

**DISSEMINATION OF RENEWABLE ENERGY IN DEVELOPING COUNTRIES:
EXPERIENCES OF A REGIONAL PROJECT IN ASIA**

S. C. Bhattacharya and S. Kumar

Energy Program, Asian Institute of Technology, P. O. Box 4, Klong Luang, Pathumthani, Thailand
Fax No. (662) 524 5439, e-mail: bhatta@ait.ac.th

Abstract - In many developing countries, the promotion of renewable energy is hampered due to various factors, and a regional collaborative approach is an excellent alternative to foster promotion of renewable energy technologies (RETs). This paper describes such a regional programme executed over a two-year period in selected countries of Asia. The countries involved were Bangladesh, Cambodia, Lao PDR, Nepal, the Philippines and Vietnam, and the renewable energy technologies studied were photovoltaics (PV), solar drying, and biomass briquetting. Details regarding the adaptive research conducted have been presented as well as the various dissemination methods adopted to promote these RETs in the selected countries.

1. INTRODUCTION

Although many countries in the Asian region are endowed with abundant renewable energy (RE) resources, most of these countries suffer from severe and widespread energy deprivation, as the best use of available resources is not being made. Various teething problems, inherent to developing almost any new technology, encountered during the process of implementation of RE projects often lead to abandoning these projects. These include lack of trained manpower, lack of co-ordination among various agencies involved (government agencies, R&D institutions, entrepreneurs and users), lack of consistent government policies, etc.

With these considerations, to develop and promote selected mature and nearly mature renewable energy technologies, a two-year regional research and dissemination programme, 'Renewable Energy Technologies in Asia' involving six Asian countries and three renewable energy technologies was sponsored by the Swedish International Development Co-operation Agency (Sida).

2. ORGANISATIONS AND RETs INVOLVED

The programme involved national research institutions (NRIs) including government agencies/ departments and non-governmental organisations from six countries, namely, Bangladesh, Cambodia, Lao PDR, Nepal, the Philippines and Vietnam. Table 1 lists the institutions involved in the programme. The technologies considered for research and dissemination were photovoltaics (PV), solar drying, and biomass briquetting. The programme addressed the country-specific requirements of these technologies. The collaborative research on each of the selected RETs involved at least two country institutions (NRIs).

3. ACTIVITIES (TECHNOLOGY-WISE)

Technical adaptation of the selected RETs, capacity building, and technology transfer in the participating countries were the major objectives of the project. Various adaptations to standard/imported and locally available technologies were carried out by the participating institutions. Local expertise was developed on the three technologies through technology transfers, and prospective local entrepreneurs who could commercialise the technology were identified and trained. Demonstration systems were installed to educate the public, of the technical and economic

Table 1: NRIs involved in the programme

TECHNOLOGY	INSTITUTE
Photovoltaics	Centre for Mass Education in Science (CMES), Bangladesh.
	Centre for Renewable Energy (CRE), Nepal.
	Grameen Shakti, Bangladesh.
	Ministry of Industry, Mines and Energy (MIME), Cambodia.
	Science, Technology and Environment Organisation (STENO), Lao PDR.
	Solar Laboratory (Solarlab), Vietnam
Solar Drying	Cambodia Institute of Technology, Cambodia
	Research Centre for Applied Science & Technology (RECAST), Nepal.
	University of the Philippines
Biomass Briquetting	Bangladesh Institute of Technology (BIT), Bangladesh
	Institute of Energy, Vietnam
	Royal Nepalese Academy of Science and Technology (RONAST), Nepal.

viability of renewable energy (RE) systems. Government policies on energy and fiscal incentives for promotion of RETs were studied in some of the countries. Promoting regional co-operation was an inherent component of the programme.

The activities of the NRIs were coordinated by Asian Institute of Technology (AIT), where certain research activities were also carried out. Logistical supports and methodologies were provided to the NRIs whenever necessary. AIT also assisted the country institutions in conducting applied research through special programmes for the country researchers. Review workshops, training programmes, and inter-country visits organised by AIT were some other key activities of the programme.

