、タイ、フィリピンの電化率はそれぞれ約20％（推定）、70％、60％（いずれもアジア開発銀行1990年データ）であり、またアジア太洋州地域では未だ10億人の未電化人口がいるといわれている。これらの国では、地方電化を促進するための政府機関（タイ：地方配電公社、フィリピン：国家電力庁）を設置し、送配電網の拡充・整備を行っているが、送配電線の延長が困難な遠隔農村地方や離島におけるPVの普及・促進についても具体的な目標を掲げて促進・普及を図っている。

途上国におけるPVの普及は、送配電線の拡充や従来方式のディーゼル発電による電化の場合

と同様に国が補助金を付けて実施しているのがほとんどであり、これを海外からの援助に頼ってきたのが実情である。一部の国では戸別型PVに関する低金利融資制度やPVパネルの輸入税免除措置の導入等により商業ベースによるPV市場の拡大といったことも試みられているが、PVシステムの価格がさらに引き下げられるまでは、当面海外からの援助は必要であり、我が国も無償、有償による資金協力と技術協力を積極的に展開していくことが望ましい。

3．地域ニーズに適したPV発電システムの選択

本調査では、戸別型（キリバス）、集中型、バッテリーチャージ・ステーション（タイ）、水供給（フィリピン）のPVシステムがそれぞれの国、村落において住民ニーズを満たし、その地域社会の中でうまく運営管理されている状況が確認できた。どのようなPVシステムを導入するかについては、計画段階において村落の経済的、社会的、物理的条件を把握することが重要となる。例えば、現在すでに電球や蛍光管、ラジオ、カセット・レコーダー等の利用のために車のバッテリーを使用している村落において、PVバッテリー・チャージャーは住民ニーズを十分満たすことが想定されるが、所得の向上とともに戸別型システム（SHS）に対するニーズが増大することも予想される。また、集中型システムを導入するとすれば、維持管理組織がどこになるのか、さらに急激な電力需要増が予想される村落の場合には発電規模をどのように設定すべきなのか、送配電線との連系をどう予測するかいったことがポイントになる。

つまり、PVシステムの導入にあたっては、村落レベルにおける維持管理組織の有無や組織活動の経験度、住民の支払い能力、PVサービスに対するニーズ、将来の電力需要の伸びを十分把握し、これを踏まえたうえで適切なシステムの導入を検討する必要がある。

4．組織・制度造り、人材養成及び住民教育の重要性

電力事業は多くの途上国においても民営化の対象となっており、電力公社等の事業体は経済効率に基づいた電源開発と電化拡充を行っているため、都市部から離れた一般的に所得の低い未電化農村地域への電化促進事業は、地方レベルでの配電公社や協同組合組織が国からの補助を受けつつ実施している場合が多い。

未電化地域においてPVシステムを導入する場合には、地域レベルでの運営管理組織のマネジメント能力が極めて重要な要素であり、既存の組織を活用する場合でも、あるいは新組織を作る場合でも、事業実施に先立ちその組織の運営管理体制をしっかり整備する必要がある。大きな故障を防ぎ、システムの寿命を最大限に延ばすために定期的なモニタリングと点検を行い、将来の修理や鉛電池のような消耗品等の部品交換のための資金を積み立てることが大切であり、そのような実施体制を確立しなければならない。そのためには、有能な責任者と、システムの運転・維持管理を行う技術者、料金徴収と財務管理、会計処理を行う要員の養成・確保が不可欠である。

さらに、PVシステムの能力や限界をしっかり住民に説明、自分たちの設備であるという意識を持たせ適切な取り扱い方や簡易な修繕方法等を指導し、高品位かつ高価な電気を大切に使おうとする意識を醸成していくことがプロジェクトの持続性を高めるために重要である。

5．総合的な提言

途上国における太陽光エネルギーの開発・促進に対してODAを供与する場合は、PVシステムの導入のみならず組織・制度造りや人材養成をパッケージで行うことがプロジェクトを成功に導くための重要な鍵となるので、無償資金協力や有償資金協力等の資金協力によるシステムの導入と組織・制度造り及び人材養成のための技術協力を効果的に組み合わせた協力を展開することが望ましい。

具体的には、開発調査によるマスタープランの作成やPVシステムのフィージビリティ調査と、専門家派遣や青年海外協力隊派遣を通じた案件の発掘や組織・制度造りと人材養成、そして資金協力によるPVシステムの設置を効果的に組み合わせ、村落電化や教育、医療分野等を含むコミュニティ開発を目的とした自立的なPVエネルギーシステムの確立に向けた協力を行う。

また、無償資金協力の供与にあたっては、農村における分散型電化が地域産業の発展にも波及するような枠組みを作ったり、また有償資金協力の場合には、貧困地域におけるコミュニティ開発として取り上げることによりソフト・ローンを供与するといったアプローチを検討する必要があろう。

さらに、EUは大洋州地域に対してPV分野の地域協力（キリバス、トゥバル、トンガ、フィジー、PNG）を実施している。この協力は、社会、経済、自然条件において類似点を有する国々に対するPVシステムの普及や技術移転という視点から、協力効果が高く、規模のメリットが得られるため、今後の協力の有効な手段となりうるであろう。

一方、PVシステムの普及には、途上国側がシステムの維持管理、バッテリー交換あるいは新規増設等を自立的に行える環境、つまり途上国の中の市場メカニズムの下でパネルやバッテリーが流通する仕組み、技術レベル、将来の電力状況などにあった基本的でシンプルなシステム、現地で生産可能な資機材を取り込んだ低価格なシステムの構築などが不可欠である。したがって世界のPV市場は必ずしもまだ大きいとは言えないが、途上国における安定的な市場形成に大きな役割を果たす製造業者側の活動にも期待したい。

収集資料リスト

地域		調査団等名称		調査種類		作成部課	鉱工業開発調査部　資源開発調査課
国名				現地調査機関	平成　年　月　日～平成　年　月　日	担当者氏名	宮川　昌明

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	THAILANND												
1	PEA STATISTICAL REVIEW 1996	A 4	書籍		オリジナル	1	PROVINCIAL ELECTRICITY AUTHORITY (PEA)						
2	Everywhere in Thailand	A 4	書籍		オリジナル	1	PEA						
3	The Project for The Electrification of Remote Areas	A 4	書籍		コピー	1	PEA						
4	PEA's Solar Power Plants	A 4			コピー	1	PEA						
5	Technical Data of Solar Power Plant Den Mai Sung Village Tak Province	A 4			コピー	1	PEA						
6	HYBRID RENEWABLE ENERGY SYSTEM DEVELOPMENT IN THAILAND	A 4			コピー	1	PEA						
7	PHOTOVOLTAIC BATTERY CHARGING STATION	A 4			コピー	1	Department of Energy Development and Promotion (DEDP)						
8	Photovoltaic Battety Charging Stations for Non-electrified Villages in Thailand	A 4			コピー	1	DEDP						
9	RESEARCH AND DEVELOPMENT OFFICE	A 4	パンフ	-	オリジナル	1	ELECTRICITY GENERATING AUTHORITY OF THAILAND (EGAT)						
10	EGAT AND ALTERNATIVE ENERGY RESOURCES DEVELOPMENT	A 4	パンフ		オリジナル	1	EGAT						
11	FANG GEOTHERMAL POWER PLANT	A 4	パンフ		オリジナル	1	EGAT						
	KIRIBATI												
12	TEITI IBUKIRA ELECTRICITY FOR EVERYONE	A 4	パンフ		オリジナル	1	Solar Energy Company (SEC)						
	PHILIPPINES												
13	SOLAR SYSTEM SUPPLIERS	A 4			コピー	2	NATIONAL ELECTRIFICATION ADMINISTRATION						
14	EXISTING MINI-HYDROELECTRIC POWER PLANTS	A 4			コピー	1							
15	RURAL PHOTOVOLTAIC ELECTRIFICATION	A 4			コピー	1							
16	RURAL PHOTOVOLTAIC ELECTRIFICATION SCHEDULE AND FUNDING REQUIREMENTS FOR CY 1997-2010	A 4			コピー	1							
17	STATUS OF PHOTOVOLTAIC APPLICATIONS AND INSTALLATION	A 4			コピー	1							

収集資料リスト

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18	Municipal Solar Infrastructure Project (MSIP)	A 4			コピー	1							
19	AN ACT GRANTING INCENTIVES TO MINI-HYDROELECTRIC POWER DEVELOPERS AND FOR OTHER PURPOSES	A 4			コピー	1	MINISTRY OF ENERGY						
20	POLICIES AND PROGRAMS ON NEW AND RENEWABLE ENERGY IN THE PHILIPPINES	A 4			コピー	1	Non-Conventional Energy Division Energy Utilization Management Bureau Department of Energy						
21	The following Technical Assistance Completion Report is attached for Regional Workshop on Solar Power Generation Using Photovoltic Technology	A 4			コピー	1	ASIAN DEVELOPMENT BANK						
22	REGIONAL WORKSHOP ON SOLAR POWER GENERATION USING PHOTOVOLTAIC TECHNOLOGY	A 4			コピー	1	ASIAN DEVELOPMENT BANK						
23	The following Technical Assistance Completion Report is attached for Rural Eenrgy Development Study (People's Republic of China)	A 4			コピー	1	ASIAN DEVELOPMENT BANK						
24	セブ州村落リスト	B 4			コピー	1	エネルギー省セブ事務所						
25	フィリピン・ドイツ太陽光発電ポンプ プロジェクトサイトデータ	B 4			コピー	1	エネルギー省セブ事務所						
26	太陽エネルギー消費量見通し	B 4			コピー	1	エネルギー省 (DOE)						
27	Inventory Update/Survey on the Use of Renewable Energy Systems in Cebu	B 4			コピー	1	DEPARTMENT OF ENERGY						
28	UNIT COST OF SOLAR HOME SYSTEM	B 4			コピー	1	NATIONAL ELECTRIFICATION ADMINISTRATION						
29	セブ州における新エネルギー開発プロジェクトのサイト一覧	B 4			コピー	1	エネルギー省セブ事務所						
30	PHOTOVOLTAIC PUMPING PROJECT WATER by SOLAR ENERGY	B 4			コピー	1	WATER RESOURCES CENTER						
	AUSTRALIA												
31	コンサルタント資料：CASE	A 4											
32	コンサルタント資料：George Wilkenfeld & Associates Energy Efficient Strategies	A 4											
33	コンサルタント資料：APACE	A 4											
34	別添1：豪州の太陽光発電事情	A 4											
35	別添2：国内支援実績	A 4											
36	別添3：SPF Reorganisation Article 関連記事	A 4											
37	別添4：EnvironNet 検索結果	A 4											

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4.Policies and Programs on New and Renewable Energy in the Philippines
5.Phipippne-German Photovoltaic Pumping Projectの概要
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7.フィリピンのSHS販売会社リスト
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1.キリバス政府から日本政府に提出されている無償資金協力要請書添付資料

GOVERNMENT OF KIRIBATI

M E M O R A N D U M

From: Secretary for Works and Energy

To: Secretary for Foreign Affairs

File ref: ES:16/7073

Copied to:

Date: 27 February 1997

Your ref:

dated:

PROJECT ON THE RURAL ELECTRIFICATION FOR HOMES AND COMMUNITY BUILDINGS IN THE REPUBLIC OF KIRIBATI

Please find attached a supplementary information on the Rural Electrification for Homes and Community Buildings Project in the Republic of Kiribati required by Government of Japan.

It is quite urgent that the Japanese Embassy in Fiji receives this document through the proper channel as soon as possible. Therefore it would be appreciated if you could treat this urgent.

Grateful your urgent attention please.

Teekabu Tikai
Secretary for Works and Energy

SOLAR ENERGY COMPANY

13, February 1997

RURAL ELECTRIFICATION FOR HOMES AND COMMUNITY BUILDINGS IN THE REPUBLIC OF KIRIBATI

Background.

The Kiribati Government determined that solar photovoltaics should be pursued for rural electrification in the mid 1980s. In response, the Solar Energy Company Ltd., (SEC) a private but Government owned corporation, was established in 1984 with the intent of selling solar PV systems to rural households and providing technical support where desired. Though there was a good initial response from rural households, by 1989 the sales has fallen to a level which can no longer support the company. The problem was analysed and it was found out that the popularity of PV systems in the rural areas has gone down as most of the people consider the technology unreliable and very expensive. The situation was further analysed and it was found that the problem was caused by the users themselves as they were not installing or maintaining the systems correctly. Furthermore most of the systems purchased can not cater for the users demands meaning that the systems were undersized. The result was poor performance of the systems and the user dissatisfaction.

In light of the above it was seen that the company can not survive on the direct sales approach. Therefore in 1990 the company was partly transformed into a utility while at the same time maintain the sales approach. As a utility it install, maintain and operate solar PV systems as well as offering a service to households at a fee. The utility concept was first tested in 1992 with a North Tarawa pilot project of 56 systems funded by the Government of Japan.

KIRIBATI RURAL UTILITY CONCEPT

In 1989 when the SEC faced bankruptcy and it was clear that the private market oriented approach to PV rural electrification was not a success in Kiribati, external assistance was sought from SPIRE (South Pacific Institute for Renewable Energy) to advise government as well as SEC Board of Directors as to what should be done. The result was a recommendation to convert the SEC from a sales oriented organization to a service organization based around a rural electricity utility concept.

The recommendations were:

1) Systems should be owned and maintained by the utility. Appliances and house wiring after the battery connection would be owned and maintained by the homeowner.

This is consistent with general electrification practice where the utility owns all generation and distribution up to the power panel in the house. This specifically was included to avoid the problems of householders modifying the primary systems components. This was intended to insure that the battery, controller and panels would be selected correctly and installed properly and that appropriate replacements would be installed should failures occur.

2) Rural Electrification districts would be set up under the utility. Each districts would be of a sufficient size to be properly serviced by a single SEC employee who would be designated as a field technician. This means that no installations would be made until at least fifty households agreed to accept service. A single technician can properly maintain about 125 systems and this would be the maximum size of districts. If more than 125 systems were installed in a district, it would be split making two districts on that island.

The component of the structure was added specifically to insure that a sufficient customer base was present on an island prior to installation in order to make it economically feasible to have a permanent local technician on the island.

3) Users would be required to sign a contract in which they agree to pay an installation fee of $50 and after installation not to tamper with any on the utility owned equipment, to maintain the panel area free of shade, to pay the levied fee monthly and to use the system in accordance with published guidelines - which includes not attaching any appliances to the system without prior approval of the utility. In return, the utility would keep the electrical supply in satisfactory repair, replacing all failed parts at no added cost except for the user owned lights and appliances.

This clause was inserted to help insure that users have the financial capability to pay and could be disconnected if they did not pay fees or use the systems as intended. It was also intended to avoid the common problem of users connecting high demand appliances or running wires to neighboring housed thereby exceeding the capacity of the systems and causing unreliable service and early battery failure.

4) Monthly fees would be set based on the actual cost of operation and maintenance which is the sum of the costs of battery replacement after and estimated life span of 4-7 years (according to the type of battery and its service requirements), the cost of replacing the controller at the end of its useful life and the operating cost of the utility organization. Fees would be different for different types and sizes of installations ranging from about A$10 for basic lighting to over A$50 per month for full system with capacity to operate a refrigerator and video as well as lights.

The intent was to fully recover the operation and maintenance (O&M) cost of each installation from the user. Initial capital investment may or may not be recovered according to government installation subsidy policy.

5) A utility employee who acts as the field technician (and lives in or near the district) would visit each installation once a month to check the equipment and to collect the fee.

The function of the monthly visit was both to perform necessary preventive maintenance and to insure that the user had not made unauthorised modifications to the system which could reduce its reliability or decrease battery life.

6) Twice a year, a senior technician from Tarawa (home) office would visit each district and audit the field technician's performance. Additionally, a senior technician would be available on call to assist field technicians in troubleshooting and repairs which are beyond the level of the field technician's training and experience.

In order to train field technicians locally, the level of training cannot usually be sufficient to qualify the trainee to provide more than basic preventive maintenance services. More complex problems in particular determining the causes of battery failure requires more experienced, better educated and more highly trained personnel. These senior technicians would be based at the SEC office but would visit each outer island at least twice a year with additional visits to assist the field technician with particular difficult problems.

7) Each rural electrification district was proposed to have a user's committee consisting of five to seven users elected by the rest of the users in that district. It would be the responsibility of that committee to carry complaints and requests from users to the utility management and to communicate utility matters (mainly reasons for fee and service charges) to the users. The committee would also arbitrate in the case of proposed disconnects due to customer failure to pay fees. It was recommended that if fees are not paid by the users after the agreed upon time, and a disconnect is not allowed by the committee, an additional, temporary, charge should be added to the district bill to pay the delinquent party's arrears amount.

This clause was included to provide for close communication between the SEC and its customers and to allow local arbitration of disconnects in order to retain the community flavour of the project but to require the community as a whole to bear the financial burden resulting from their decision to not disconnect a user who fails to pay the fee.

8) Annually the utility would have a general meeting with representatives from all user districts and would publish its fee system for the next year and provide justification for that structure. The user representatives could also air their problems and complaints for utility management response. Simultaneously with the annual meeting would be a week long training workshop for all field technicians to introduce new equipment and concepts and to provide a refresher course for general PV maintenance.

Quality communication with the communities served was considered essential to avoid misunderstandings about fee structures, maintenance policies and opportunities for service modification. Additionally, the meetings would provide an opportunity for upgrading and refreshing training of the field technicians.

These recommendations were accepted by the Board of Directors of the SEC and a new management team was selected in late 1989 to implement the PV based utility concept for the SEC.

THE JICA FUNDED PILOT PROJECT

To test the institutional concept and to establish a base for further development. JICA was approached to fund a pilot rural electrification project. After several visits by Japanese teams, a project was developed which would provide sufficient installations to allow the electrification of a complete RE district at a rural North Tarawa site which was typical of outer island communities both economically and culturally while it could be easily accessed for monitoring and evaluation.

The goal of the project was to provide the most realistic rural electrification experience possible while allowing close and continuing monitoring of the technical and socio-economic aspects of the projects. The project was therefore designed around the following criteria:

1) There would need to be at least 50 systems in the project which could be serviced by a single technician since that was considered the minimum acceptable size for a single rural electrification district.

2) Households provided the systems would be self selecting through the same process as produce for full scale rural electrification and initial $50 fee paid at the time of the sign up and agreement to contractual terms for service provision and fee payments. All fees charged and terms provided to users would be the same as for full scale projects.

3) The services to be provided would be the same as could be provided under the terms of full scale RE.

4) A local person would be selected and trained to serve as the SEC field technician and that person would provide the technical service and act as the SEC agent for fee collections under the same conditions as proposed for full scale RE.

The JICA team in co-operation with SEC designed the standard system to be installed. In order to meet the future needs of Kiribati rural electrification, the system needed to be high in reliability due to the difficulty and cost of accessing most of the future sites for the replacement of components. Since this would be a pilot for permanent rural electrification, not a short term attempt to satisfy the basic need for electrical services for a few years before a grid could be provided, the alternative. For this reason, the design was established through detailed computer modeling based performed in the RE district area and that information coupled with experience from other Pacific Island photovoltaic projects provided the basis for the load estimates. Using this load estimate, the system was designed to have no more than four days per year of full battery discharge. The design included:

1) Single crystal or poly crystal panels of 100Wp battery charging capacity.

2) 100 Ah deep discharge battery.

