Experiences from a Regional Research and Dissemination Project on Renewable Energy Technologies in Asia

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ABSTRACT

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 renewable energy 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. Regional collaborative approach is an excellent approach to foster promotion of renewable energy technologies (RETs) in developing countries.

With these considerations, to develop and to promote selected mature and nearly mature renewable energy technologies, a five-year regional research and dissemination programme, 'Renewable Energy Technologies in Asia' involving six Asian countries has been sponsored by the Swedish International Development Co-operation Agency (Sida). The countries involved are Bangladesh, Cambodia, Lao PDR, Nepal, the Philippines and Vietnam, and the renewable energy technologies studied are photovoltaics (PV), solar drying, and biomass briquetting. This paper describes the first phase of the programme, its achievements so far, and overall impact in the countries involved. Details regarding the adaptive research conducted so far have been presented as well as the various dissemination methods adopted to promote these RETs in the selected countries.

1. INTRODUCTION

In order to promote selected mature and nearly mature RE technologies, a regional research and dissemination programme on 'Renewable Energy Technologies (RETs) in Asia' was initiated by Sida in 1997. The programme is coordinated by a senior faculty member of the Asian Institute of Technology, a Thailand-based international postgraduate institute. The first phase of the programme (RETs in Asia-I) involving 12 National Research Institutions (NRIs) from six Asian countries (Bangladesh, Cambodia, Lao PDR, Nepal, the Philippines and Vietnam) covered the period of 1997-1998. The RE technologies involved were photovoltaics (PV), solar drying, biomass briquetting and briquette stoves. A three-year second phase of the programme started in 1999. The programme attempts to address the country-specific requirements of these technologies. The activities and achievements of the first phase are being described in this paper.

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2. TECHNOLOGY-WISE ACTIVITIES

Technical adaptation of the selected RETs, capacity building and dissemination 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 selected 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 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.

Table 1: NRIs involved in the first phase of 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 & 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 Los Banos & Diliman
Biomass Briquetting	Bangladesh Institute of Technology (BIT), Bangladesh
	Institute of Energy, Vietnam

The activities of the NRIs were coordinated by the 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.

2.1 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.

2.1.1 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 various accessories (e.g.: charge controllers, inverters, converters, ballasts and compact fluorescent lamps) were fabricated in all the countries. Certain PV appliances (e.g.: PV-operated sewing machine, soldering iron, fan) were also developed by some NRIs.

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**).

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. 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.

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	• high cost • non-availability of local technology	Development of simple, low-cost models; technology transfer from other countries
	Converter	• 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	• high cost • non-availability of local technology	Development of low-cost inverters; technology transfer from other countries
Nepal	DC lamp assembly/ CFL	• frequent failures • high cost • blackening of lamps	To be solved by manufacturers
	Batteries	• short life of automotive batteries	Remains to be solved
	Charge controller	• failure of control IC • misuse of equipment	Use of high quality components; regular training to users
Vietnam	Batteries	• topping-up • short life of automotive batteries • non-availability of solar deep-discharge batteries	User training; careful 'brand' selection
	Inverter	• overloading	user training
	CFL	• blackening	To be rectified by lamp manufacturer
	Charge controller	• overloading • performance deterioration in the long run	User training; regular maintenance by local technicians

Solar Laboratory in Vietnam tested various existing PV accessories 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.

2.1.2 Dissemination and Training

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. Many PV systems and accessories developed after adaptive research were also demonstrated in the field by the respective NRIs. Solarlab demonstrated several applications of PV technologies at a village in the Mekong

Delta and at a Energy Park in HCM City. The demonstration systems included solar lighting, pumping and battery charging. PV systems demonstrated in the vollage were selected based on the requirements of the local community.

A battery charging system and a few Solar Home Systems (SHSs) 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. 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 installed SHSs in 39 houses in a village near Sihounovkvilla, 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. Training programmes were conducted not only for the local technicians, retailers and users, but also for NRI researchers from the other countries.

A one-week 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 local technicians and entrepreneurs. Manuals for training courses were prepared by the NRIs. Following training manuals were brought out:

(i) Photovoltaic Technology and Maintenance - by Solarlab, Vietnam
(ii) Training Manual for Installers of PV Home System - by CRE, 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 to facilitate technology transfer and other aspects related to promotion of PV. A team from Bangladesh visited Nepal to obtain information on the details regarding the accessories (charge controllers, inverters and ballasts), marketing, financing, etc.

Videos were prepared and telecast in national televisions. Several articles were also published in local magazines and newspapers.

2.2 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 some countries, for drying specific agricultural products. Many types of dryers are fabricated using locally available raw materials for drying 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 RECAST, is being used for drying vegetables and fruits, such as apples, ginger cardamom, jack fruit, banana and potato chips (**RECAST, 1998**). A rack type solar dryer developed by RECAST is also used popularly, for drying fruits and vegetables.

In Cambodia, natural open-air sun drying is the popular drying method. 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 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 the technology, were distributed to the participants.

2.2.1 Adaptive Research

Based on a survey of the various dryer types available in the region, a tunnel type dryer suitable for dissemination in the selected countries was selected. A prototype of the adapted design was fabricated at AIT, and tested for its performance by drying banana and chilli. The performance of the dryer was found very satisfactory, especially with the introduction of a PV-operated ventilation system (**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 the ceramic industry in the Philippines, the University of Philippines Engineering Research and Development Foundation (UPERDFI) carried out extensive research using Three-dimensional Computational Fluid dynamic analysis on an existing flat-bed 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 adaptive research, and tested with various fruits and vegetables (**MIME, 1998**).

2.2.2 Dissemination and Training

Dissemination was carried out through demonstrations, workshops, publications, and manpower development. The dryer designs adapted by the NRIs themselves to suit the specialised needs and local conditions of their respective countries, as well as the dryer developed at AIT, were demonstrated. 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 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.

2.3 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 re-introduced by this project (**IoE, 1998**).

2.3.1 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. 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 electrical die heaters was also tested. The stove performance was found to be excellent, and it could therefore effectively replace the electrical die-heater, and avoid its associated electrical energy consumption.

A number of biomass briquette-fired stoves suitable for institutional kitchens or cottage industries were designed, fabricated and tested at AIT. These include: 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, 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.

2.3.2 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 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.

3. CONCLUDING REMARKS

Overall, the regional networking approach of the RETs in Asia programme has provided an excellent model of project formulation, as well as research and development through collaboration and regional coordination. *RETs in Asia* has contributed to local capacity enhancement in the participating countries through training, technology transfer and adaptive research.

Field demonstration has served a number of purposes: i) improvement in the quality of life of local people through introduction of autonomous renewable energy-based sustainable energy supply systems, ii) local employment generation, and iii) development of public awareness on RETs in and around the demonstration villages.

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