3.1 Photovoltaics

Most of the PV-related projects in the participating countries so far were sponsored by donors and non-governmental organisations (NGOs) for implementation in rural areas, specifically for lighting, health centres and water pumping. A lack of access to PV energy technologies exists in almost all the participating countries. Service structures required for the promotion, distribution, sales, technical assistance and maintenance are not fully developed. In stand-alone small-scale applications, performance of PV systems

are often poor due to improper application, system design and selection of inappropriate Balance of System (BOS) components such as the battery, charge regulator, inverter, support structures, cables, switches etc. (EPIA & Altener, 1996). Various other technical, economical, and social problems have also been reported with the different PV accessories in the collaborating countries.

In order to ascertain the problems of the various accessories of PV systems, a questionnaire was prepared and sent to the representatives of local suppliers, dealers of PV systems and equipment in the various countries to record their experiences and views on the PV accessories. The results of the survey, giving information on the problems/difficulties related to accessories and technologies, and the possible solutions to these commonly occurring problems, are compiled in Table 2.

After identifying the problems on selected accessories, efforts were made to overcome them. Adaptive research was carried out to rectify these problems and to improve the performance and design of these accessories.

Workshops and Training Courses were also conducted at AIT and in other participating countries. Experiences with specific designs and technologies were shared among the participating countries. Training programmes were conducted by those NRIs, which are proficient with specific technologies, for the benefit of the others.

3.1.1 Adaptive Research

In all these countries, PV modules and some of the accessories are generally imported. The imported accessories available in the local market often posed technical difficulties while in operation since in many cases they are not designed for the specific requirements of the PV systems or are not particularly suited for the operating conditions in the region or country. In certain cases, accessories manufactured locally also could pose many technical problems. It thus becomes necessary that these accessories are modified suitably or 'adapted' to the local conditions and requirements, through technology and design improvements. Adaptive research thus formed a key objective of this programme.

Adaptive research was mainly aimed at developing low cost, high-performance accessories, to suit the requirements of specific applications. Prototypes of these accessories were fabricated in almost all the countries.

The Centre for Renewable Energy (CRE) of Nepal conducted a detailed survey to identify the various PV technologies and systems available in the country, and also the problems experienced with PV systems and accessories. Availability of quality spares and accessories was identified as one of the major problems with the use of PV systems in Nepal. Adaptive research was hence concentrated on improving the design and performance of selected PV accessories such as Charge Controllers and Converters, while reducing the cost. Certain improved PV systems such as DC lamp assembly and Universal Solar Lantern were also developed (CRE, 1998).

Table 2: Problems encountered with local accessories and possible solutions of PV technologies in the participating countries (Kumar et al., 1998a)

Country	Accessory	Problems reported	Possible solutions
Bangladesh	Charge controller	<ul style="list-style-type: none"> high cost non-availability of local technology 	Development of simple, low-cost models; technology transfer from other countries
	Converter	<ul style="list-style-type: none"> high cost non-availability of a wide range of output voltage in a single equipment 	Development of low-cost converters, incorporating a wide range of output voltage
	Inverter	<ul style="list-style-type: none"> high cost non-availability of local technology 	Development of low-cost inverters; technology transfer from other countries
Nepal	DC lamp assembly/CFL	<ul style="list-style-type: none"> frequent failures high cost blackening of lamps 	To be solved by manufacturers
	Batteries	<ul style="list-style-type: none"> short life of automotive batteries 	Remains to be solved
	Charge controller	<ul style="list-style-type: none"> failure of control IC misuse of equipment 	Use of high quality components; regular training to users
Vietnam	Batteries	<ul style="list-style-type: none"> topping-up short life of automotive batteries non-availability of solar deep-discharge batteries 	User training; careful 'brand' selection
	Inverter	<ul style="list-style-type: none"> overloading 	user training
	CFL	<ul style="list-style-type: none"> blackening 	To be rectified by lamp manufacturer
	Charge controller	<ul style="list-style-type: none"> overloading performance deterioration in the long run 	User training; regular maintenance by local technicians

The Science, Technology and Environment Organisation (STENO) in Lao PDR was involved in the development of PV accessories adapted to local application requirements. A State-of-Charge Indicator and Electronic DC Ballast were developed, to provide low-cost alternative to expensive imported accessories.

Grameen Shakthi and CMES in Bangladesh worked on the development of high performance, low cost PV accessories. As a result, CMES developed Improved DC Ballasts, Charge Controllers, and Converters, after conducting numerous laboratory tests on locally available and imported accessories. Development of a PV-driven sewing machine, and DC hand-drilling machine is a key contribution of these institutions towards promotion of PV in the country through income-generating PV applications.