3) Charge and discharge controls.

4) High efficiency PL type lights with two 7 Watt and one 11 Watt fixture per system

5) A low power night light using high intensity LEDs.

More than one manufacturer was represented in the purchase of many of the materials allowing the gathering of comparative field data on the products.

The initial survey results which indicated that at least 120 households would be willing to sign up for the service and preparations were made to distribute the 55 available systems by lottery if more than 55 households paid the $50 installation fee. The lottery was not needed, in actuality it required some promotional efforts and support by the local government to get 55 households to actually pay the installation fee and sign the service contract for the available systems.

Two homes were instrumented to provide detailed charge and discharge current flow information every ten minutes. Also, a fully instrumented weather station was installed at the site with automatic data logging.

Installation, Operation and Monitoring

In early 1993, the systems were installed using local labour with the supervision and participation of a technical team from Japan. All systems used pole mounted panels and the same mix of lights. For the initial year of test, no other appliances or changes to the appliance mix was allowed. This restriction was applied in order to insure that the design was tested under the conditions used for its creation. The restrictions also were intended to aid in learning the actual desires of the users for added service since it was anticipated that the actual user requirements would not be met by the modular "one system fits all" approach and by restricting service, requests for change and complaints about the restrictions would be recorded and those needs could be integrated into future projects.

In mid-1993, the Japanese team returned for a technical evaluation and found the systems to operating as designed with no problems of significance. One year after the installations of the systems, the team again returned both for a technical and socio-economic evaluation of the project.

Pilot Projects Findings

In general the project results were as hoped. User satisfaction was high with the exception of a strong desire for radio and tape player attachments. Fee collections were high and technical problems minimal. The design performed as predicted and the project was considered an unqualified technical success. The only significant design error was the decision to set the charge cut off voltage at 15.3 V rather than the more common 14.5 to 14.7 V. This decision was made on the basis of recommendations from the battery manufacturer but resulted in excessive loss of water from the batteries which required maintenance service more frequently than could be managed by the single technician. Additionally, the need for high quality battery water was greater than could be supplied from the sources available to the SEC. Therefore, at the end of the year pilot period, other cut off voltages were tried in order to determine the highest voltage which could be used without excessive water loss. A setting of 14.8 to 15.0 V was found to be suitable for the class of battery being used.

The institutional arrangements were also shown to be generally sound. The primary problems were with the performance of the field technician in terms of fulfilling both the technical responsibilities and the fiscal responsibilities. As a result, the method of selection of the field technician was modified to be more comparative and to emphasize responsibility rather than just technical capability. The field technician was changed half way through the first year and there was a marked improvement in both the quality of technical service and fiscal responsibility.

THE LOMÉ II PROJECT

Following the completion of the initial trial year of the Japanese funded pilot project, the Ministry of Works and Energy concluded that the technical and institutional approach being used was satisfactory and met the needs of rural electrification for Kiribati. The decision was made to extend the concept beyond the pilot stage and to commence full scale electrification through photovoltaic power.

During the early stages of rural electrification, donor support for the initial capitalisation was considered essential since the fees which could be collected from rural customers would not be sufficient to fund further capitalisation until a customer base of at least 500 households was present. Fortunately, by the beginning of the JICA project, the European Union had already decided to provide support for PV based rural electrification projects in five Pacific nations: Papua New Guinea, Tonga, Fiji, Tuvalu and Kiribati. Recognizing that Kiribati had the capability and desire for a full scale project, funding sufficient to provide about 250 solar home systems was budgeted for Kiribati.

Two island had already been selected for the next stage of rural electrification, Marakei and Nonouti. To meet the expected initial demand, 75 systems were allocated to each island. The remaining 100 systems were allocated to North Tarawa where the success of the JICA pilot project had developed a strong demand by households which had not participated in the initial project. This demand, which was in sharp contrast to the cautious attitude of North Tarawa households at the initiation of the JICA project, showed clearly that there was a high level of user satisfaction among the pilot project customers.

The design of the systems for the Lome II project was carried out by S.P.I.R.E. the manager of the project for the FSED. Using design methods developed by S.P.I.R.E. specifically for the Pacific Islands, a design was developed which was essentially the same as that produced by the Japanese team. The components were purchased by the FSED under international tender using specifications provided by S.P.I.R.E. The equipment provided per household was:

- 100Wp Siemens photovoltaic panels
- Locally made Charge Discharge controller
- 100Ah Oldham deep discharge battery
- Two 7 Watt PL lights and one 11 Watt PL light from AWA-Compac of Fiji ½ Watt locally made night light

TRAINING COMPONENT

The Lomé II. Photovoltaic Follow-Up Project, of which Kiribati was a component, was primarily intended to provide advanced training to national implementing agencies in the development, implementation and operation of photovoltaic rural electrification projects. The training was provided both through formal courses provided by S.P.I.R.E. and through hands-on training through participation in all phases of the project.

The initial courses provided by S.P.I.R.E. was on component specification, tendering and purchasing during which the country representatives evaluated the tenders for the component purchases. The second course which precede the delivery of the system components was a technical course covering installation, troubleshooting and maintenance.

The hands-on components of the training included participation by the country implementing agencies in project design, site selection, site surveys, receiving testing management system design, field technician selection installation and project operation.

The method used for the in-country component of the training in Kiribati was for the S.P.I.R.E. expert to visit the country to work with the SEC in planning the following phases of the project. The SEC would then carry out the project phases as planned. Should there be difficulties, the S.P.I.R.E. expert was constantly available by fax or phone. At the completion of the planned project phase, the S.P.I.R.E. expert returned to Kiribati for an evaluation. Where problem areas were found, S.P.I.R.E. and SEC worked together to solve them. Through this process, not only was the project carried to completion smoothly and on schedule but the SEC gained invaluable experience while fully supported by S.P.I.R.E.

Project Implementation

During the six month period between the ordering of the materials and their delivery, the SEC concentrated on identifying the recipients of the systems and selecting the candidates for the field technician posts on Marakei and Nonouti.

FIELD TECHNICIAN SELECTION

Following the experience from the pilot project, the process for selection of the field technicians was intended to result in hiring a mature person with adequate technical capability and fiscal responsibility. The process included five stages:

1) Advertising the availability of the position about two months before delivery of the project materials

2) Administration of a screening test to insure that prospects would have adequate reading writing and math skills.

3) Interview by SEC senior staff resulting in the selection of a short list of candidates.

4) Vetting of the candidates by the Island Council (local government)

5) Technical performance testing through participation in the system installation process at all three projects sites.

But the time the materials had been delivered to the islands for installation, three candidates from Nonouti and Marakei had been selected. These six men joined with the field technician from North Tarawa and the technicians from the SEC main office to install the systems beginning with North Tarawa followed by Nonouti and Marakei.

THE STATUS OF PV BASED RURAL ELECTRIFICATION IN KIRIBATI IN 1996.

The Lomé II installations were completed in early 1995. Since that time, the technical problems have been minor with deficiencies in the 7 Watt lights causing the most problems. The lights were subsequently replaced by the manufacturer with improved versions. A S.P.I.R.E. representative inspected all the installations and few problems with the quality of maintenance which had been carried out.

Fee collections have continued to be greater than 80% on time and virtually 100% within two months of the due date. This high level of fee collections is attribute to the high quality of service provided and resulting user satisfaction and to the fact that systems are in fact disconnected for non-payment beyond two months and removed for non-payment beyond three months unless special arrangements have been mad with the SEC. Since the initiation of the project, less than 1% of the users are disconnected for non-payment at any given time. Removals for non-payment have been necessary only for systems abandoned when a family moves from the district.

In response to the demand for radio and tape player connections, the SEC has installed high efficiency DC/DC converters as a trial in households on North Tarawa with an increased fee of $1 per month. The response of the users has been uniformly positive and the converters will be provided to customers on Nonouti and Marakei during 1996 under the same terms.

A few customers have expressed the desire for further expansion of services and the SEC is in the process of devising a method of handling those requests.

OTHER ACTIVITIES

With 250 systems installed under the utility, there is insufficient revenue to cover all costs of their operation and maintenance. Until at least 500 systems are installed, there will be continue to be a modest short fall in revenue. That shortfall is being made up through cross subsidy from other operations of the SEC. In addition to its primary business of the Rural Electrification Utility, the SEC has significant income from:

1) the manufacture of controllers and DC/DC converters for scale in Kiribati and overseas;

2) management of PV projects for Government agencies, such as Health Department, Public Works Department and Secondary Boarding Schools on outer islands.

3) sale of imported PV components to private individuals and institutions in Kiribati and their installation.

From a commercial point of view, since its reorganization in 1989, the SEC has moved from near bankruptcy and chronic losses to a profitable, commercial enterprise with income more than sufficient to insure sustainability of the PV systems provided to rural customers.

EXPANSION OF PHOTOVOLTAIC BASED RURAL PV ELECTRIFICATION IN THE REPUBLIC OF KIRIBATI.

In response to the high demand for basic electricity need by the rural population of Kiribati, the Kiribati Government agreed that the existing rural electrification concept which has been successfully managed by the SEC, shall be expanded to cover all outer islands in the Kiribati Group and further expansion to the Line and Phoenix Group.

In February 1993, the JICA pilot study in North Tarawa was commissioned and handed over to be maintained and managed by the Solar Energy Company. In 1995 the Lome II project add 255 new systems. 115 were installed alongside the JICA PV systems in North Tarawa and the remaining 140 units were distributed equally on Nonouti and Marakei.

Since 1995 no other installations were installed. The SEC would require at least 550 units to reach a break even mark. Due to the insufficient number of systems, the SEC utility activities currently in operation is subsidized by other income from sales and other services.

The successful JICA project had demonstrated the viability and feasibility of a sustainable project. The fee charged to the users is affordable and services provided by the SEC has been satisfactory. It is now nearly 5 years since the installation of the JICA project and up to the present, none of the batteries has been replaced. The replacement cost of battery and other component has been deposited in an interest bearing account and it has reached $30,000 by February 1997.

The project is now well known through out Kiribati and the inhabitant of islands not yet covered by the rural electrification program are demanding for similar services to be established on their island. The SEC at this stage could not cover initial cost for project expansion to new islands but will be able to do this if the number of systems has been increased to 2000.

With the full support of the Ministry of Works and Energy, a plan to expand the number of SHS is approved. The Kiribati Government approached the French Government for the electrification of the existing 3 utility sites plus 5 new islands also located in the Gilbert Group. The 5 new sites are Abaiang, Maiana, Kuria, Abemama and Arorae. The feasibility on this project is anticipated to be carried out in April 1997.

In 1995 the Kiribati Government requested to the Japanese Government for Technical Assistance which initially involved 500 solar home systems. However, in view of the great demand for basic electrical services among the rural dwellers in Kiribati, the Kiribati Government will request to the Japanese Government for consideration, the increase in number of solar home systems up to 1965 SHS as can be justified by this supplementary paper.

In table 1, the name of the sites or islands were proposed to be electrified under the Japanese technical assistance.

Table 1. Proposed number of Solar Home Systems for Each Selected Atoll.

ISLAND	NO. OF HOUSE HOLDS	DEMAND FOR ELECTRICAL SERVICES	PROPOSED NO. OF HOUSEHOLDS SOLAR PV SYSTEMS TO BE INSTALLED
Butaritari	633	100%	300
Makin	292	100%	200
Aranuka	169	100%	100
Tabiteuea Meang	585	100%	300
Tabiteuea Maiaki	250	100%	200
Beru	539	100%	300
Nikunau	369	100%	200
Onotoa	431	100%	215

Tamana	263	100%	75
Banaba	80	100%	75
TOTAL	3631		1965

Table 2. Distribution by villages and recommended number of Field Technician to be recruited by SEC

Table 2a. BUTARITARI ATOLL: 300 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	SEC FIELD TECHNICIANS
Butaritari	50	1
Ukiangang	50	
Tanimaiaki	50	
Tanimainiku	50	1
Keuea	50	
Bikaati	25	
Kuuma	25	1

Table 2b. MAKIN ATOLL: 200 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF SEC FIELD TECHNICIAN
Kiebu	100	1
Makin	100	1

Table 2c. ARANUKA ATOLL: 100SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF SEC FIELD TECHNICIANS
Buariki	50	1
	25	
Takaeang	25	

Table 2d. TABITEUEA MEANG ATOLL: 300 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF FIELD TECHNICIANS
Utiroa	25	1
Eita	25	
Tenkiai	25	
Buota	25	
Tanaeang	25	
Tekaman	25	1
Tekabuibui	25	
Kabuana	25	
Bangai	25	
Tenatorua	25	
Aiwa	25	1
Tauma	25	

Table 2e. TABITEUEA MAIAKI ATOLL: 200 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF SEC FIELD TECHNICIANS
Buariki	50	1
Tewai	50	
Katabanga	25	
Taungaeaka	25	
Nukutoru	25	
Takuu	25	1

Table 2f. BERU ATOLL: 200 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF SEC FIELD TECHNICIANS
Nuka	34	1
Taboiaki	28	
Tabiang	27	

Ieriko	27	
Autukia	27	
Aoniman	27	
Teteirio	27	1

Table 2g. NIKUNAU ATOLL: 200 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF SEC FIELD TECHNICIANS
Nikumanu	100	1
Manriki	100	1

Table 2h. ONOTOA ATOLL: 215 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF SEC FIELD TECHNICIANS
Buariki	36	1
Tanaeaog	35	
Tekaawa	35	
Otoae	35	
Aiaki	35	
Tabuarorae	35	1

Table 2i. TAMANA ATOLL: 75 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF SEC FIELD TECHNICIANS
Bakaakaa	38	1
Barebuka	37	

Table 2j. BANABA ISLAND: 75 SHS

VILLAGE	NO. OF SOLAR HOME SYSTEMS	NO. OF SEC FIELD TECHNICIANS
Antereen	75	1

MONTHLY INCOME PROJECTION AND COST OF MAINTAINING PROJECT

Fee Structuring Methodology

The most basic factor in the analysis of a project is its assumed life. In the case of conventional rural electrification, it is common practice to assume a project life based on either the effective life of the major capital components. In the case of solar, the major capital components are the solar panels. Their operational life is not accurately known since panels produced using current technical processes have not been in the field more than about 20 years. Under this warranty, any degradation of output from the panes in excess of 10% over the rated value will be compensated by the manufacturer. Since the major capital components are warranted to last at least 20 years, for the purpose of project analysis, a period of 20 years is reasonable and was chosen.

Component Life and the Salvage Value

The assumed life of all components is based on actual field experience with the components being used. The capitalized components of the solar home systems provided under the JICA pilot study and Lome II project are solar panels, batteries, appliances (lights), controllers, wiring, switches, mounting hardware and installation labour. With the exception of the batteries and panels, these components of solar home systems have no salvage value at the end of their assumed life.

The salvage value of the components in place at the end of the 20 years is assumed to have a value proportional to the remaining life of eight years, there will be a replacement at the eight and 16 year points in the project time line. At 20 years, the installed controller will still have four years life - half of its assumed life - remaining and therefore salvage value is assumed to be half of its initial cost. This approach is justified by the continuing operation of the project beyond the 20 year period. Rural electrification is a continuing process, not one which is totally renewed every 20 years. Therefore it is reasonable to assume that the controller which is in place at the 20 year point will continue to used until it wears out rather than salvaged and replaced by a new one.

BATTERIES.

The lead present in spent solar batteries has a resale value of about 3% to 4% of the initial price of the battery. However, recycling of spent solar batteries is an important environmental protection component of solar based rural electrification. For Kiribati, to recycle the batteries requires separating the lead from the other battery components and shipping the separated components to a battery manufacturer in Fiji or Papua New Guinea. The cost of recycling is about equal to the salvage value of the spent battery and therefore for the fee analysis, no battery salvage value is assumed.

PANELS.

The solar panels are special case since they rarely fail outright and their loss of capacity is so slow. Since the manufacturer warrants the panels to have a degradation of no more than 10% for 20 years, it is reasonable to assume that the panels will have an available capacity of at least 90% on initial value at the end of the 20 years analysis period.

As with other components, it is not reasonable to assume that panels will be scrapped at the end of 20 years if they still have 90% of their original power producing capability intact. What is expected to happen is that additional panel capacity will have to purchased to replace that lost over the first 20 years of the panel's life. Since there is no evidence that further degradation is faster than that which took place the first 20 years, the end result is that in the second 20 years of the project, the power is likely to produced by a mix of newly purchased and older panels.

Therefore for the analysis, the panels are assumed to have a salvage value proportional to the percentage of available capacity remaining. Since the manufacturer warrants the panels to have 90% of initial capacity remaining after 20 years, the effective value of the panels after 20 years would be the cost of a new panel with 90% of the capacity of the original value.

One factor which can be expected to reduce the salvage value of the panels is the probability that panel costs will continue to fall slowly. At present, the panel capacity can be replaced for about US$4.50 per rated Peak Watt (Wp). Many manufacturer and Government analysts expect that the panel capacity will drop to a minimum of about US$2 per Wp over the long term. It is unlikely to go lower unless an unforeseen technical breakthrough occurs since the cost of glass, frames and packaging is not likely to fall significantly. To compensate for the likelihood that replacement capacity will be cheaper than the initial capacity a salvage value of 80% of initial cost rather than 90% - the percentage of actual capacity remaining - was used in the analysis. This effectively assumes a replacement cost of US$2.25 per Peak Watt.

Monthly Cost of Component Replacement.

Since the initial capitalisation is assumed to be provided through external or internal subsidy and will not be recovered from the user, the fee that is collected from the user to replace a component should be an amount which will, when totaled at the end of the component life, be sufficient to replace that component. For the analysis, monthly fee collection is assumed since system maintenance is normally carried out on a monthly basis. The fee which is collected is placed in an interest bearing account, therefore the future value of the string of received fees placed at the available rate of interest for a period of time equivalent to the life of the component should equal the replacement cost of that component.

The interest rate assumed is that of interest bearing accounts at a commercial bank in Kiribati. Presently, that is typically 4% to 5%. The replacement cost of the component is not necessarily the same as the capital cost since replacements do not have to be the same units which were supplied under the restricted tender used by the donor. This is a particularly noticeable in the case of batteries since a U.S. made replacement (a pair of 6 Volt Trojan T105 batteries connected in series) can be landed in the Pacific Islands for a fraction of the cost of the excellent but expensive Oldham battery supplied under the Lome II tender. Laboratory tests as well as field experience in Fiji indicates that two T-105 batteries connected in series have greater capacity and a life at least equal to that of the Oldham battery. Two T-105 batteries can be landed in Kiribati for about one-third the delivered cost of the Oldham unit.

Support Costs

In order to perform maintenance, fee collection and the other activities associated with the operation of the project, there are institutional costs consisting of administration and technical labour costs, overhead costs and travel costs which must be incurred. Most Organizations implementing rural electrification projects have other activities. Therefore, many of the institutional costs must be allocated based on the percentage of each cost which applies to the rural electrification project.

It is assumed that the technical support will be a combination of service by locally based field technicians and by more experienced technicians based on the capital island. In many cases, the local field technician will perform services on the project not part of the rural electrification program, such as maintenance of private school solar systems, but for a purpose of this analysis, the full cost of locally based technicians will be assumed to be directed to the rural electrification project. This includes salary, local transport and other support costs. For the senior technicians, a justifiable percentage of salary and office support costs plus the actual cost of travel to field sites are allocated to the rural electrification project.