Solar Laboratory conducted extensive adaptive research in Vietnam. Various existing PV accessories were tested, to develop low-cost accessories, which can replace expensive imported ones, but with improved efficiency. Accessories adapted include improved DC lamp assembly, Intelligent Regulator, and Colour TV Adapter.

The results of the research programmes were disseminated through various conferences, seminars, and journals.

3.1.2 Dissemination and Training

The PV systems developed after adaptive research were demonstrated in the field by the respective NRIs. Demonstration systems were installed in sites carefully selected after considering various factors such as availability of national grid, potential for diffusion of the demonstrated technology in the local community, user requirements etc.

Several applications of PV technologies were demonstrated by Solarlab in Vietnam, in a special location named RETs village. The demonstration systems included solar lighting, pumping and battery charging. PV systems to be demonstrated were selected based on the requirements of the local community, and capacities were decided after analysing the energy-economics of the PV systems.

Demonstration systems were set-up by STENO in Lao PDR, to educate the people on the economic and environmental benefits of solar energy. Involvement of village communities in PV projects is necessary, for sustained operation of installed systems for the benefit of the communities. Various training programmes were conducted for technicians and users of PV systems on operation and maintenance aspects (STENO, 1998). The Ministry of Industries, Mines, and Energy (MIME) in Cambodia also set up Solar Home Systems in 39 houses, and three in Buddhist temples (Pagodas), as demonstration units, to popularise the technology and to educate the people on the benefits of PV electricity.

Within a country, technology demonstrations were carried out by the respective NRIs, for entrepreneurs, managers and other persons involved in the RET business, to encourage the local industry, or in some cases, to start one, which was non-existent earlier. Training programmes were conducted not only for the

local technicians, retailers and users, but also for NRIs from the other countries using the technology.

A one-week International Training Course on PV technology and Charge Regulator, was conducted in Vietnam for technicians and engineers on installation and maintenance of PV powered Battery Charging Stations and Solar Home Systems. Participants were NRIs from Bangladesh, Lao PDR, Nepal and Cambodia. Training was offered on PV systems and components in the design, fabrication, installation and maintenance, troubleshooting and repairing. The training course consisted of theory classes, electronic workshops, table discussion, as well as visits to PV module assembly line and Solar Test Park.

Another one-week training was provided to an engineer and a technician each from Cambodia and Lao PDR at SOLARLAB, Vietnam on 'PV Charge Controller and Maintenance'. This training emphasised manpower development for the two participating countries, on fabrication, installation, troubleshooting and repairing of Charge Regulators. An International Technology-transfer cum Training Course was organised in Nepal for technicians and engineers from Bangladesh and Lao PDR, on Photovoltaic Charge Controllers.

Apart from inter-institutional training, national training programs were also organised by the respective participating institutions for the benefit of local technicians and entrepreneurs.

Manuals for training courses were also prepared by the NRIs. The following training manuals were brought out:

- (i) Photovoltaic Technology and Maintenance - by Solarlab, Vietnam
- (ii) Training Manual for Installers of PV Home System - by Centre for Renewable Energy, Nepal
- (iii) Report on Technology Transfer Training Program on Solar Charge Controllers - by Solar Electricity Company Pvt. Ltd., Nepal
- (iv) Solar Charge Regulator - Making and Repairing - by Solarlab, Vietnam.

Exchange visits were arranged between NRIs for technology transfer. A team from Bangladesh visited Nepal to obtain first hand information on the details regarding the accessories (charge controllers, inverters and ballasts), marketing, financing, etc.

A video film was prepared by Solarlab in Vietnam through the HCM Television Agency. Articles on the project were prepared for magazines such as Science and Life, and Popular Science and Technology, and published in Vietnam.

3.2 Solar Drying

Open-air drying is the common traditional drying method practiced in all the participating countries. Although limited, solar drying is also used in certain countries, for drying some specific agricultural products. Various types of dryers usually fabricated using locally available raw materials, are used with a variety of agricultural commodities.

An extensive review made on the existing solar dryers helped to identify the different types of solar dryers used in individual countries, their applications, and products used in the dryer. Open-air drying is the traditional drying practice in Nepal for post-harvest storage of agricultural products and ayurvedic (herbal) medicines. A box-type solar cabinet dryer developed at the Brace Research Institute and modified by the Research Centre for Applied Science and Technology (RECAST), is being used for drying vegetables and fruits, such as apples, ginger cardamom, jack fruit, banana and potato chips. This is the most widely used type of solar dryer in Nepal (RECAST, 1998).