With the small number of employees and limited number of different activities being handled by the institutions responsible for Pacific Island solar based rural electrification, personnel and support costs can be allocated among projects based on actual time spent on each. Where that is not practical, as in some administrative costs and general overhead they can be allocated on the basis of the percentage of total gross income generated by each activity.

Supplementary Project Income.

Besides the periodic fees which are collected from users for the solar home systems, users are usually required to pay a one time charge. This could be considered a negative capital component in the setting of fees but for clarity in the analysis, it is assumed to be supplementary project income which offsets some of the operation and maintenance cost of the project. For all the independent Pacific Island countries except Nauru and Western Samoa, rural electrification is in its early stages and expansion can be expected to continue for many decades into the future.

The actual situation is likely to be an irregular growth with large numbers of installations some years and none in others. Since there is no predictable pattern to the growth of rural electrification in Kiribati, it is reasonable to assume a constant growth which appears appropriate in the light of past growth and long term development plans. Since the effect of this supplementary income is small, an assumption of linear growth in system numbers and growth based on difficult to substantiate but reasonable estimates will not introduce a significant error in the result.

In any project requiring repayment by users, there will rarely by 100% of the imposed fees actually collected. The percentage actually collected will differ according to many factors including customer satisfaction, the method of collection, the affordability of the fee, whether or not systems are disconnected due to non-payment and the relative importance to the user of the service being provided. In Kiribati where there are well maintained systems and a demonstrated policy of disconnection for non-payment, on-time fee collections of 90% not paying within six months

Paying customers must cover the cost of non-paying customers if the project is to be sustainable without operating and maintenance subsidy. Therefore the fee charged must be reflect the expected rate of non-payment of fees. For this analysis, 85% collection is assumed as reasonable since collections have been better than 85% n the recent projects of Kiribati.

For the JICA pilot project, the small installed base of 56 systems would have resulted in an unacceptably high fee if all costs had to be recovered from just the served households. Therefore, a fee of A$9 was set based on actual 1994 SEC operating costs and the projected fee income for 500 systems (which was considered to be an achievable number of installed systems within five years) rather than on the immediate system size of 56 installations. This was consistent with the intent of the project which was to test not only the technical aspects but also user acceptance of the fee which would be required to cover O&M costs of PV based rural electrification on a large scale. It also allowed a fee structure comparable to existing expenditures of households on kerosene and dry batteries. From the SEC and Government point of view, setting the fee as though 500 systems were installed was considered justifiable since: (a) if the JICA project was successful, the intent of the Kiribati Government was to continue rural electrification through photovoltaics as rapidly s possible with an average of 200 new installations per year coming on line beginning in 1995 or 1996 and continuing until rural electrification is complete; and (b) fee income could be averaged over four or five years when batteries probably will require replacement.

With the completion of the Lome II project in 1995, the customer base rose to 306 which, keeping the JICA project fee of $9 for lighting and adding A$1 for those desiring a radio connection, still results in about an A$9,000 per year shortfall. In establishing the Lome II fee structure, it was decided not to change the basic JICA fee structure because the break-even point of 525 systems was expected to be passed by 1997 and after that the surplus from further growth would cover the short-fall of the early years. On a 10 year basis, assuming the expected average of 200 systems added per year - representing about 30% rural coverage by 2005 - there should be a net of surplus sufficient to not only cover the initial short-fall but to capitalize system expansion for long time customers desiring more services. If the rate of growth is slower than projected, the SEC is prepared to provide a cross subsidy for a few years from profitable components of the SEC activities which include contract work done for Government Departments (currently Ministry of Health, PWD, Boarding Church owned Secondary Schools etc.,), contract work for private organizations such as religious schools and the local sale and export of imported and locally made solar components. While this cross-subsidy could delay the ability of the SEC to increase levels of service to existing customers, the demand for load growth during the early years is not expected to be great and this should not seriously reduce user acceptance.

KIRIBATI COST ANALYSIS FOR SETTING OF USER FEES

Effective Interest Rate = 4%

Finance Charges = 12%

Term of Analysis = 20 Years

MINIMUM MONTHLY FEE NO DC/DC CONVERTER = $8.95

MINIMUM MONTHLY FEE WITH DC/DC CONVERTER = $9.22

1995 FEE CHARGED NO DC/DC CONVERTER = $9.00

1995 FEE CHARGED WITH DC/DC CONVERTER = $10.00

Replacement cost, systems with no DC/DC converter = $4.68

Replacement cost, systems with DC/DC converter = $4.95

Prior to the installation of systems, the SEC will recruit 19 full time Field Technician for the selected 10 islands. They will be trained by the SEC in the repair and maintenance of the systems as well as the collecting of monthly fees. The training will be carried out before and during the installation of the solar PV systems to ensure that the Field Technicians can do the required work without external supervision. The Senior Technicians who are stationed at the SEC office in Tarawa will make regular visits to the sites not only to ensure that the Field Technicians are doing their job but to actually see that the systems are well maintained and fees are properly documented and/or recorded.

All expenses incurred in the maintenance of the systems, which include the salary of Field Technicians, replacement of defective or damaged components, cost of the SEC visits to the project will be met from the fees collected from the users of the solar PV systems. It has been established that a minimum of 75 units per site is viable to recruit 1 Field Technician. Please refer to Table 2a-2h for the distribution of solar home systems for each site. Table 3 below shows anticipated income from the project.

Table 3. Monthly income projection and cost of maintenance per site.

ISLAND	No. of SHS	Total Income per month (A$)	Cost of Maintenance per month (A$)	Cost of Administration and overhead	Replacement cost per month	Net Profit/(Loss) per month
Butaritari	300	2,700	(375)	(75)	(1,404)	846
Makin	200	1,800	(275)	(75)	(936)	514
Aranuka	100	900	(175)	(75)	(468)	182
Tabiteuea Meang	300	2,700	(375)	(75)	(1,404)	846
Tabiteuea Maiaki	200	1,800	(275)	(75)	(936)	514

Beru	300	2,700	(375)	(75)	(1,404)	846
Nikunau	200	1,800	(275)	(75)	(936)	514
Onotoa	215	1,935	(275)	(75)	(1,006.3)	578.8
Tamana	75	675	(175)	(75)	(351)	74
Banaba	75	675	(175)	(75)	(351)	74
Total	1,965	17,685	(2,750)	(750)	(9,196.2)	4,988.8

CONCLUSION

The experience in Kiribati powerfully illustrates the contrast between PV based rural electrification based on individual purchase and institutional management. The attempt at rural electrification through the sale of systems to users, even with available service and support, failed to bring electrification to a significant number of rural dwellers and resulted in systems which performed so poorly that confidence in PV was lost by rural households. The shift to service provision by a utility type institution has completely turned around the situation with high user satisfaction and rural households now paying in advance to be put on a waiting list for systems. The problem of the SEC has shifted from trying to locate customers to provide sufficient operating revenue to expanding sensibly yet rapid to fill the demand for extended and expanded services.

2.タイ・地方配電公社のハイブリッド方式による再生可能エネルギー研究要約

HYBRID RENEWABLE ENERGY SYSTEM DEVELOPMENT IN THAILAND

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ABSTRACT

This paper describes PEA's programme on design, implementation and evaluation of pilot hybrid renewable energy systems for electrification of remote villages in Thailand. It is proposed that three hybrid energy systems namely, PV/Microhydro/Diesel/Battery, PV/Diesel/Battery and PV batteryless grid connected power stations be installed to demonstrate and evaluate advanced renewable technologies. Methodologies used in systems design, descriptions and operations of the systems are given in details.

KEYWORDS

Photovoltaic; diesel generator; microhydro generator; hybrid energy system; remote area power supply; rural electrification

INTRODUCTION

PEA is a state enterprise responsible for the distribution of electricity in all parts of the country except Bangkok Metropolitant area, which is over 99% of the total area of the country. This includes remote areas which do not have access to the grid. At present there are about 1,400 out of 64,000 villages remain to be electrified which some of them are remote from the grid such as islands and along the border of the country. Recently, PEA has initiated a programme on the implementation of pilot hybrid renewable energy power plants at remote villages.The programme is a bilateral cooperation between PEA and International Centre for Applcation of Solar Energy (CASE), a UNIDO agency. Thailand's Chiang Mai University and Australia's Curtin University of Technology are also participating in the programme. The main objectives of the programme are to demonstrate and evaluate advanced renewable technologies and to familiarise PEA staff with the hybrid energy system design, components sizing, costing, installation, operation and maintenance. In this paper, overviews of the three hybrid renewable energy systems are given below.

HYBRID RENEWABLE ENERGY SYSTEM

System configuration

Diesel power generation is PEA common practice for supplying electricity to remote villages as diesel generator is relatively cheap and power plant construction time is short. However, the generator has very poor fuel consumption efficiency at light load. Furthermore, fuel cost at site is quite high as access to remote site is usually difficult resulting in high transportation cost. A novel hybrid energy system, where electricity is generated using multiple fuel sources (Nayar, 1994) significantly improves efficiency of the diesel. A typical configuration of the system is depicted in Fig 1.

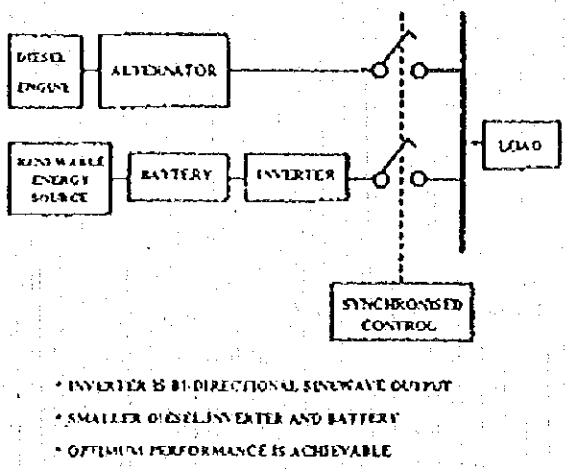

Fig 1. Hybrid Energy System

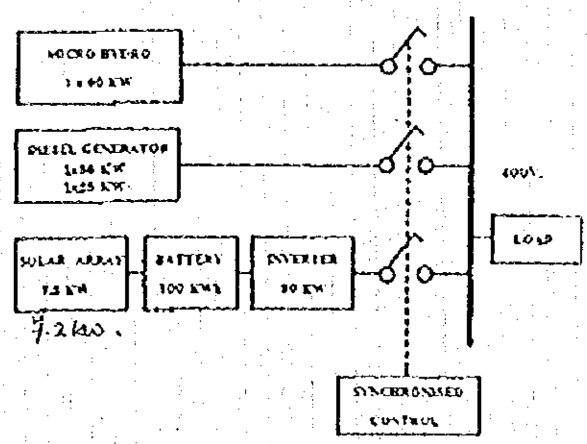

Fig 2. PV/Microhydro/Diesel/Battery Hybrid System

System operation

The system has three operating modes as the inverter is capable of bi-directional operation. At light load and the battery is sufficiently charged, the system supplies the load from the battery. At medium load, the diesel is automatically started to supply the load and also to charge the battery. During peak load, both the battery and the diesel operate in parallel to supply the load. The major advantages of this systems are that diesel, inverter and battery can be sized smaller than stand alone system and optimum performance can be achieved.

System design approaches

In designing a hybrid energy system it is necessary to have information concerning energy source available, energy demand and load profile. These information is normally obtained by a technical site survey which includes load study as well as socio-economic and cultural study. When peak demand, daily energy demand and load profile are estimated, the system operation and system component sizing can be determined. Under this programme, all of the demonstration sites are located between latitude 12 - 19 N and longitude 98 -112 E. The average horizontal surface sunshine equivalent of 4.5 Peak Sun Hours is used in the design.

In rural Thailand, a typical daily load profile has two peaks, one at around 6 AM and the higher one at around 7 PM. The daily energy consumption per household is about 1 kWh. The typical loads are lighting, television, refrigeration, and rice cooker.

PV/MICRO-HYDRO/DIESEL/BATTERY SYSTEM

The existing microhydro/diesel power system at Kun Pae village in Chiang Mai Province comprises a 90 kW micro hydro generator which caters for the entire current energy demand for approximately 9 months of the year. During the remaining summer months, power is generated only for 5 hours average per day from a 56kW diesel generator set. At present, the system supplys electricity to about 100 households for 14 hours a day and the monthly energy consumption is about 3200 kWh. PEA is extending the distribution system to nearby villages and the daily load will be increased. A peak load of 35 kW and daily energy demand of 250 kWh are anticipated. It is proposed to introduce solar photovoltaic array and battery storage with power conditioning, control and remote monitoring into the system as illustrated in Fig 2.

System operation

The system will have two modes of operation, namely the wet season and the dry season. The availability of water flow for the hydro plant is the key aspect. In the wet season, the hydro generator supplies the load and will partly charge the batteries through the inverter working as a battery charger. The battery will also be charged during the day from the photovoltaic panels. When the system load is very low to support the hydro generator, the load is met by the battery inverter in the stand alone mode. In the dry season, when the system load is low the solar array supplies part of the load directly. The mismatch between solar power input and the load is either supplied by the battery or stored by the battery. It is proposed that the diesel runs between 6-10 pm every day to supply the load and charge the battery.

PV/DIESEL/BATTERY SYSTEM

The existing power system at Ko Kut, Trat Province comprises two 56 kW diesel generator sets supplying interrupted power to about 250 of the houses through an overhead line. Power is mainly used for lighting, television, radio and rice cooker. The peak load of 50 kW is anticipated. The proposed hybrid system comprises solar photovoltaic array, diesel generators and battery storage with power conditioning, control and remote monitoring as shown in Fig 3.

PV GRID CONNECTED SYSTEM

Three PV/Battery/Inverter power systems were commissioned in 1986 by PEA to meet the then villages power requirements. Recently, PEA has extended the 22 kV distribution system into the villages and made this renewable energy system redundant. In order to maintain full use of the existing 60 kW solar array, it is proposed that the existing 40 kW inverters at Den Mai Sung, Tak Province and Mae Ka Si, Nakorn Sawan Province be replaced with a new 45 kW grid connected inverter of the latest technology (Borle et el., 1993) which operates in a battery less mode to input into the grid the anticipated 45 kW from the solar array during daylight hours. The block diagram of the proposed system is shown in Fig 4.

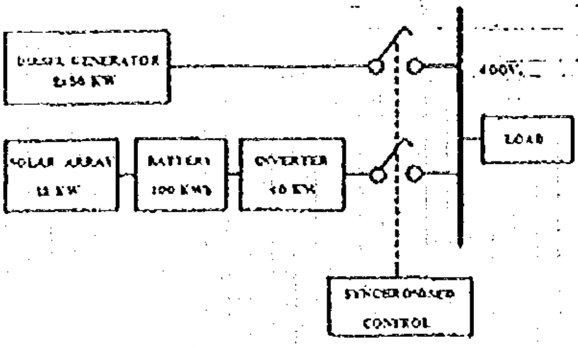

Fig 3. PV/Diesel/Battery Hybrid System

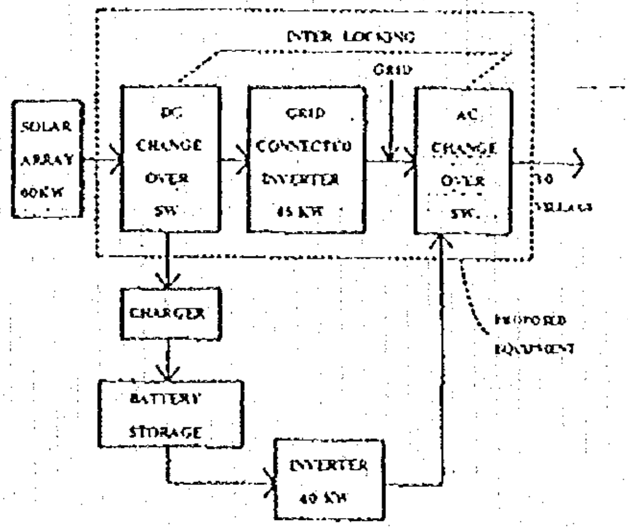

Fig 4. PV Grid Connected System

REMOTE MONITORING

It is proposed that at each of the four demonstration sites a suitable telecommunications link be established such as a radio phone with a modem be installed to remotely monitor the performance of the system. The following parameters will be monitored; system load (kW), current, voltage and frequency; solar insolation level; diesel fuel consumption; battery current and battery room temperature etc. The remote monitoring system is introduced to demonstrate appropriated application of computer and telecommunication to small power plant operation and control.

CONCLUSIONS

The programme seeks to identify and apply a number of new technologies and design approaches so as to achieve a suitable and acceptable cost power supply for remote villages in the PEA areas of operation. For this first phase of the programme technical site surveys have been carried out at three different sites. At present, system design has been completed and ongoing activities involve equipment procurement, construction and commissioning of the power plants. Then, the system performance will be monitored and evaluated. Finally seminar and training courses will be organised to transfer the technologies to PEA staff.

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3. The Philippine PV Experience and Programs

THE PHILIPPINE PV EXPERIENCE AND PROGRAMS [1]

by

Jessie C. Elauria [2]

Abstract

This paper discusses the Philippine experience for more than twelve (12) years of research, development, promotion and commercialization of the photovoltaic (PV) technology. A macro-overview of selected and major past and present PV projects are presented. This gives a rich perspective of the various roles of traditional and occasional operators in the PV sector. Lessons learned from these projects are also indicated. Additional highlights of the paper include the government's mandate, policies, plans and programs on PV.

I. Introduction

The Philippine government is committed in the full development and utilization of new and renewable sources of energy (NRSE). Centrally mandated to accelerate the research, development, promotion and commercialization of these resources, the Department of Energy (DOE) explicitly defines the potential role and contribution of NRSE in the strategic long-term Philippine Energy Plan (1995-2025). Various utilization and conversion technologies for these resources are envisioned to help build the links to economic sustainability of rural economy. Specifically, NRSE is seen to play a vital role in public infrastructures development like rural electrification. Among the pools of renewable energy technologies that are available today, the solar photovoltaics (SPV) offers the most flexible and practical solutions to address rural electrification imbalance.

Solar PV today has gone a long way and is already in the road to commercialization. Several strides have been achieved. PV applications for remote locations were proven feasible. Private sector role seems very promising. Past projects provided the impasse for developing a long-term national plan for developing the PV market, thus paving the way for a declared national policy on decentralized rural electrification. This clearly supports the preferential bias the government maintains for promoting NRSE.

The government could play a vital role in directing the development thrust of the Philippine PV program. The DOE for this matter is preparing the groundwork for involving electric cooperatives, private sector and NGOs in sustainable decentralized rural electrification (DRE). Although the route to sustainable development and use of PV is long, the government will try to optimize resources so that in the end the PV technology can contribute to our energy security and sufficiency objectives.

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[1] *Paper presented during the 'Regional Workshop on Solar Power Generation Using Photovoltaic Technology' held on February 20-23, 1996 at the Asian Development Bank.*

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II. The Philippine New and Renewable Energy Development Program (NREDP)

The NREDP consists of three sub-programs. First, the Technology-sub-program which aims to strengthen the competitiveness of NRETS; Second, the Promotion and Commercialization sub-program which aims to prepare the market and growth of the renewable industry; and Third, the Area-based Noncon-Energy sub-program (ABNEP) which aims to implement NRSE projects and programs in rural areas using the area-based, decentralized, bottom-top energy planning strategy.