The Modified rack type solar dryer developed by RECAST has a double-glazed solar collector of 2m² area, and has two DC-operated fans for forced ventilation. The capacity of the dryer is 8-10kg of fresh fruits/vegetables, and the cabinet with a volume of 0.3m³ has four trays in it.

In Cambodia, natural open-air sun drying is the popular drying method practised. Bamboo baskets are used in some cases, where the products to be dried are spread and left in open sun for drying. In certain advanced cases, wire mesh racks are used to replace bamboo baskets (Cumberland, 1996).

Majority of the farmers in the Philippines relies heavily on traditional sun drying of their harvest, especially paddy. Other grains, vegetables, fruits and fish are also dried in open sun. Solar tunnel dryers, locally known as tent dryers, are typical natural convection direct solar dryers used in the Philippines to dry crops with low density and porosity like soya beans and peanuts (Jerez, 1997).

After analysing the various types of solar dryers used in developing countries, a dryer suitable for the tropical climates of the participating countries was developed and demonstrated in some of the collaborating countries.

Workshops and Training Courses were conducted at AIT as part of technology transfer and extension works. Experiences with specific designs and technologies were shared among the participating countries. A one-day workshop was organized to discuss the objectives of national solar drying projects, the methodologies to be adopted and the expected results from the country activities. Background Information containing various aspects of solar drying techniques, including state-of-the-art, and additional material, which served as project guidelines and reference materials on solar drying technology, were distributed to the participants.

3.2.1 Adaptive Research

Different types of dryers, classified according to the mode of heat transfer, airflow, and products used to dry, were analysed of their design and performance. From all of these dryers in use, a tunnel type dryer suitable for dissemination in the selected countries was selected and adapted to suit the drying requirements of the small farmers in the Asian region. A prototype of the adapted design was fabricated at AIT, and tested for its performance with drying banana and chilli. The performance of the dryer was found very satisfactory, especially with the

introduction of a PV-operated ventilation system. The dryer was disseminated to the participating countries through the NRIs involved. A Construction Manual and a Video were also brought out, for better dissemination (Kumar et al., 1998b).

RECAST conducted an exhaustive survey to evaluate the existing solar drying technologies in Nepal. Adaptive research was conducted to develop technically and economically viable solar dryers, and prototypes were fabricated. Demonstration and training programmes were conducted for the manufacturers as well as users of solar dryers, and the dryer technology offered to local entrepreneurs. Appropriate marketing strategies were also formulated, to stimulate the commercialisation of solar dryers in the country.

In the development of a solar-biomass hybrid dryer for a ceramic factory in the Philippines, the University of Philippines Engineering Research and Development Foundation (UPERDFI) carried out extensive research on the overall design aspects of the system. Three-dimensional Computational Fluid dynamics analysis was performed on an existing flat-bed dryer in the process of designing the ceramic dryer, and a prototype dryer was fabricated. Performance evaluation on the prototype dryer revealed large scope for such dryers in the ceramic industry of Philippines (UPERDFI, 1998).

In Cambodia, research on solar drying included development of economically viable solar dryers to suit local products, and which can be built with locally available materials and expertise. A tunnel type cabinet dryer and a chimney type dryer were fabricated after the adaptive research, and tested with various fruits and vegetables (MIME, 1998).

3.2.2 Dissemination and Training

Dissemination was carried out through demonstrations, workshops, publications, and manpower development. Demonstration involved not only the dryer designs adapted by the NRIs themselves to suit the specialised needs and local conditions of their respective countries, but also the dryer developed at AIT. For the dissemination of AIT solar tunnel dryer, a Construction Manual and a video illustrating the construction of the dryer were brought out. Results of the various drying experiments conducted with banana and chilli drying, were communicated to the NRIs for wider dissemination of this technology.

A one-month special student program on solar drying was organised at AIT within the framework of the project, for researchers from the participating countries. The study focused on the design and construction of solar dryers. The participants also gained hands-on experience by conducting actual experiments on the solar tunnel dryer and a natural convection type dryer at AIT.

The results of the research programmes were also disseminated through national conferences and seminars.

3.3 Biomass Briquetting

Biomass occupies a predominant place as an energy source in rural villages of developing countries. However, transportation

and combustion of agricultural residues is difficult due to their low bulk density. Briquetting of biomass thus carries tremendous scope and potential in converting agricultural residues into a more usable form of fuel.