New and renewable sources of energy (NRSE) provide an alternative for meeting rural energy requirements. There are renewable energy-based technologies which provide an option for electrifying areas that can not be economically connected to the power grids. Aside from being an abundant energy resource in developing countries like the Philippines, renewables are likewise more environmental friendly than fossil fuels.

The DOE and other government and private companies have drawn up programs/projects to promote the large-scale use of renewable energy. These include the following: (1) Renewable Energy Power Program (REPP); (2) Financing Energy Services for Small Scale Users (FINESSE); (3) Isang Libong Bahay: Pailaw Mula sa Araw; (4) the MILIEV PV Program (Environmental Improvement for Economic Sustainability or EIES), (5) the Agrarian Reform Communities' PV Program of the Social Reform Agenda (SRA), (6) the Solar Municipal Infrastructure Program, (7) RP-India NRSE Technology Cooperation, and others.

The DOE expects to support these programs with market development activities such as conduct of market survey, market characterization of supply and demand, market projections, pre-feasibility and detailed feasibility studies, and drawing up of marketing plans, among others.

Likewise, intensive promotion through awareness-building activities shall be undertaken to encourage private sector participation, improve public acceptance and boost the appreciation of decision makers and government planners of the commercial use of new and renewable sources of energy.

Strategies in NRE Development

Consistent with the country's overall energy policy and objectives, the DOE has established the following specific strategies in the NRE sub-sector:

- Support technological research and development on NRE
- Intensify promotion of judicious utilization of NRSE
- Assist private sector in the manufacture of NRE equipment and devices
- Create favorable market environment for NRSE technologies
- Institutionalize area-based energy planning and management for NRE
- Support commercial scale NRE projects
- Enhance coordination and planning of NRE policy and program
- Strengthen private sector participation and technical capability of CRIs
- Conduct of state-of-the-art technology study for NRE
- Conduct and update technology market assessment

Rural Electrification

Roughly, the government's electrification program has reached only about 51 percent of the total household population. Given the most favorable economic, political and social conditions, electrification by grid networks can only reach about 67.57% by the year 2000. This still leaves about 32.5% of households unelectrified.

The country's archipelagic configuration, that is, comprising more than 7000 islands make the use of renewable energy a least cost option for meeting the basic electricity demand of rural people. Distribution networks and installation of medium-sized power plants are not feasible in many communities because of remoteness of locations mostly in upland communities and coastal areas, low load densities, and scattered house locations.

National Plans for PV Development

The government plans to pursue a comprehensive PV program that will propel its widespread dissemination and commercialization.

DOE's development plans for PV include the following:

- Development of measures for the improvement of supply of solar PV technologies for rural areas (improvement of the general conditions, systems, and marketing)
- Development of measures to intensify the acceptance and demand for solar PV technologies for rural areas (demand analysis, demonstrations, maintenance services, financial instruments).
- Development and identification of strategy for the dissemination and commercialization of solar energy technology.
- Development of requirements for advanced training related to solar energy.
- Conduct of research on the production of solar cells or local PV panel assembly plant, if perspective feasibility studies show favorable results.
- Pursue demonstration projects for large-scale or utility connected PV systems

Support Programs for PV

Support for R and D Activities	The current R&D thrusts for PV technology are being redefined by the DOE-UP-NEC Solar Laboratory. Major components of the R&D work, however are focused on the development of low-cost and efficient PV components, establishment of minimum product standards, and quality control. The DOE through the Solar Lab will continue to conduct field monitoring of existing PV installations. Likewise, technical advisory services will be provided to the ANECs, private groups, and others.

The Solar Laboratory has already developed a certain level of technical capabilities in handling PV projects. The DOE, as a matter of policy, will continue to support the efforts initiated and is considering the vast potentials of using PV in economic development.

Support for Pre-commercial/Pilot, Demonstration Applications

The archipelagic nature of the Philippines requires that most unelectrified barangays be provided with appropriate PV models for future commercial dissemination plans. Although a few PV demonstration units have been installed and pre-commercial ventures implemented, there is also perceived need to support R & D activities leading to the development of standard testing for PV systems in varying locations.

The standard solar home system developed for rural electrification has demonstrated its technical feasibility and social acceptability. However, in several aspects of commercial implementation, failures have been reported, such as technical problems in locally manufactured PV balance of systems, poor collection rates, unattended maintenance problems, and so forth.

Nonetheless, a great potential exists for using PV systems for domestic (household) applications, specifically in households located in off-grids small islands, mountain villages and inaccessible costal areas. The NEA's electrification program has benefitted only 51% of the rural population.

Support for Development of Product Research, Standards and Quality Control

At present, no product research and standards and quality control for PV system exists. The lessons learned from implementation of two major island rural electrification projects suggest the need for development of quality control and product standards for PV to sustain long-term commercialization plans.

There is a need for at least a minimum product standard to address product reliability, durability, serviceability and field testing protocols to be developed and published.

Support for Developing Strategic Marketing Links (Users/NGO/PVO/NEA-REC, Others)

In the nationwide efforts to promote the commercial use of PV systems, the government is faced with problems related to supply mechanisms and establishment of maintenance workshop and laboratory facilities. These are physical demands that could be met in the near future.

The most important development the government has started is the establishment of institutional mechanisms to provide strategic marketing links between sellers and buyers. The ANECs are now seen as the rural-based service institutions that can be developed to participate in the "Supply mechanisms" for PV. The ANECs may establish links with urban-based national consultancy firms to strengthen their capabilities. This is significant because the ANECs can be fully developed into energy service firms and this would mean that expertise could be made available nationwide and not just in the country's capital and large urban centers. This is strategically important because projects on PV technology which are decentrally applied and are used mostly in rural and remote areas, would then have ready access to expertise within their regions and provinces.

NGO's are also being encouraged to participate in the dissemination of PV systems. NGOs in the Philippines which have become involved in energy-related matters range from an association of energy equipment, engineers, and suppliers (REAP) to a voluntary organization of scientists, technologists and engineers dedicated to the service of the people (STEP). There are a number of NGOs that can build the links between commercialization of PV and community development.

Support for Human Resources Development Training Programs

This will address the specific manpower trainings and professional development of the PV sector manpower pool. Trainings will also be directed to the financing/banking communities for facilitation of PV financing.

III. OVERVIEW OF PAST AND PRESENT PV INITIATIVES

1. Research, Development and Demonstration Phase

PV for Lighthouses Philippine Coast-guard, 1964 - present)

The photovoltaic technology (PV) is already in use in the Philippines since the 60's for providing power to lighthouses of the Philippine Coast Guard. The PV panels used were the first generation type of encapsulations which until now perform satisfactory even if they are exposed to adverse environmental conditions.

PV for Military Transceivers MOE/AFP, 1978

The Ministry of Energy (MOE) and the Armed Forces of the Philippines (AFP) field tested the use of PV systems to provide power supplies for field military transceiver sets. These systems were proven to be technically and economically viable compared with conventional power supply systems.

PV for Water Pumping
MOE/USC, early 80's

Likewise, the MOE through the University of San Carlos (USC) and the USAID demonstrated and promoted the development of the PV technology for potable water supply and irrigation systems to spur economic and social development of rural areas in Central Philippines. There were also similar PV systems installed for the same purposes with funding support of the UNDP.

PV for Medical Refrigerators
DOH/Australia, early 80's

The Department of Health (DOH) and the Australian government demonstrated the feasibility of PV-powered refrigerators in rural health centers. The systems were proven viable compared to kerosene-powered refrigerators.

PV Technical R&D, Demonstration Program Philippine-German Solar Energy Project (PGSEP) MOE/GTZ, 1981-89

The Philippine Ministry of Energy and the German Agency for Technical Cooperation (GTZ) of the Federal Republic of Germany embarked in 1981 a bilateral technical cooperation program for the development of PV technology. So far, this almost 10-year initiative is the most significant that paved way to what the status of the technology is right now in the country.

Major contributions of the PGSEP:

a. <u>Technical Studies</u>

Demonstration of the Technical Feasibility of a 13.3 kWp Central PV Village Power Supply and PV Field Laboratory

A pilot solar power plant was installed in 1982 in a small village of 62 households, 60 kms. from Manila. The plant was put into operation in February 1983 and since then supplied the basic electrical needs of the community of Pulong Sampaloc, Bulacan. The objective is to monitor the behavior, performance, reliability and durability of the photovoltaic system components, e.g., solar array, battery, control devices, inverter and load.

Demonstration of the Technical Feasibility of Small PV Applications

The testing of the technical feasibility of small PV power systems as a component of the project led to the direction of providing growth conditions for market development and introduction. Decentralized supply options were proven to be feasible and simple. The project's multi-disciplinary team were trained on the job by making each of them responsible for one small project. Particularly, local engineers and technicians were trained to develop local PV components such as control devices, fluorescent tubes, small inverters, and others which made possible to gather data and experience on locally available equipment such as frames, batteries, DC motors, pumps, among others. This resulted to the development of systems adapted to the local market. The PGSEP has demonstrated and established the techno-economic viability and social acceptability of the following small scale PV projects:

- stand-alone individual power supply for rural households. (popularly known as the solar home systems)
- PV for community battery charging stations
- PV for remote telecommunication facilities.
- PV for navigational aids/airport marker
- PV for medical refrigerators
- PV for water pumping
- PV for poultry incubators
- PV for video cinemas in rural areas.
- Solar fence controller
- PV for streetlights
- PV for small beach resorts
- PV for electronics repair shop
- Other PV power supply systems developed and tested

b. Economic studies on PV applications

Based on the technical data and experiences gathered from the actual PV installations, thorough economic evaluations are undertaken to provide better and more reliable cost-benefit analysis for PV systems.

The studies on economic feasibility are focused on the comparison of various PV power systems with conventional energy supply options such as diesel gen-sets, kerosene for lamps, etc. using generally-accepted methods of economic evaluation such as net-present value calculation, internal rate of return and payback period. A special computer program for economic evaluation was developed and is continuously used. Valuable results have already been obtained from remote stations and on several small applications in non-electrified rural areas. At the end of the project, a list of photovoltaic applications which, based on the calculations and evaluation, appear to be economically feasible for the Philippines in the near future was made.

c. Social Studies on PV Applications

Critical in the market introduction of the PV technology is the assessment of users attitude and the general socio-economic-cultural factors. Sociological studies were conducted to determine the effect of the technology on the recipients value system, to find the degree of resistance against or acceptance of the technology and the general social impact of the project on the community. As problems and obstacles occur, short-term and long-term solutions were proposed, and if found feasible were immediately implemented. Educating the people is also a main concern of the studies. This enables the people to better understand how the technology operates and thus, maximizes the benefits while minimizing potentially harmful side-effects, if there is any. Another related activity involves the comparison of non-related villages with electrified villages such as Pulong Sampaloc in terms of energy use patterns, receptivity to the introduction of a new technology, which will serve as guide for similar undertakings in the future. Furthermore, social aspects have always been considered as a criterion in the selection of sites for field experiments for small photovoltaic applications.

d. Linking Private and Banking Sector in Commercial Dissemination of PV systems

In increasing the local content of a PV system, the project turned over to private companies the technical findings and specifications of various R&D balance of systems (BOS) components for local production. While preparing for this, the banking sector was also convinced to finance the first PV rural electrification project. This will be discussed later.

e. Establishment of a Solar Laboratory

To sustain the momentum of the early R & D phase, the DOE established a solar laboratory at the University of the Philippines - National

Engineering Center (UP-NEC) to provide technical assistance and continuing support to the growing market for PV systems. The center likewise extends support activities in PV system design, installation and servicing as well as technical trainings to develop local capability to undertake PV projects. Standardization of PV products will also be undertaken.

Photovoltaic Water Pumping (PVP) Project
DOE/GTZ/USC/LWUA, 1991 - 1995

Another project supported by the DOE, GTZ and the Local Water Utilities Administration (LWUA) is the demonstration of the technical and economic feasibility of PV Pumping (PVP) Project. The lead implementor for this project is the University of San Carlos (USC) through its Water Resources Center (WRC). The project which run from 1991 up to 1995 demonstrated the viability of 14 PV pumping systems (approx. 25 kWp) installed in remote island communities. Economic studies show that PVP systems are economical compared with diesel pumps. However, its economics varies from site to site. The technical and social acceptability of the systems by the users has been very positive. After four (4) years of experiences, the PVP project has now a realistic criteria for suitable PVP sites. Likewise, the project has successfully trained local personnel for the design and implementation of these projects. Much of the practical experience gained will be useful for practical optimization and for cost cutting measures of future PVP installations.

Special Energy Programme (SEP)/ Rural Photovoltaic Electrification (RPE)
NEA/GTZ, 1987-1995

The Special Energy Programme (SEP) started in 1987. A joint undertaking of the NEA and GTZ, it aims to develop and demonstrate the model dissemination of solar home systems integrated into the mainstream of rural electric cooperatives (RECs) for rural electrification and also to attain financial viability without subsidies. Under the SEP concept, the PV technology provides the following advantages: access to long-term financing at prime conditions, tax-free privileges for energy commodities, capacity to buy bulky quantities, work with experienced electrification professionals, nationwide organizational network, and familiarity with specific regional conditions. After achieving a great deal of practical experiences in PV dissemination, the RPE was developed primarily with the concept in which the RECs own the solar generators, finance them on long-term loans and offer them to their consumers as an electricity service at low, yet cost recovering fees. The model dessimation considers PV as a pre-electrification scheme. In this, the RECs now avail of another avenue to perform their mandate and record more members and electrified villages. SHSs provide greater flexibility to be included in the workplan and may be relocated when the load demand reaches a level attractive for conventional electrification.

PROSOLAR: Isang Libong Bahay: Pailaw Mula sa Araw DOE/GTZ, 1994-95

The "Prosolar" project is a joint cooperation project of the DOE and GTZ. It seeks to involve PV private companies in the installation of 1000 solar home systems in Regions 3, 4 and 11. The concept involves providing cash incentives to PV suppliers that will package community-based PV electrification projects. Accredited companies can tie up with cooperatives registered with Cooperative Development Authority (CDA), consultancy firms engaged in renewable energy development, NGOs, and LGUs which have demonstrated managerial and technical capability in handling rural-based community projects.

2. PV Commercialization Projects/Government and Private Sector Links to PV Investment Promotion

The DOE plays a major role in opening up markets and increasing private sector's promotion and commercialization of NRSE specifically PV. In the past, most PV projects are traditionally dependent on cooperation projects with external donor agencies. Capitalizing on the practical experiences and preferential bias for promoting PV, the government's pronouncement to involve private sector becomes a reality. Much of the future success of PV commercialization rests on this.

The DOE, NEA and PNOC-Energy Research and Development Center (ERDC) take the lead role in demonstrating the commercial viability of PV technology, specifically the solar home systems (SHS). Efforts from these organizations catalyzed the eventual participation of the private sector and commercialization take off for PV is at hand.

Government-led PV Commercialization Projects

PV Electrification of Burias Island DOE/GTZ/DBP/SAP-MASOPCO, 1990 - present

Burias Island is an area characterized by low load density, thus, not warranting the viability of installing a conventional grid system. The PV electrification project is conceived primarily to demonstrate the commercial viability of locally developed solar home systems. The project is managed by San Pascual Masbate Solar Power Cooperative (SAPMASOPCO), a local organization created to oversee its operation and management. Through the project, some 120 units of SHSs of 55 Wp were installed in 1989 on a full-cost scheme with financing secured from the government's Development Bank of the Philippines (DBP). The financing introduced to the users entails a 25% down payment of the total system cost with the balance to be amortized in 36 equal monthly installments. The monthly payments approximate the users' monthly expenses for kerosene (lighting) and dry cell batteries (radio). The bank passes the loans to the cooperative at 12% and the cooperative passes the loans to users at 16%, which enables SAPMASOPCO to cover administrative expenses.

PV Electrification of Verde Island/ NEA/GTZ-SEP/VISPA, 1990 - present

The Verde Island PV electrification is implemented under the auspices of the Special Energy Programme (SEP) of GTZ and NEA. To sustain success, the project established the Verde Island Solar Power Association (VISPA) that acts as the project manager. Some 80 units of individual SHS were installed on the island to test the conditions suited for rural electrification. Appropriate financing schemes were developed to suit the affordability level of potential users. Likewise, a mini-central PV power plant was installed in a small village and users pay their dues on a flat rate basis. PV battery chargers were also introduced to provide charging services to car battery owners which they used to power lights, radio or black and white TV.

Utility Participation in PV Electrification NEA/GTZ-SEP/ECs, 1987 - present

The PV electrification of rural areas is introduced into the mainstream of electric cooperatives by NEA and GTZ-SEP. Started in 1991, some 14 utilities are now involved in the RPE project. The project has already installed more than 1000 SHSs and more requests are lined up for installation. NEA and GTZ act as interested lender to ECs and they in return disseminate the systems on a full cost recovery scheme to users. Initially, utilities consider PV as pre-electrification option with the flexibility of relocating the systems to other areas once conventional electrification becomes feasible. Users may have the option to lease or purchase the system.

Decentralized Energy Systems (DES) for NRSE Entrepreneurs PNOC-ERDC/EEC, 1990 - present

The PNOC-ERDC manages the DES program. The funds are provided by EEC. The objective of the project is to promote the commercialization of selected decentralized energy systems through entrepreneurs or private businesses that would manufacture and market them. The strategy is to provide financial assistance such as loan and/or loan guarantee to qualified private businesses. The project has already provided loans for PV dissemination.

2. Private Sector-Led PV Commercialization Projects

BELSOLAR Project Philips/DGIS/ITW/ AES/DBP/DOE/SJ, 1993 - present

The project introduced PV electrification in an upland community of Belance, Dupax del Norte, Nueva Vizcaya. The Saint Joseph Credit Cooperative acts as the project manager of the project. There are about 100 SHS installed. Special funding arrangement was granted by DBP and the SHS users amortized the units on equal monthly installments in four (4) years. The DOE provided tax-free importation for the PV panels.

Tingloy Island PV Electrification C.C. UNSON, Isang Bisig Cooperative, 1992 - present	Tingloy PV electrification is a hundred percent initiative of a private company, C. C. Unson. More than 30 SHSs were installed and managed by Isang Bisig Cooperative. Financing was provided by C. C. Unson based on a prevailing commercial lending rate.

3. Lessons Learned from Past Projects

1. Apply the appropriate PV application

In many rural communities in the Philippines, the physico-socio-economic setting vary. These differences are further complicated by the extent of the level of organizational experience, affordability level and the need for the PV service. These factors must be carefully considered in selecting the appropriate PV applications. In many barrios in the Philippines, for instance, there a number of households that currently use car batteries to provide power supplies for their bulbs or fluorescent tubes, radios, cassette recorders and other low power appliances. In these communities, the introduction of PV powered battery charger would practically suit their need for a PV service. In communities which are "better off" economically, solar home systems are the most suitable and appropriate options for rural electrification.