In heated die screw press briquetting machine, the screw is prone to wear caused by the abrasive behaviour of biomass. The wear of screw results in significant operating costs, and calls for a rather regular attention of the plant owner. The high electrical energy consumption by the briquetting process was another area of concern, which limits the widespread use of the technology. The objective of research on biomass briquetting was to eliminate or reduce these technical and operational problems, and to adapt the technology to individual countries according to the type and quality of raw materials available locally.

Status of the biomass briquetting technology in the participating countries were studied. Biomass briquetting has been popular in Bangladesh for the past few years, and more than 900 heated-die screw press briquetting machines are in operation in the country (BIT, 1998). Briquetting technology is being commercially developed, and briquettes are recognised as an alternative for fuelwood. Ricehusk and sawdust are the usual biomass fuels briquetted.

In Vietnam, biomass briquetting technology was introduced by the regional project (IoE, 1998).

3.3.1 Adaptive Research

Towards one of its objectives, the effect of preheating raw material before densification on electrical energy consumption of a heated-die screw-press briquetting machine was studied at AIT. A raw material preheating system consisting of a gasifier, a gas combustion chamber and a pre-heater was designed and tested. The pre-heater could heat raw material to about 180°C. By preheating saw dust, the electrical energy input to the motor, heaters and overall system was reduced by 22.0%, 5.2% and 16.3% respectively. Electrical energy saving potential by preheating was less for ricehusk. When ricehusk was heated to 154°C, the electrical energy input to the motor, heater and overall system was reduced by 17.66%, 4.6% and 12.32% respectively.

A biomass fired stove designed to replace the die electrical heaters was also tested. It was found that the stove could produce heat necessary for heating the die of the briquetting machine so that use of electrical die heaters and associated electrical energy consumption could be avoided.

A number of biomass briquette-fired stoves suitable for institutional kitchens or cottage industries were designed, fabricated and tested. A total of five stove designs were studied, e.g. i) a gasifier stove, ii) a two-stage top burning stove, iii) a brick stove, iv) a charcoal making stove and v) an adjustable grate stove. Although all the tested designs showed low levels of smoking, burning in the gasifier stove appeared to be particularly clean. Highest stove efficiency was however achieved with the insulated two-stage top burning stove (Bhattacharya et al., 1998).

Besides the above research carried out at AIT, in Bangladesh, where the technology is already popular, the adaptive research was aimed at developing and demonstrating improved briquetting screws to enhance the service life of screws by reducing the wear on them. Several hard-facing electrodes were experimented, and as a result, two electrodes (ChromCarb N6006 and XHD N6715 of Larson & Toubro, India) have been found to increase the average screw life to about 86 and 121 hours respectively, from the present 23 hours achieved with Ferrospeed electrode. Biomass pre-heating research was also carried out at Bangladesh Institute of Technology, to reduce the energy consumption of the briquetting process.

3.3.2 Dissemination and Training

Institute of Energy in Vietnam demonstrated the briquetting technology at several demonstration centres in the country, to familiarise the concept among general public. Prototype briquetting machines were also fabricated, after a detailed adaptive research. In Bangladesh, two briquetting machines were installed in remote villages, and demonstrated.

AIT provided the design details, including the construction, drawings, and experimental results on improved briquetting machines to the NRIs, for dissemination in their respective countries. Technology for the manufacture of biomass briquetting machines was provided to Vietnam, where the technology was relatively new. Improved designs of community type stoves, which can be used to burn rice-husk briquettes efficiently and cleanly, were developed at AIT and were provided to the NRIs.

A one-month special student programme was conducted at AIT for researchers from the country institutions on biomass briquetting technology, with and without raw material pre-heating. Inter-country visits were arranged between NRIs. A team from Institute of Energy, Vietnam visited the Bangladesh Institute of Technology, to train themselves on the design and fabrication of briquetting machines and screws.

Workshops and Training Courses were conducted at AIT and in other participating countries as part of technology transfer and extension works. Experiences with specific designs and technologies were shared among the participating countries. Training programmes were conducted by the respective NRIs, for entrepreneurs, managers and other persons involved in the RET business, to encourage the local industry.

Dissemination also included publications in conferences, seminars, workshops, and journals.