2. Consider Rural Electrification Policy

In the context of the Philippine Rural Electrification Program; rural electrification is a major infrastructure program which aims to accelerate the socio-economic development in remote areas by providing new and better opportunities for increasing income, facilitating communication and mobility and improving the general level of awareness and self-reliance. Rural electrification is commonly brought to these areas through the use of conventional means that are heavily subsidized by the government. The rural population expects the government to put in their places commercial grids and at low cost. Due to the differences in location and distribution of houses, and their low demand for power, common rural electrification cannot be made available to them. In such situations the government cannot provide "grid power" because economics does not permit it. Solar home systems offer realistic options to rural electrification. However, it is recognized that a conducive environment is needed for the promotion of SHSs. Although the limitations of the PV systems should be recognized, these systems must be given equal opportunities as the other conventional sources to add to other energy sources and thus complement the electrification program. For example, the SHS cannot compete with the subsidized cost of electricity produced from diesel generator sets installed on small islands. Electrification plans should be carefully laid out to avoid waste of effort, time and money. It has been shown that conflicting plans and implementation of energy projects also effect wider acceptance by the people of PV technology.

3. Co-operate with Viable Organizations

In the PV project sites, the task of collecting the user's monthly amortization and monitoring of the systems has to be performed by a local organization. It was learned that the implementing group somehow does not gain acceptance and confidence of the members because the foreign assistance image invites abuse. Even the creation of local organization proved problematical. In replicating the Burias and Verde projects, emphasis must be given to sites with an already existing active organization which would accept project duties and go beyond mere collection.

4. Establish and Secure Sound Financing

In the case of the Burias project, financing entails 25% down payment 16% interest in three years maturity. Today, however, the SEP follows a clear arrangement in which the 25% down payment has been transformed into an initial investment equivalent to the BOS components at the co-operator's cost and property. Only the generator and mounting are amortized which enjoy a 10 year warranty.

5. Secure Product Quality

Local manufacture of the BCU, batteries etc. seemed to be cheaper but taking into account the number of failures and replacements, it turned out to be far more expensive than proven imported products. To improve the quality of the electronic components, the SEP/DOE-NCED follows a dual strategy: The UP Solar Lab sets up strict standards and tough test conditions to eliminate weakly designed units and in new projects conducted by the SEP, imported units are used in order to demonstrate state-of-the-art performance standards.

Projects with conflicting objectives cannot succeed and the objective of commercializing an affordable and reliable SHSs may indeed conflict with the objective of developing local electronics manufacturing and assembly facilities.

Warranties and the responsibility for equipment reliability must be clearly spelled out as a contractual obligation.

		Poor component reliability can threaten successful commercialization.
6.	Provide Close Monitoring.	Previous projects have not been properly monitored because of the remoteness of the installations and partly due to lack of funds. However, it was learned that organizations that will be involved in the PV projects must obtain equity positions trough contributions of any form (to be determined) which is crucial to the success of the project.
7.	Train Implementors	Project implementors must be knowledgeable about the aspects of the site identification, system installation and operation. Regular training programs must include training of technicians, collectors and other persons involved in the implementation.
8.	Inform Users	People initially expect from solarization the same magnitude of benefits as in grid electrification. Information dissemination at this stage is very important, so that this new technology and the system capabilities as well as limitations are fully assessed.

CONCLUDING REMARKS

The Philippines has an appropriate energy policy, achievable objectives, and implementable strategies that have been proven to be effective in the power sector. The crucial test of appropriateness of said policies is that it had led to active priate sector involvement.

In the alternative energy sector, the government also has the right policy, objectives, and strategies. Alternative energy in fact plays a central role under the Ramos government where there is conscious desire to address other energy issues (i.e. energy price affordability and environmental production) in addition to energy security. As with the rest of the energy sector, government has also sought and encouraged private sector involvement in alternative energy.

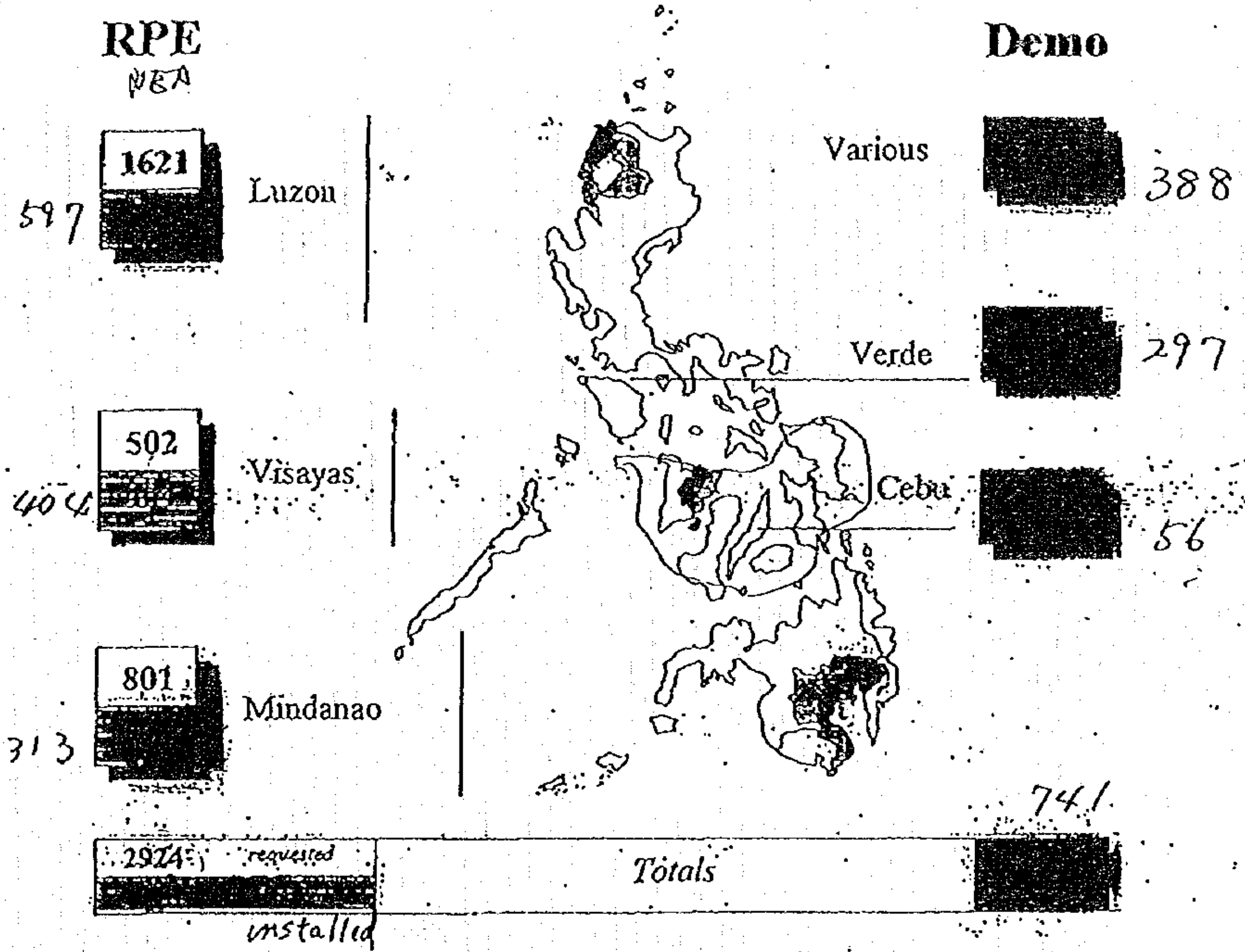
The PV technology will continue to be a priority technology in the NREDP. The future role of PV as a decentralised rural electrification option will give a major boost in supplying the electricity demand of rural households and small scale industries. The government plans to increase private sector participation not only in the commercial dissemination of market-ready PV systems but also in the local assembly and/or production of PV panels/cells.

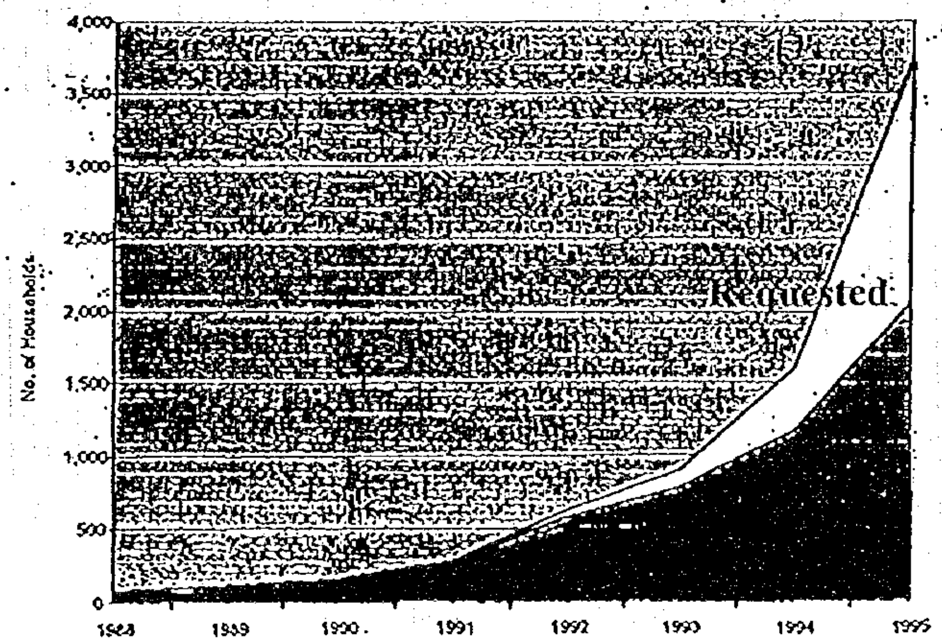
フィリピンにおける[illegible]のPV地方電化計画

フィリピン—GTZ PV技術協力

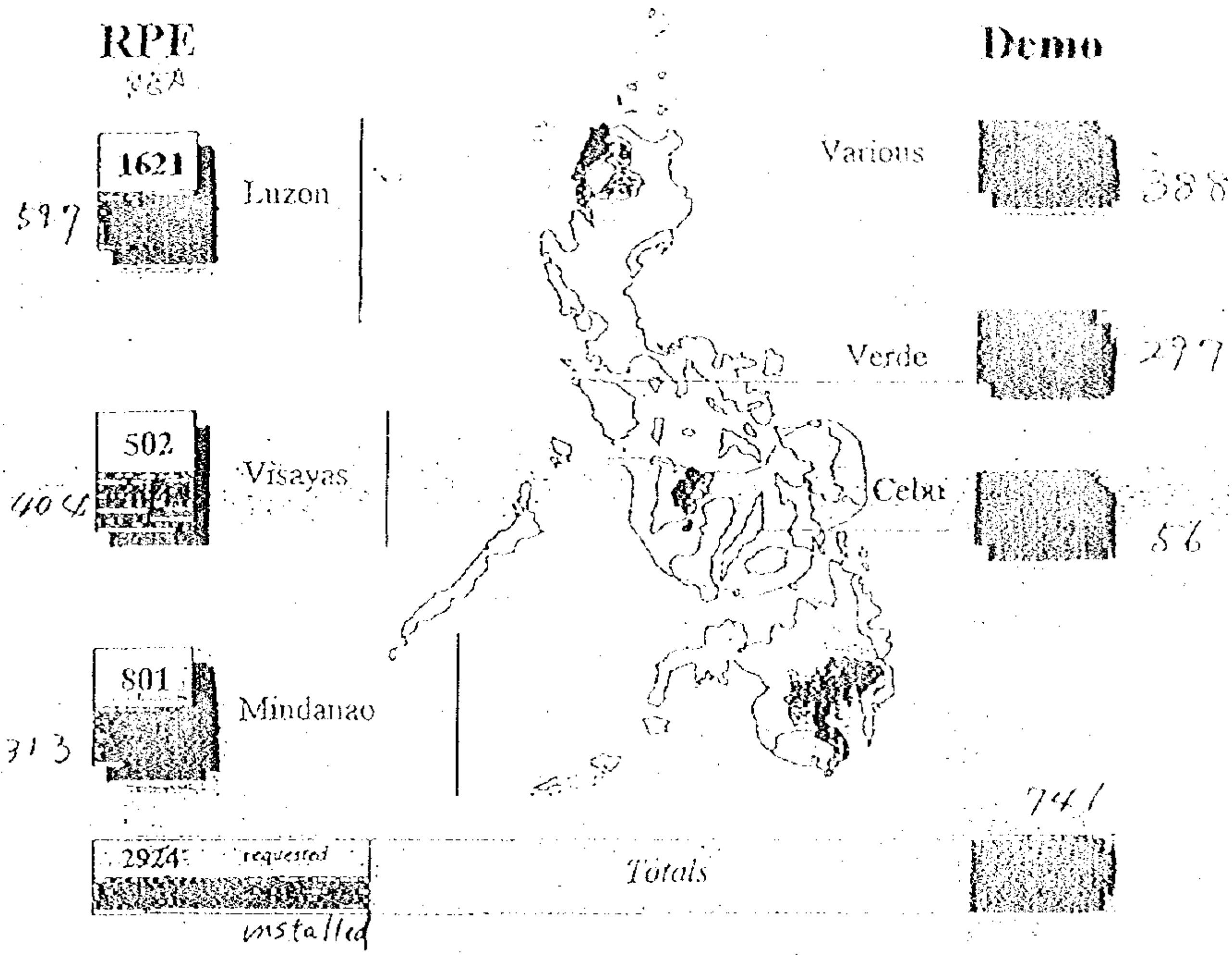
1. Philippine-German Solar Energy Project (PGSEP) 1981--89
2. Photovoltaic Water Pumping (PVP)Project 1991--1995
3. Special Energy Programme(SEP) Rural PV Electrification(RPE) 1987--1995
4. PROSOLAR 1994--95
5. PV Electrification of Burias Island 1990--96
6. PV Electrification of Verde Island 1990--96

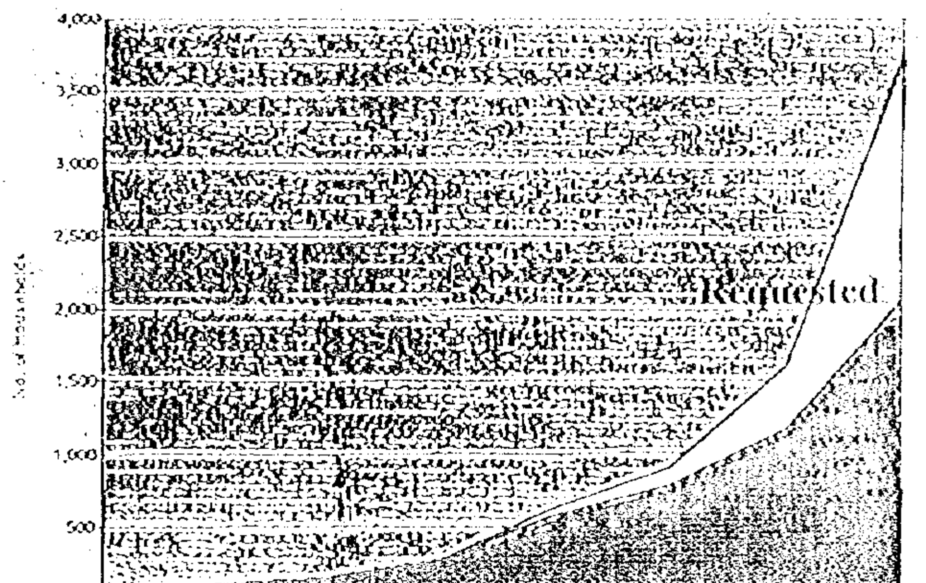
Households Energized





Households Energized





4. Policies and Programs on New and Renewable Energy in the Philippines

POLICIES AND PROGRAMS ON NEW AND RENEWABLE ENERGY IN THE PHILIPPINES

September 1996

Non-Conventional Energy Division
Energy Utilization Management Bureau
Department of Energy
Merritt Road, Fort Bonifacio
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ABSTRACT

The New and Renewable Energy Program (NREP) aims to accelerate the promotion and commercialization of new and renewable energy systems. Towards the pursuit of this goal, the NREP is anchored on the following policies: (a) pursue large-scale use of new and renewable energy sources (NRES); (b) enhance energy self-sufficiency through continuous exploration, development and exploitation of indigenous energy sources; and (c) encourage greater private sector investment and participation in all energy activities.

Meanwhile among the strategies to be implemented include the intensification of research, development and demonstration of techno-feasible and socio-environmentally acceptable NRES; institutionalization of area-based energy planning and management for NRES; encouragement of a favorable market environment for manufacturers/ suppliers and users of NRES; intensification of promotion of commercially-viable NRES such as solar and wind; and continuous adaptive research and development for less-advanced technologies such as ocean thermal energy conversion, tidal wave, fuel cells and municipal wastes, among others.

The specific sub-programs for the new and renewable energy sector are as follows:

- **Technology Sub-Program** aims to develop economically viable NRES to levels of technical maturity at which NRESs can be commercially competitive with conventional energy.
- **Commercialization Sub-Program** envisions to create favorable market environment to encourage private sector investment and participation in NRES projects and activities;
- **Promotion Sub-Program** attempts to heighten public awareness on the use of NRES;
- **Area-based Energy Sub-Programme** - a mechanism to accelerate the promotion and commercialization of NRE systems at the regional and sub-regional levels through a decentralized, area-based approach.

POLICIES AND PROGRAMS ON NEW AND RENEWABLE ENERGY IN THE PHILIPPINES

1.0 INTRODUCTION

The Department of Energy has been mandated under Republic Act No. 7638 to coordinate, supervise, control and prepare an integrated plan for all efforts, programs, projects and activities of Government relative to energy exploration, development and utilization. In the execution of this mandate, the Department firms up its long-term goal of energy sufficiency, reliability and affordability within the context of environment promotion and protection through the following efforts:

- formulation of clear policies and responsive plans and programs;
- intensive development of indigenous energy sources;
- effective coordination of downstream energy activities;
- provision of regional benefits to host communities;
- enhance private sector participation in energy projects; and,
- close coordination and cooperation with other government agencies and private sector entities.

Specific to new and renewable energy are the following policies and strategies:

- pursue large-scale use of new and renewable energy sources (NRES);
- enhance energy self-sufficiency through continuous exploration, development and exploitation of indigenous energy sources;
- encourage greater private sector investment and participation in all energy activities.

The strategies being adopted to implement these policies include:

- intensify research, development and demonstration of techno-feasible and socio-environmentally acceptable NRES;
- institutionalize area-based energy planning and management for NRES;
- encourage a favorable market environment for manufacturers/ suppliers and users of NRES;
- intensify promotion of commercially-viable NRES; and,
- continue adaptive research and development for less-advanced technologies such as ocean thermal energy conversion, tidal wave, fuel cells and municipal wastes, among others.

2.0 THE NEW AND RENEWABLE ENERGY PROGRAM

The Department through its Non-Conventional Energy Division strengthens its New and Renewable Energy Program (NREP) of accelerating the promotion and commercialization of NRES in coordination with other energy-related agencies including the National Power Corporation (NPC), Philippine National Oil Company - Energy Research and

Development Center (PNOC-ERDC), National Electrification Administration (NEA), Department of Science and Technology (DOST) and its attached agencies.

The Program has four strategic sub-programs each addressing a scope of concerns, namely:

- **Technology Sub-Program** aims to develop economically viable NRES to levels of technical maturity at which NRESs can be commercially competitive with conventional energy.
- **Commercialization Sub-Program** envisions to create a favorable market environment to encourage private sector investment and participation in NRES projects and activities;
- **Promotion Sub-Program** attempts to heighten public awareness on the advantages and benefit of the use of NRES;
- **Area-based Energy Sub-Programme** - a mechanism to accelerate the promotion, commercialization and use of NRE technologies at the regional and sub-regional levels through a decentralized, area-based approach.