4. CONCLUDING REMARKS

Photovoltaics:

A significant number of solar home systems have been installed in all the participating countries as demonstration units. The performance of PV accessories (mainly batteries, converters, inverters, and charge controllers) were studied, and adaptive research conducted to suit local conditions. Low wattage income generating devices such as PV operated sewing machines and

drills were developed. If the market for similar productive end-uses proves to be cost-effective, the dissemination of PV systems may reach low-income people. However, there seems to be a lack of expertise in the field of marketing and dissemination, especially in Lao PDR and Cambodia.

Solar Drying:

Six designs of solar dryers have been tested by the NRIs, and improvements over previous designs have been demonstrated. The Philippines approach in the project was market-led, with a clearly identified end-product, solar assisted ceramic dryer. The solar drying in general, has been demonstrated with varying degrees of success in the countries involved, through exhibitions, advertisements, workshops, and training.

Biomass Briquetting:

Development of hard-facing techniques in Bangladesh has improved the performance of heated-die screw press briquetting machine considerably. Although some of the materials research seems too advanced to be of direct use in the field, they have added to the research capability of the NRI. Marketing activities undertaken in Vietnam were more effective, with the target beneficiaries identified clearly (Khennas and Anderson, 1998). Institutional type briquette stoves, which can burn biomass briquettes, were developed at AIT. Bangladesh and Vietnam have also developed briquette-burning domestic stoves for dissemination in their countries. Results of adaptive research carried out at AIT are expected to be used for developing an improved briquetting system in the second phase of this regional programme.

Acknowledgement: The financial support by the Swedish International Development Co-operation Agency (Sida) for this study in the framework of the project "Renewable Energy Technologies in Asia - A Regional Research and Dissemination Programme" (RETs in Asia) is gratefully acknowledged.

REFERENCES

Bhattacharya S.C., Pham H.L., Siddique A.H.Md.M.R., Augustus Leon M., and Animesh Dutta, August 1998, An Experimental Study of Improved Biomass Briquetting, Report prepared by AIT for Sida for a collaborative project, *RETs in Asia*.

BIT, August 1998, Bangladesh Institute of Technology: Report submitted to AIT in the framework of GS-BIT/AIT collaborative project, 'Renewable energy Technologies in Asia'.

CRE, August 1998, Centre for Renewable Energy, Nepal: Report submitted to AIT in the framework of the CRE/AIT collaborative project, *RETs in Asia*.

Cumberland Judi, August 1996, Solar Energy in Cambodia, *Seminar on Financing and Commercialisation of Solar Energy Activities in South and East Asia*, Kunming, China.

EPIA (European Photovoltaic Industry Association) and Altener, Photovoltaics in 2010, European Commission Directorate-General

for Energy, Office for Official Publications of the European Communities, Luxembourg, 1996.

IoE, August 1998, Institute of Energy, Vietnam, Report submitted to AIT in the framework of IoE/AIT collaborative project, *RETs in Asia*.

Khennas Smail, and Anderson Teresa, November 1998, Intermediate Technology Development Group, and Intermediate Technology Consultants, Final Evaluation Report on RETs in Asia project, funded by Sida.

Kumar S., Augustus Leon M., and Diwaker Basnet, 1998a, A Study on Photovoltaic Applications in Selected Asian Countries, Report prepared by AIT for Sida for a collaborative project, *RETs in Asia*, August 1998.

Kumar S., Augustus Leon M., and Diwaker Basnet, 1998b, A Study on Improved Solar Drying for Agricultural Products in Asia, Report prepared by AIT for Sida for a collaborative project, *RETs in Asia*, August 1998.

MIME, August 1998, Ministry of Industries, Mines and Energy, Government of Cambodia: Report submitted to AIT in the framework of MIME/AIT collaborative project, *RETs in Asia*.

RECAST, August 1998, 'Report on Solar Drying', Research Centre for Applied Science and Technology of Tribhuvan University, Nepal: Report submitted to AIT in the framework of RECAST/AIT collaborative project, *RETs in Asia*.

STENO, August 1998, Science, Technology and Environment Organisation, Government of Lao PDR, Report submitted to AIT in the framework of STENO/AIT collaborative project, *RETs in Asia*.

UPERDFI, August 1998, University of Philippines, Engineering Research and Development Foundation Inc., Report submitted to AIT in the framework of UPERDFI/AIT collaborative project, *RETs in Asia*.