3.0 NRE NATIONAL CONSUMPTION PROFILE

In 1973, indigenous energy contribution to the total energy mix accounted for about 8% or 5.57 MMBFOE with NRE sources contributing a meager share of around 3 percent or 2.25 MMBFOE. Because of the country's heavy dependence on imported oil, the NRE Programme was launched to increase the contribution of NRE in the total energy consumption. In 1994, the imported energy (oil and coal) accounted for 104.3 MMBFOE or 71 percent of the total energy mix while indigenous resources posted about 42.51 MMBFOE or 28.9 percent. Under the indigenous energy, conventional energy (oil, gas, coal, hydro and geothermal) gave the largest share of about 28.47 MMBFOE or 19.4 percent. The remaining share of 9.6 percent was attributed to new and renewable energy sources (see Figure 1).

The contribution of renewable in the mix was posted at 14.03 MMBFOE which is a 1.9 percent increase from the previous year's figure of 13.78 MMBFOE. Bagasse and agriwastes are the major contributors providing about 13.49 MMBFOE of the total renewable energy share. On the other hand other NRES, namely solar, wind, micro-hydro, biogas and black liquor contributed about 0.546 MMBFOE of the country's total energy requirement. This is a 15.7 percent increase from its previous year's contribution of 0.472 MMBFOE.

4.0 NEW AND RENEWABLE ENERGY SUPPLY POTENTIAL

Data and statistics from various government agencies gave an optimistic picture of NRE in the future.

Based on the projections of the Department of Agriculture and the Department of Environment and Natural Resources, the aggregate biomass supply potential in 1996 is equivalent to 132.8 MMBFOE and still is expected to exhibit a modest growth by 288.4 MMBFOE in 2025 (see Table 1). Contributors to this aggregate biomass supply potential are woodwastes, bagasse, coconut and rice residues, animal wastes and municipal solid wastes (see Figures 2 to 4).

The PAG-ASA weather data showed that the country has a good potential for wind energy. The national average mean wind power density is about 30.8 watts per square meter (W/m^2). The data also showed that Region I has the highest potential for wind energy applications with an annual wind power density of 88 W/m^2) (see Figure 5). Estimated also from PAG-ASA's weather data, the country's average solar radiation based on sunshine duration is 161.7 W/m^2 with a range of 128-203 W/m^2 (see Figure 6).

DOE and NEA data also showed that the country has an aggregate micro-hydro power potential of about 27.8 MW (see Figure 7) located in various areas of the country.

The country's ocean resource area is 1,000 square kilometers. Based on a study, the potential capacity for this resource is estimated to be about 265 million MW (see Figure 8). Although, there is very little information available on the potential of ocean energy, navigational experiences hypothesize that these systems are significant resource options.

5.0 DEMAND FOR NEW AND RENEWABLE ENERGY

In 1996, NRE consumption is estimated at 61.94 MMBFOE. This is projected to increase by 29 percent or 214.4 MMBFOE by 2025 (see Table 2). Biomass resources are the major contributors (99 percent) with woodwastes giving in the largest share of 47.1 MMBFOE or 76 percent. By 2025, biomass shall account for 181.25 MMBFOE or 84 percent in the total renewable energy share. Other NRES such as solar, micro-hydro and wind, on the other hand, shall provide 0.01 MMBFOE contribution in 1996 and steadily grow to 33.11 MMBFOE by 2025.

6.0 NRE PROJECTS AND ACTIVITIES

6.1 Technology Sub-Program

6.1.1 Biomass

In 1992, a Pre-Investment Study on the Commercial Potential for Power Production from Agricultural Residues was undertaken by the Department, showed the following conclusions:

- some biomass projects are cost-effective and present an attractive investment opportunities;

although a significant number of biomass projects are possible, only a small fraction of the potential can be developed in the near-term to help alleviate the power shortage;

- The sugar sector can be very conservatively estimated as having potential to contribute from 60-90 MW to grid supply in the near-term;

- For the rice sector, a realistic estimate of its potential aggregate contribution is not likely to exceed 40 MW;

- The coconut sector is estimated to have an aggregate potential contribution of 20 MW.

Recognizing the need for consumer protection and product reliability, the Department shall pursue the establishment of the Biomass Energy Conversion Systems Product Standards and Testing Procedures.

The Department also plans to demonstrate the viability of modular ricehull power plants to be supplied by a cluster of ricemills. Specific sites identified for this project are Nueva Ecija, Bulacan and Isabela. Another focus for 1996 is the project on the demonstration of biogas systems in slaughterhouses for towns and cities in the country.

6.1.2 Solar Energy

A lot of projects on solar energy have already been undertaken. The Department continuously supports the activities of the Solar Laboratory at the University of the Philippines - National Engineering Center to undertake research and development activities on solar energy. To date, the Laboratory has prepared and submitted to the Bureau of Product Standards of DTI, the draft PV components product standards and the test procedures for review and accreditation. To strengthen the capability of the Laboratory, a locally-funded project is proposed to upgrade its current equipment and facilities.

Similarly, the Department supports the Phil-German Photovoltaic Water Pumping Project (PG-PVP) through the University of San Carlos - Water Resource Center. The Project has installed a total of 15 PVP systems with a total capacity of 21 kWp for pumping potable water in remote villages of Cebu Province, Bohol, Mindoro among others. Rural Water and Sanitation Associations were also organized to manage the operations of the systems.

The Department shall consider for the local assembly of solar PV panels which will lead in the medium term to its full-scale local production. This activity is geared towards reducing the over-all system cost to make the technology more affordable to the local end-users.

6.1.3 Wind Energy

There is a growing interest on wind energy for power generation from the foreign investors. In 1992, a UNIDO-assisted opportunity study on wind energy conservatively estimated about 250 MW of wind power can be tapped and made an integral part of the Philippine Power Development Program.

Taking off from this study, the NPC is currently monitoring the wind energy profile in seven identified potential sites. The wind energy data that will be produced from this monitoring are vital in designing future activities on wind. NPC is also implementing a 10 kW Pilot Wind Turbine Generator Power Project in Pagudpod, Ilocos Norte.

The Renewable Energy Program Support Office (REPSO), the local arm of WINROCK International, will be conducting the Philippine Wind Energy Mapping project which will produce a wind resource atlas for the country based on comprehensive analysis of existing and new international and local wind data sets. This will be crucial in identifying site-specific areas for putting up actual wind turbine in the country.

6.1.4 Micro-hydro

There are existing eight (8) demonstration units of micro-hydro systems installed with an aggregate capacity of 121 kW. These micro-hydro systems have been used both for mechanical application (i.e., rice and corn milling) and power generation for lighting and for electrical machines.

Future projects on micro-hydro will be focused on the demonstration of other applications particularly for hybrid installations.

6.1.5 Ocean Energy

With the persistent interest coming from the foreign institution on ocean energy technology, and considering the vast potential the country has, the Department has convened a National Committee on Ocean Energy Development and Utilization. The inter-agency committee is tasked to formulate guidelines and regulations pertaining to the exploration, development and utilization of ocean energy.

At present, NPC is implementing a Tidal Current Assessment Project with assistance from PCIERD. The project aims to gather the resource profile of four potential sites namely Gaboc Channel in Surigao, San Bernardino Strait in Samar, Hinatuan Passage in Surigao del Sur and Basiao Channel in Bohol.

With support from UNDP, a project on Assessment of Wave Power Potential in the Philippines is being proposed to prepare the wave map for the country. This will be used to prepare an ocean energy development plan and to identify specific sites for actual resource assessments.

6.2 Commercialization Sub-Programme

Complementing these technological developments, the Department launched a broad-based project to accelerate the commercialization of NRES. These are:

6.2.1 PROSOLAR

The Project is an extension of the Special Energy Programme of the German Government which aimed to provide financial incentive to private manufacturers/sellers of PV systems. A fund facility has been established to target the installation of about 5 kWp capacity through private sector participation. Specific project sites include Nueva Ecija, Tarlac, Palawan, Mindoro, Batangas, Quezon, Davao del Sur, Davao del Norte and South Cotabato.

6.2.2 Environmental Improvement for Economic Sustainability (EIES)

A cooperation with the Dutch Government, the project aims to install 15,000 SHS in three (3) years through provision of a 40 percent grant of total project cost. It further envisions to institutionalize a mechanism for effective marketing of SHS in the remote areas through ensuring stable supply of spare parts and developing local expertise to address potential operational problems of the system.

6.2.3 Solar Electrification of Pangan-an Island, Mactan, Cebu Province

A 27.6kWp centralized PV power plant shall be installed in Pangan-an Island, Cebu for electrification of 210 households. Another 70 individual solar home systems and a battery charing station shall be installed for scattered and isolated households in the area. This will be undertaken with funding assistance from the Belgian government.

6.2.4 Davao Solar PV Electrification Project

In the same manner, the Davao PV Electrification Project is targeted to benefit 500 unelectrified households in Davao provinces. The project is focused less on the technical issues concerning PV but more on the institutional arrangements in order to develop sustainable structures for implementation and replication of future PV projects.

6.2.5 Wind/Microhydro Projects

These projects aim to overcome the barriers in the promotion and commercialization of micro-hydro and wind technologies. The implementation of the project entails the installation of these technologies to demonstrate their economic viability. Ultimately, the project shall open the market for future projects on a private economic basis.

6.2.6 Decentralized PV Systems for Rural Electrification

Feasibility studies in installing decentralized PV systems for rural village electrification shall be conducted under this project. Target areas for this undertaking include Marinduque and Romblon.

6.3 Promotion Sub-Program

In intensifying promotions and information campaigns on NREs, the following projects and activities were undertaken:

6.3.1 Provincial Fora on NRSE

The activity is considered as the most effective information awareness vehicle which attempts to present to LGUs, NGOs and local private sector groups the various NRE technology options and to facilitate identification of user and need-oriented project opportunities.

6.3.2 Renewable Energy Association of the Philippines (REAP)

To effectively mobilize private sector participation, the Department supported the organization of the Renewable Energy Association of the Philippines (REAP). The association is composed of private manufacturers, importers and distributors of various NRES products and devices. The Department continuously provided financial assistance to implement REAP projects and activities.

Other activities of the sub-program include the conduct of trainings/seminars/ workshops, participation to trade fairs and exhibits; development, and production and dissemination of various NRE promotional and information materials.

6.3.3 INNERTAP

To strengthen information network among institutions involved in new and renewable energy, the "Information Network on New and Renewable Energy Technologies for Asia and the Pacific" has been initiated. The project aims to provide effective information management systems to renewable energy researchers, policy makers, investors and others.

6.4 Area-based New and Renewable Energy Sub-Program (ABNEP)

6.4.1 Establishment and Maintenance of ANECs

In response to the increasing demand for rural energy, as well as recognize the site specificity nature of NRE, the Department established the Affiliated Nonconventional Energy Centers. These Centers serve as the extension arm of the Department at the regional and provincial levels. As the link between the national and local structures, the ANECs are envisioned to improve the local energy situation through an area-based planning approach. The ANECs' activities include among others, the formulation of rural energy plans and programs including their implementation; installation of NRESs demonstration units; maintenance and rehabilitation of non-operational demonstration units; conduct of trainings/ seminars for end-users, manufacturers and other key players; and assistance to local/rural clienteles. At present, the Department manages and supervises 20 ANECs in the various state universities and colleges in the country (see Figure 9).

One of the important achievements of the ANECs was the inventory of NRESs installations in 1994 in the twelve regions of the country. The data gathered estimated the actual contributions of NRESs in the national energy mix. This same information also serve as baseline data to determine future policies and strategies for NRE in rural areas.

6.4.2 Area-based Energy Technology (ABET) for Sustainable Development

Recently, the Department piloted a new strategy to strengthen local-level participation in identifying, prioritizing and implementing energy projects that will directly address their needs. Piloted in Mountain Province, the project was able to consolidate and maximize efforts and resources of local government, non-government organizations, and local private sector in bringing about the desired level of energy sufficiency in their local communities. Future plan is to replicate this in other areas of the country.

6.4.3 Wood Energy Development Programme in the Philippines

Recognizing the large contribution of woodwastes/fuelwood as a traditional fuel in the rural areas, the Department collaborated with the Regional Wood Energy Development Programme of the Food and Agricultural Organization (RWEDP-FAO) on the development of wood energy programme in the country. The regional undertaking seeks to contribute to a sustainable production of woodfuels, its processing, marketing and its rational use by household, industries and other productive enterprises. Activities include conduct of local studies and manpower development.

6.4.4 Integrated Rural Energy Planning for Rural Development

The project aims to institutionalize the integrated, area-based and decentralized approach to energy planning at the local levels. The framework which was prepared in 1991 shall be pilot-tested in Cebu province. The pilot-testing shall include the involvement of the local government units since they will be ultimately responsible in its eventual operationalization at the local level.

6.4.5 National Non-Conventional Energy Systems Demonstration Project

Other NRE systems, such as biogas digesters, micro-hydro systems, improved cookstoves, biomass-fired ovens/dryers, among others are continuously being promoted to enhance its development and utilization. Several demonstration projects shall be installed to determine the economic, financial, social and technical viability of these systems in the different areas of the country.

6.4.6 National Biogas Demonstration Project

Spearheaded by the Department of Agriculture, the project shall enhance the development and utilization of biogas technology in key livestock areas. The project shall involved the design and packaging of locally appropriate biogas systems and the conduct of training on biogas technology for public dissemination.

7.0 CAPITAL INVESTMENT REQUIREMENTS

The 1996-2025 New and Renewable Energy Program shall require an aggregate amount of almost ₱627.6 billion in financial requirements, comprising 8.0 percent of the total energy program requirements. Of this, the local private sector shall shoulder almost 43.7 percent (₱274 billion) to implement commercialization activities for the different renewable energy systems and products. Foreign sources shall provide for ₱314.5 billion or 50.1 percent of the total requirement to upgrade NRE technologies and increase system efficiency and reliability (see Figure 10). The latter, shall also finance installations of large-scale wind power systems and various incineration plants for power generation. Participation of private research groups are also considered important to complement government-led research and development activities on renewables. Government contribution is around 39 billion pesos.

8.0 INCENTIVES FOR NRES

8.1 Renewable Energy Power Program (REPP)

Launched in 1990, the Program aims to increase private sector participation by providing additional financial facility for NRE projects. Priority shall initially be given to mini-hydro and biomass technologies. In the long-term, the focus will shift to solar and wind energy projects. By 1998, it is targeted that at least 50 MW of power generating capacity from renewable energy resources will have been installed.

A total amount of ₱750M or $30M shall initially be allocated for the program. This will be sourced out from the Government Service Insurance System (GSIS) and the Social Security System (SSS) which will contribute ₱500M and ₱250M respectively. The financial terms are currently being finalized with the two funding institutions. The Development Bank of the Philippines (DBP), Land Bank of the Philippines (LBP) and Philippine National Bank (PNB) shall act as the conduit banks for the program.

8.2 BOI Investment Priorities Plan 1996

The Plan provides incentives for those power generation facilities which do not utilize petroleum fuels. The privileges include various tax exemptions such as 3% duty on imported capital equipment and spare parts. Additional privileges may include tax credits, income tax deductions and other non-fiscal incentives.

8.3 Mini-Hydro Law

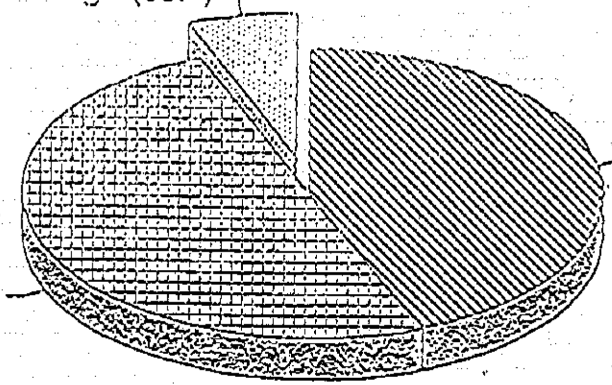
For those authorized to engage in mini-hydro electric power development, the Law provides tax incentives and privileges in the following forms:

- special privilege tax rates - 2% of gross receipts from sales
- tax and duty free importation of machinery, equipment and materials
- tax credit on domestic capital equipment equivalent to 100% of the value of special realty tax rates on equipment and machinery which shall not exceed 2.5% of the original cost
- exemption from 10% VAT, and
- income tax holiday for seven years

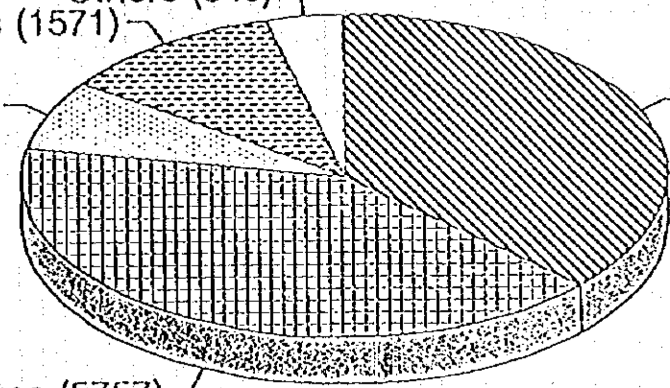
8.4 NPC Window on NRE

Starting 1998, the NPC will open a window that will accommodate NRE projects into the national grid. It is envisioned that 300 MW NRE generating capacity will be installed by year 2003. The projects in order to qualify must meet price criteria, must be viable and must run on 100% renewable energy sources.

Capital Investment Requirements
(in Billion Pesos)



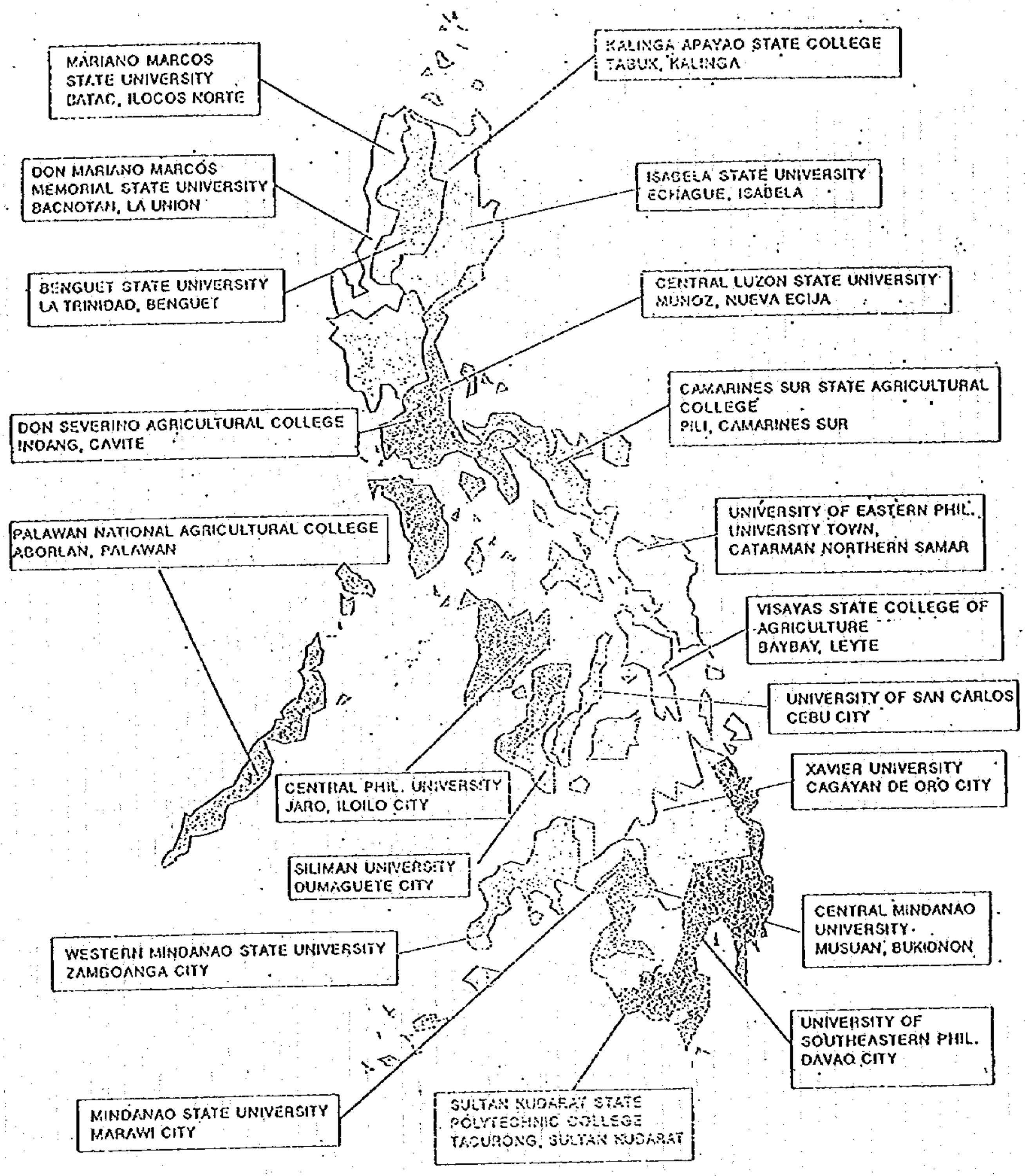
NEW AND RENEWABLE ENERGY CONSUMPTION
1994



	1996	2000	2005	2010	2015	2020	2025
BIOMASS	61.93	69.74	82.89	101.82	122.96	148.19	181.23
WOODWASTE	*47.05*	*49.74*	*55.28*	*61.98*	*70.29*	*80.87*	*94.67*
MUNICIPAL WASTE	*0.00*	*0.00*	*0.00*	*2.92*	*4.38*	*5.11*	*7.30*
BAGASSE	*5.88*	*7.44*	*9.90*	*13.08*	*17.17*	*22.42*	*29.14*
COCO RESIDUES	*5.78*	*7.32*	*9.56*	*12.18*	*15.25*	*18.82*	*22.98*
RICE RESIDUES	*2.54*	*3.41*	*4.76*	*6.55*	*8.88*	*11.92*	*15.86*
ANIMAL WASTE	*0.52*	*1.66*	*3.21*	*4.92*	*6.79*	*8.84*	*11.06*
BLACK LIQUOR	*0.16*	*0.17*	*0.18*	*0.19*	*0.20*	*0.21*	*0.22*
OTHERS	0.01	0.40	1.19	1.73	3.08	14.29	33.11
MICRO HYDRO	*0.00*	*0.01*	*0.03*	*0.04*	*0.06*	*0.10*	*0.20*
WIND	*0.00*	*0.37*	*1.10*	*1.54*	*2.56*	*6.94*	*13.66*
(SOLAR)	*0.01*	*0.03*	*0.06*	*0.15*	*0.45*	*1.41*	*4.65*
OCEAN	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*5.84*	*14.60*
TOTAL	61.94	70.14	84.08	103.55	126.04	162.48	214.34

Table 2.
PHILIPPINE NEW AND RENEWABLE ENERGY CONSUMPTION PROJECTION 1996-2025
(In Million Barrels of Fuel Oil Equivalent)

AFFILIATED NON-CONVENTIONAL ENERGY CENTERS



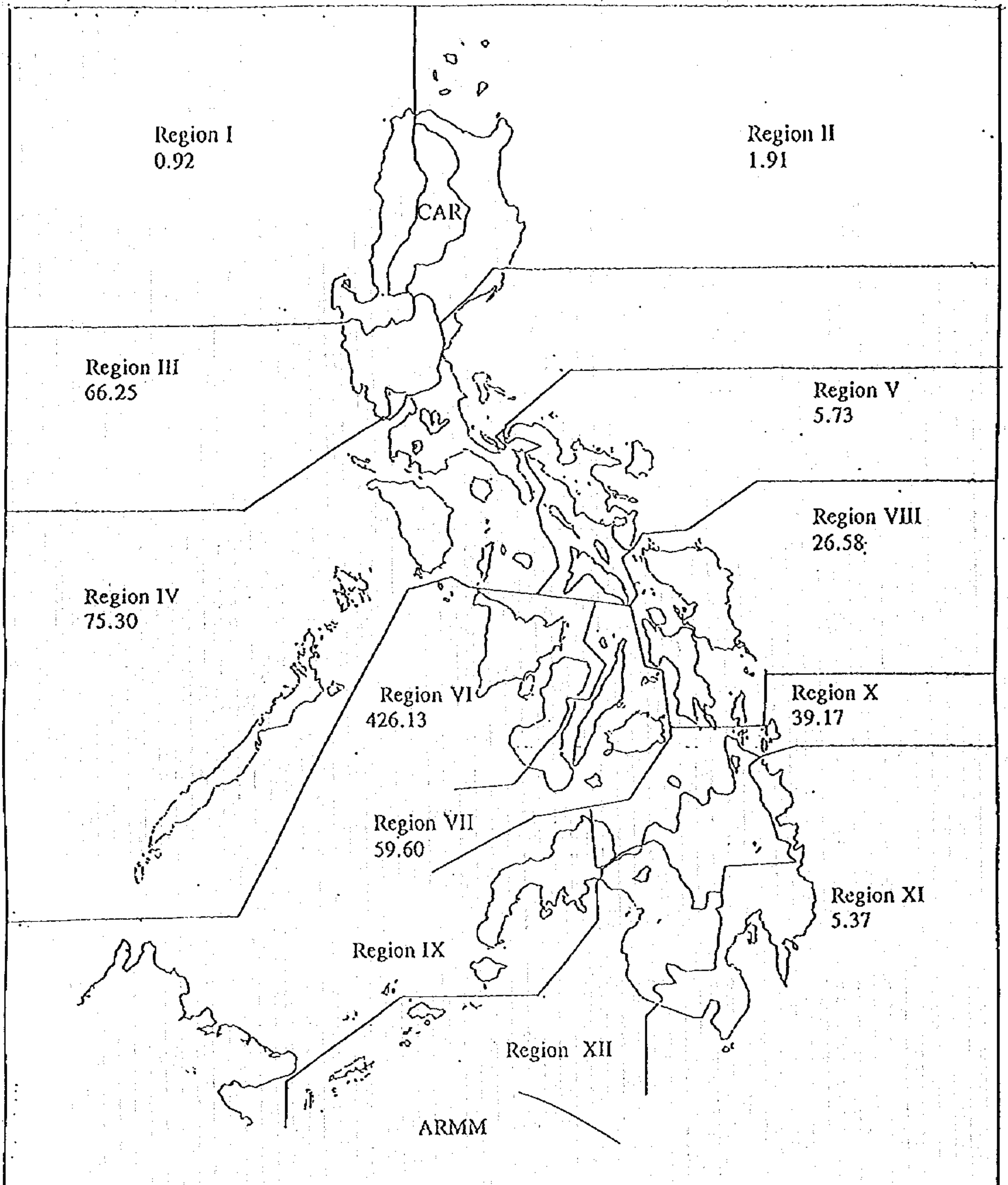


FIGURE 2
Philippine Biomass Resource Potential
Bagasse
(in MW)

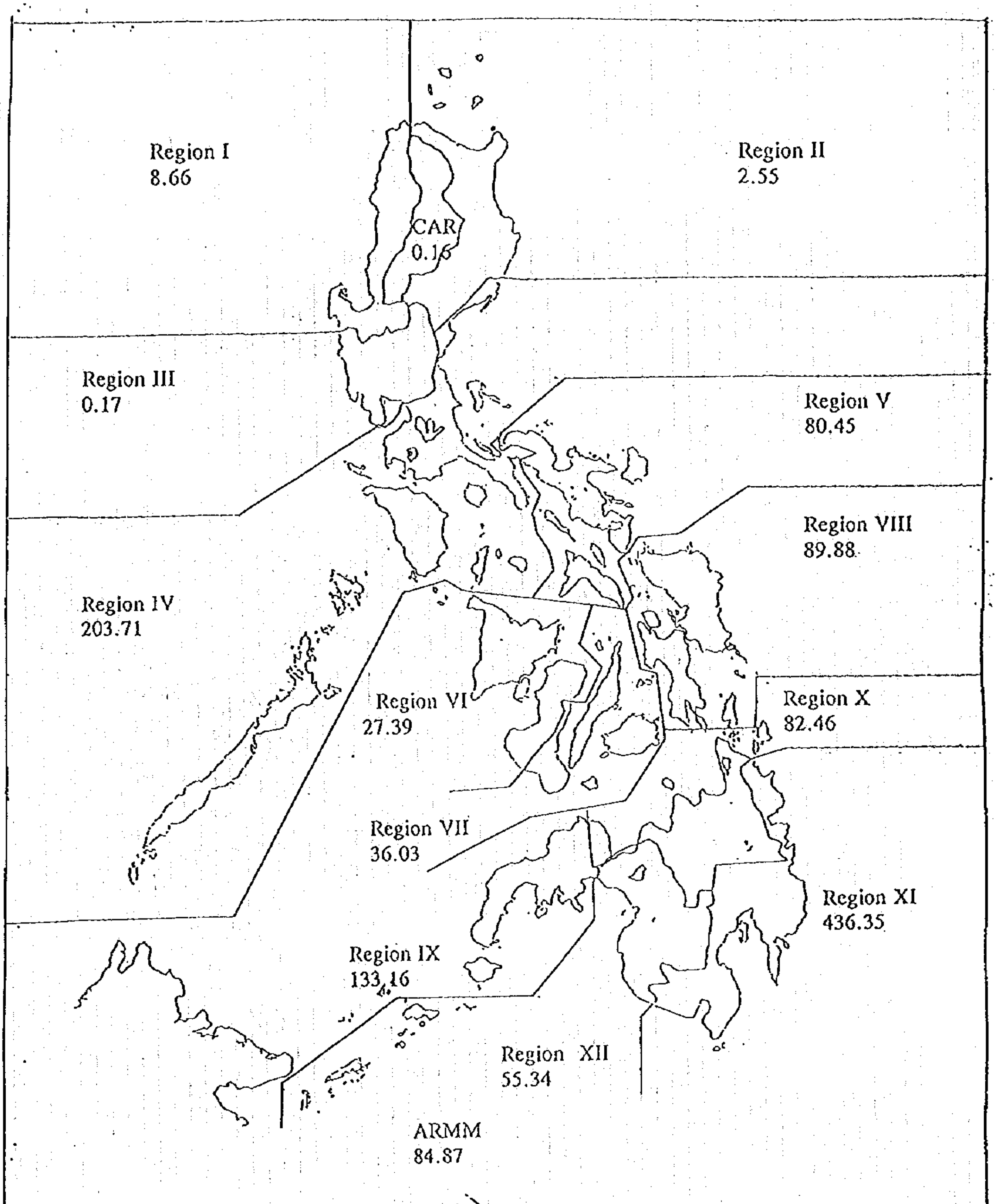


FIGURE 3
Philippine Biomass Resource Potential
Coconut Residues
(in MW)

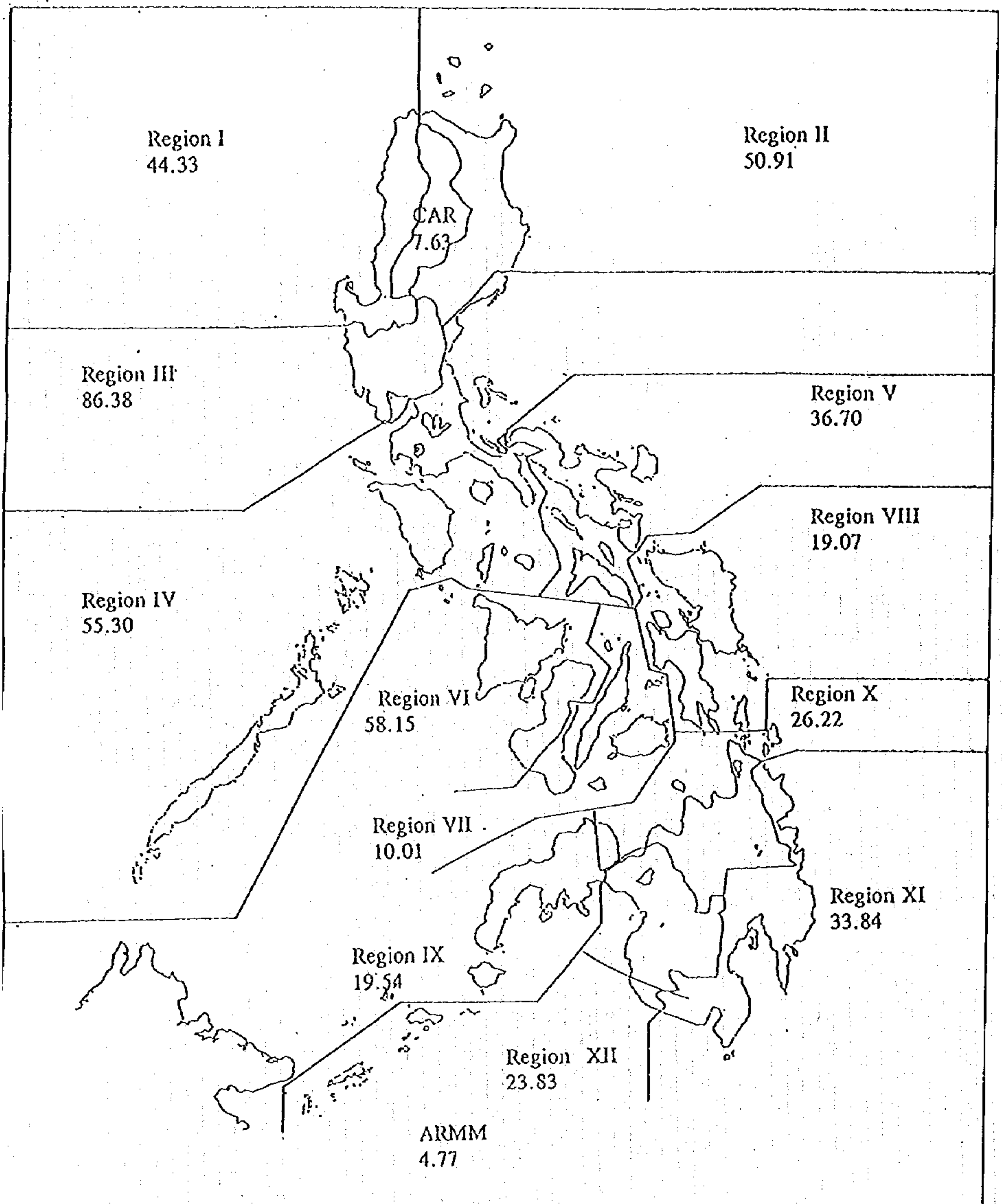


FIGURE 4

Philippine Biomass Resource Potential
Rice Residues
(in MW)

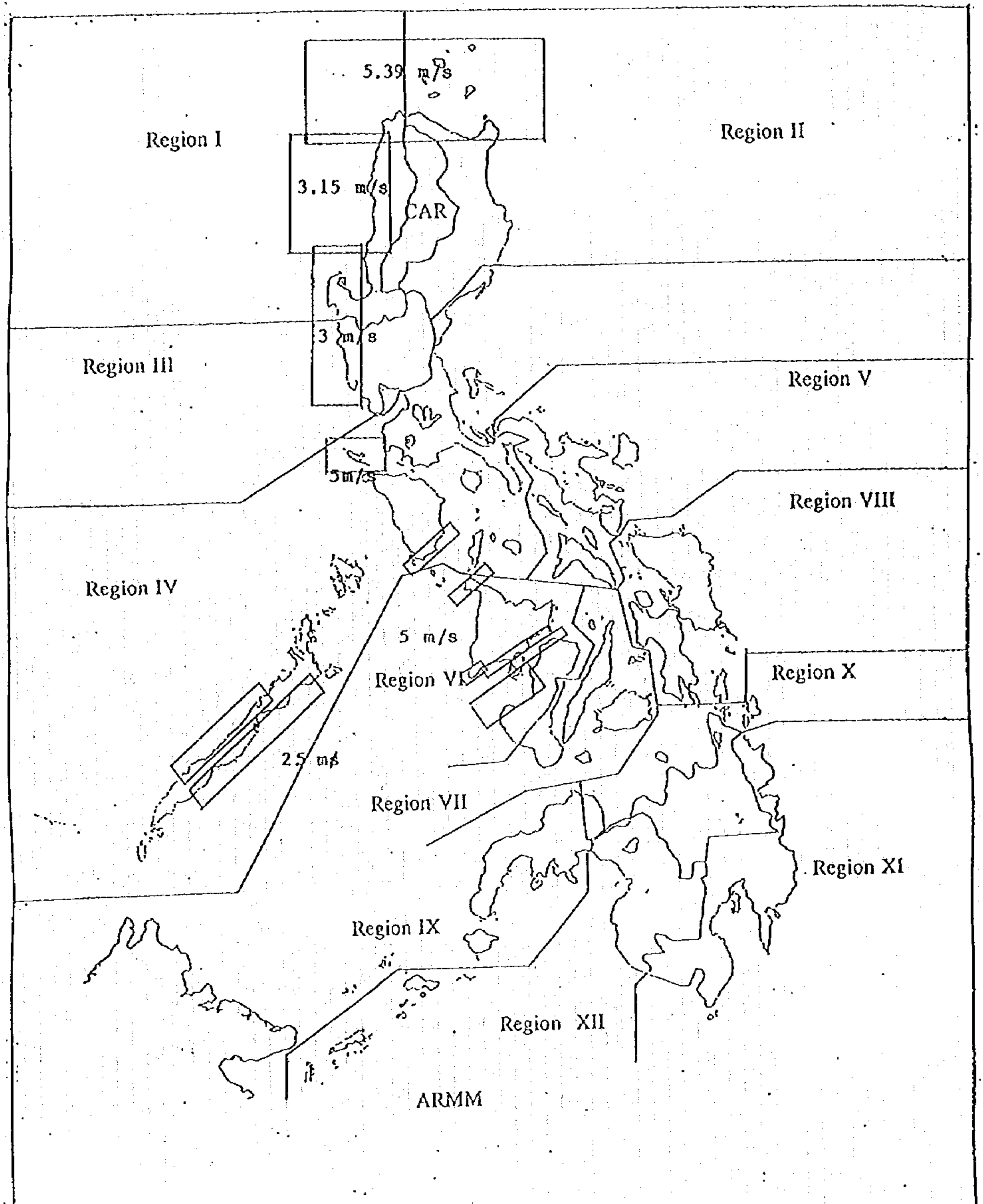


FIGURE 5
Philippine Wind Energy Resource Potential

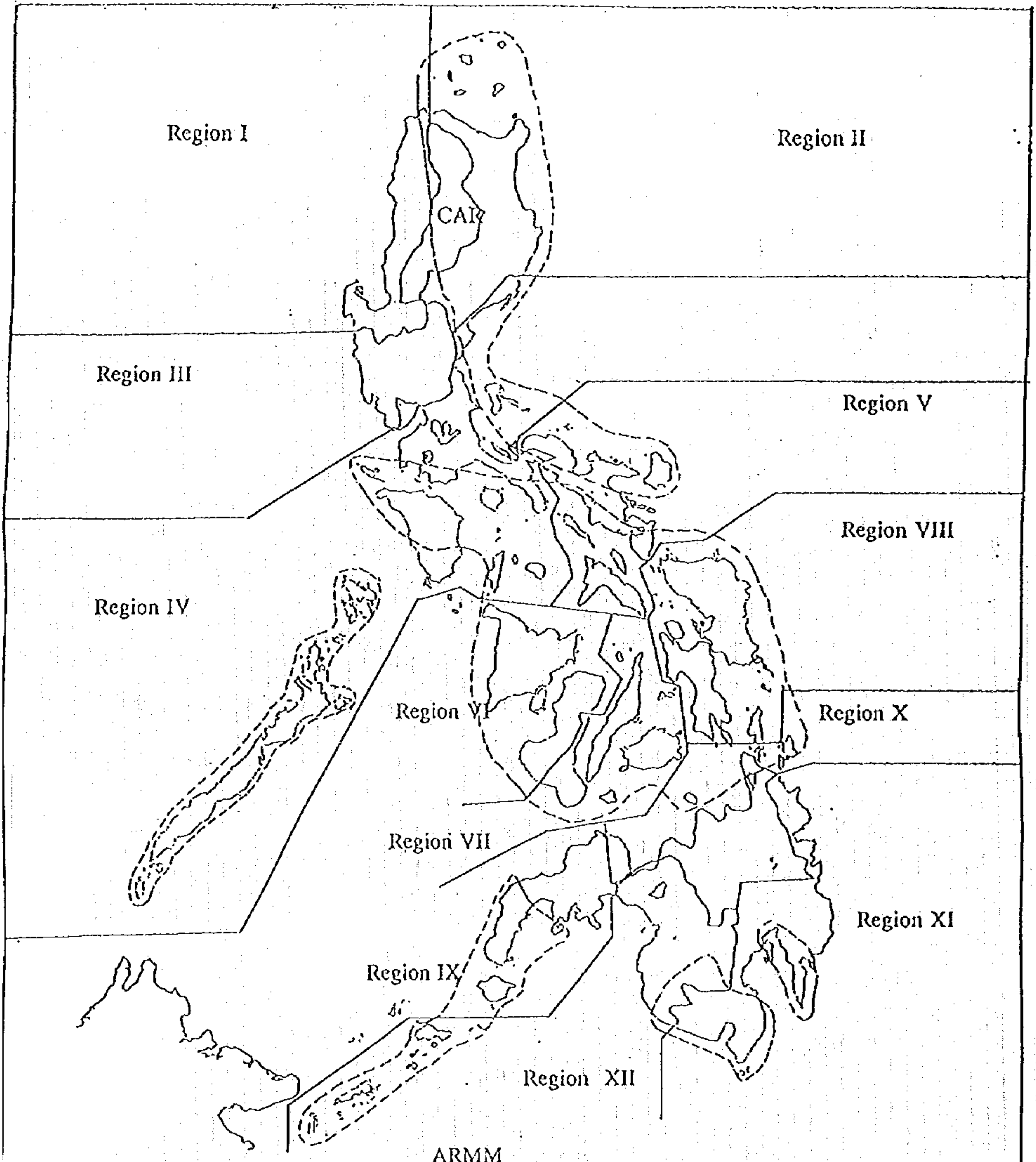


FIGURE 6
Potential Areas for Solar Energy Installations
Philippines (Average daily insolation ≈5 kWh/m²/d)

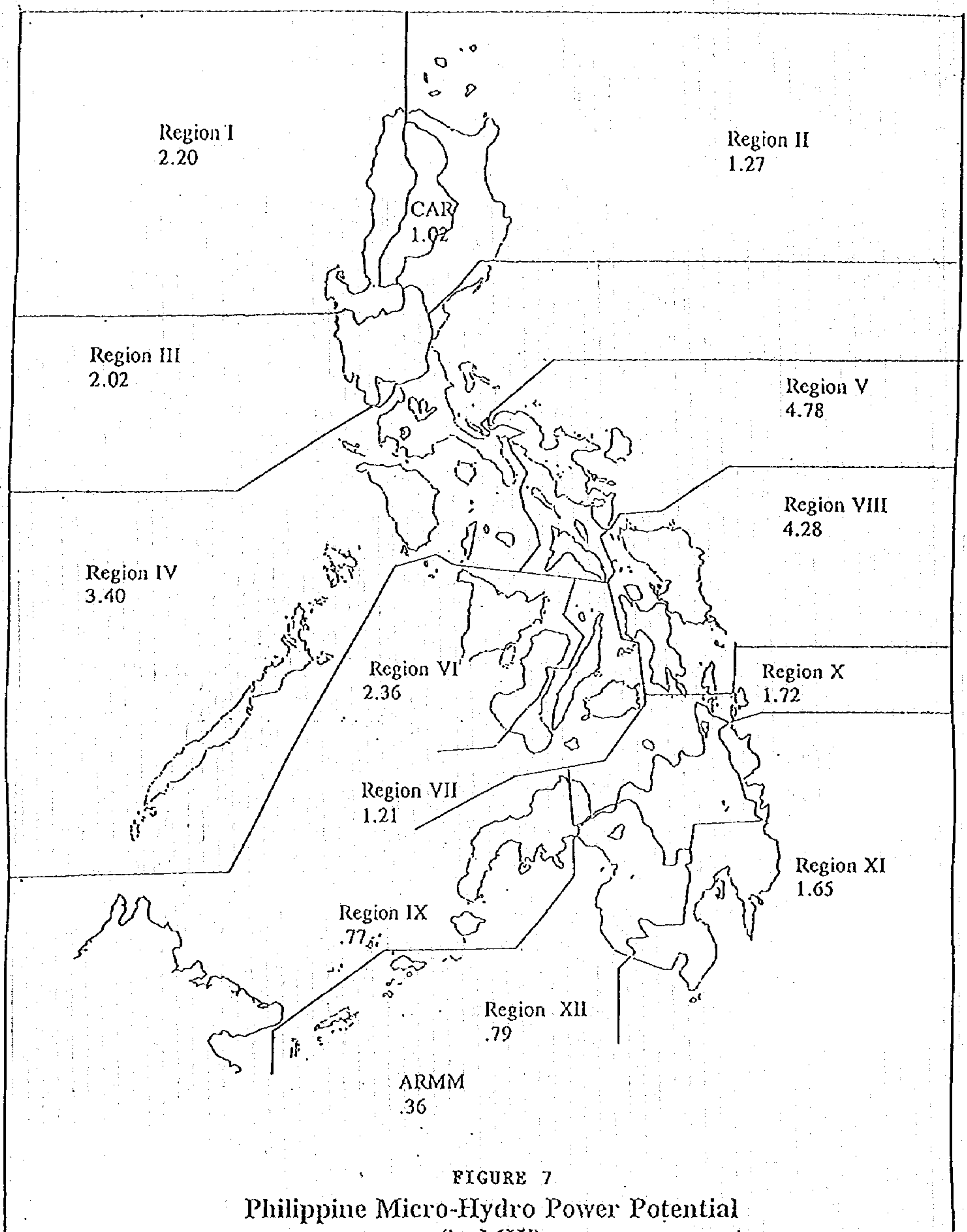


FIGURE 7
Philippine Micro-Hydro Power Potential
(in MW)

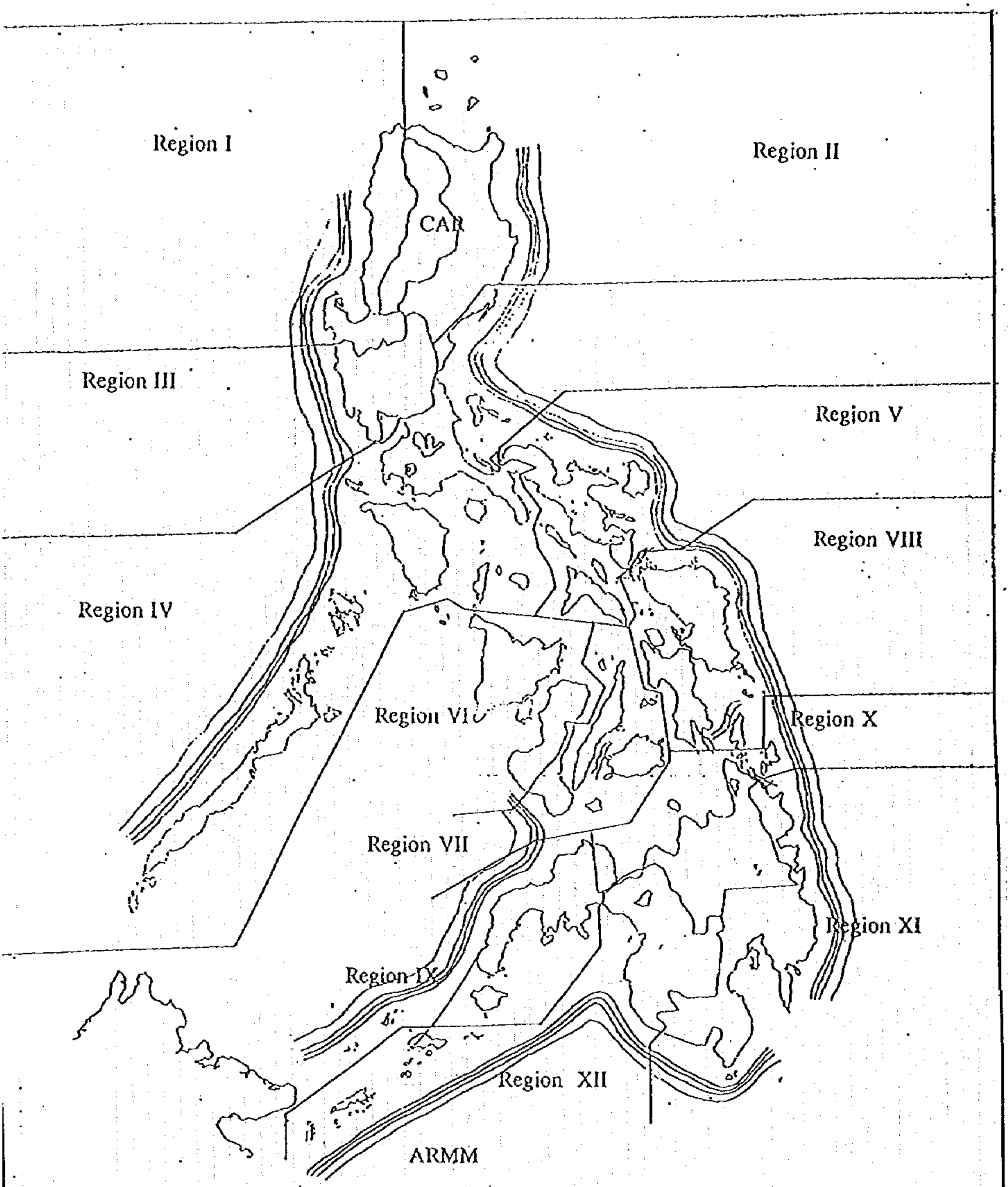


FIGURE 8
Potential Areas for Ocean Energy Applications

Philippine-German

PHOTOVOLTAIC PUMPING PROJECT

WATER BY SOLAR ENERGY

PROJECT DESCRIPTION

General

The Philippine-German Photovoltaic Pumping Project PGPVP is part of a worldwide research and development program carried out in seven countries of South America, Africa and Asia. It should prove the technical and economical viability of solar pumping systems in tropical developing countries. The German Ministry for Research and Technology (BMFT) and the Ministry for Economical Cooperation (BMZ) engaged the German Agency for Technical Cooperation (GTZ) to implement the program in 1989, the Philippine project started in July 1991. The Philippine counterpart agencies are the Office of Energy Affairs (OEA), the Local Water Utilities Authority (LWUA), the Provincial Planning and Development Office Cebu and - as implementing institution - the Water Resources Center (WRC) of the University of San Carlos, Cebu City.

Goals

Within a project period of four years some 15 Photovoltaic Pumping Systems will be installed preferably in the Central Visayas Region, to improve the water supply conditions in unelectrified rural areas. A close monitoring of the technical and socio-economic data will be performed for further development of the technology and also to show, how a relatively sophisticated technology will influence the development of rural communities.

In cooperation with the German industry, several universities and independent laboratories, the technology of PVP systems should be transferred to Philippine counterparts. Philippine companies should be enabled to manufacture components or even complete pumping systems in the country. After a successful operation of the first systems, a dissemination strategy should be worked out for the whole country.

Technology

Photovoltaic Pumping Systems utilize the energy of the solar radiation to pump water from a well, a spring or any other source to an elevated reservoir from where the water will be distributed to the consumers. A typical set up is shown in figure 2.

The solar generator converts the sunlight directly into electricity by means of the photovoltaic effect. The direct current (DC), generated by the solar panels can directly drive a DC-motorpump. This is mostly done for smaller systems, where the DC-motors can reach quite high efficiencies. The DC-power can also be converted into an alternating current (AC) by means of a DC/AC inverter in order to drive a common AC-motorpump. A 3-phase AC-motor is the most reliable electrical drive and it can be operated without any maintenance requirements.

So the typical PVP system consists of the following three main components:

- Solar Generator
- DC/AC Inverter
- AC-Motorpump

in cooperation with

WATER RESOURCES CENTER
USC-TC
Talamban, Cebu City 6000
Tel.: (032)-460583
Fax: 0063-32-461356

OEA OFFICE OF ENERGY AFFAIRS
Non-Conventional Resources Division
LWUA LOCAL WATER UTILITIES ADMINISTRATION
PPDO PROVINCIAL PLANNING & DEVELOPMENT OFFICE
GTZ GERMAN AGENCY FOR TECHNICAL COOPERATION

SITE DATA						
Philippine - German Photovoltaic Pumping Project						
Site Name	Sablayan	Limasawa	Cajel	Managase	Sacsac	Compostela
Barangay	Yapang	San Agustin	Cajel	Managase	Sacsac-Olango	Compostela
Municipality	Sablayan	Limasawa	Borbon	Borbon	Aloguinsan	Alegria
Province	Occidental Mindoro	Leyte	Cebu	Cebu	Cebu	Cebu
Date Installed	Apr 94	Apr 94	May 94	May 94	May 94	May 94
Date Commissioned	Apr 94	Apr 94	May 94	May 94	May 94	May 94
Solar Array Rating	1400 Wp	1750 Wp	1113 Wp	2120 Wp	1696 + 1696 Wp	1272 Wp
Panel Type	M50 Siemens	M50 Siemens	M55 Siemens	M55 Siemens	M55 Siemens	M55 Siemens
Inverter	SA 1500 Grundfos	SA 1500 Grundfos	SA 1500 Grundfos	SA 1500 Grundfos	2 x SA 1500	SA 1500 Grundfos
Pump / Motor Type	SP 5A-7 Grundfos	SP 5A-7 Grundfos	SP 5A-7 Grundfos	SP 2A-15 Grundfos	2 x SP 2A-15	SP 2A-15 Grundfos
Pumping Head	23 m	45 m	28 m	66 m	70 / 97 m	30 / 80 m
Daily Delivery Rate (design)	25 cu.m	20 cu.m	17.5 cu.m	15 cu.m	17.4 cu.m	4.6 cu. m
Ave. Daily Delivery Rate (actual)	15 cu.m	10 cu.m	10 cu.m*)	10 cu.m	10 cu.m	2 cu. m
Type of Water System	level II	level II	level II	level II	level II	level II
Type of Source	drilled well	spring	spring	spring	spring	spring
No. of Storage Reservoir	1	1	1	1	2	2
Total Reservoir Capacity	60	15	30	30	20 + 20	10 + 10
Collection Tank Capacity	none	2 cu. m	6 cu. m	5 cu. m	10 cu. m	5 cu. m
Distribution Pipeline	3.4 km	0.8 km	2.5 km	3.0 km	3.6 km	1.8 km
Total Project Cost	P 2.91M	P 1.2M	P 1.8M	P 2.5M	P 2.9M	P 1.6M
No. of Tapstands	15 units	2 units	6 units	5 units	10 units	5 units
No. of Users	215 HH	93 HH	175 HH	180 HH	350 HH	146 HH
Water Tariff	P 20 per cu.m	P 20 per cu.m	P 20 per cu.m	P 20 per cu.m	P 20 per cu.m	P 20 per cu.m

SITE DATA						
Philippine - German Photovoltaic Pumping Project						
Site Name	Bagtik	Tabla	Hilantagaan	Cawasan	Nangka	Pilar
Barangay	Bagtik	Tabla	Hilantagaan	Cawasan	Nangka	Opao, Kawit
Municipality	San Remegio	Liloan	Sta. Fe	Aloguinsan	Boljoon	Pilar
Province	Cebu	Cebu	Cebu	Cebu	Cebu	Cebu
Date Installed	Feb 93	Dec 92	Feb 93	Feb 93	Feb 93	Dec 92
Date Commissioned	Mar 93	Dec 92	Feb 93	Feb 93	Feb 93	Dec 92
Solar Array Rating	4500 Wp	2000 Wp		3600	1200 Wp	2000 Wp
Panel Type	M50 Siemens	M50 Siemens	M50 Siemens	M50 Siemens	M50 Siemens	M50 Siemens
Inverter	Simovert P Solar	SA 1500 Grundfos	SA 1500 Grundfos	Simovert P Solar	SA 1500 Grundfos	SA 1500 Grundfos
Pump / Motor Type	UPA 100 4/30 KSB	SP 3A-10 Grundfos	SP 5A-7 Grundfos	UPA 100 4/25 KSB	SP 5A-7 Grundfos	SP 3A-10 Grundfos
Pumping Head	125 m	56 m	34 m	116 m	27 m	56 m
Daily Delivery Rate (design)	17.5 cu.m	16 cu.m	21 cu.m	12 cu.m	17 cu.m	16 cu.m
Ave. Daily Delivery Rate (actual)	10 cu.m	8 cu.m	15 cu.m	8 cu.m	6 cu.m	8 cu.m
Type of Water System	level II	level II	level II	level II	level II	level II
Type of Source	spring	open dug well	open dug well	open dug well	open dug well	open dug well
No. of Storage Reservoir	2	1	1	2	1	1
Total Reservoir Capacity	15 + 30 cu.m	30 cu.m	60 cu.m	25 cu.m	30	30
Collection Tank Capacity	2 cu.m	5 cu. m	none	5 cu. m	2 cu. m	5 cu. m
Distribution Pipeline	6.2 km	2.8 km	5.7 km	3.6 km	2.1 km	2.8 km
Total Project Cost	P 4.36M	P 2.09M	P 2.54M	P 3.09M	P 1.59M	P 2.09M
No. of Tapstands	12 units	17 units	13 units	10 units	6 units	15 units
No. of Users	380 HH	210 HH	549	210 HH	78 HH	210 HH
Water Tariff	P 20 per cu.m	P 20 per cu.m	P 20 per cu.m	P 20 per cu.m	P 20 per cu.m	P 20 per cu.m