

Renewable Energy Technologies in Asia

A Regional Research and Dissemination Programme

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Cooperation, SAREC**

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EXECUTIVE SUMMARY

This evaluation encompasses phase I of the programme on "Renewable Energy Technologies in Asia". This programme was co-ordinated by the Asian Institute of Technology (AIT) with much of the field work being undertaken by twelve National Research Institutes (NRIs) in six Asian countries. It was implemented over a two-year period between 1996 and 1998. This report also includes the evaluation of the proposal submitted for the second phase.

Three technologies were selected for study during the programme implemented in phase I: solar photovoltaic (PV), solar drying and biomass briquetting. These technologies cover both domestic end uses and income generating activities which may contribute, if widely disseminated, to a significant improvement in the provision of energy services in the rural areas of the six countries. Each technology was studied and implemented by at least two countries. In addition, as the characteristics of biomass briquettes are different from conventional biomass fuels, AIT carried out further adaptive research on improved gasification of briquettes and on improved direct combustion in institutional stoves.

This regional collaborative project has facilitated and developed greater cooperation between NRIs and between NRIs and AIT. The latter has played a crucial and efficient role in both the management of the project and in providing technical support for the NRIs, particularly in the fields of biomass briquetting and solar drying. In the field of photovoltaics, AIT has produced a comprehensive report to help NRIs address the issues related to adaptive research.

The common objectives carried out were adaptive research, demonstration, training and dissemination. In general, the adaptive research, demonstration and training objectives have been achieved and where this is not the case, reasons identified and largely acted upon. The results particularly in the fields of research and demonstration are satisfactory. However, training courses, in some cases, seemed to be an end rather than a means to an end. This was because technologies had not been developed enough. This is an aspect that needs a higher priority in future projects and training.

For most NRIs, and in particular Cambodia and Laos, there is not a clear strategy or a set of guidelines for the dissemination of RETs. This seems to be largely due to targets set being at a level which is beyond the human and financial resources available in these two countries. Nevertheless, Bangladesh's report produced by Grameen Shakti (GS), and that of the Philippines on solar drying, provide good strategies and guidelines in the domains of marketing and dissemination. These lessons need to be fully transferred to other NRIs during the second phase.

The extent to which the project is seen to have succeeded, in terms of satisfying overall objectives depends upon the relative achievement of the specific objectives

carried out by the NRIs. All countries displayed strengths in some areas but few displayed strengths in all areas; this was due, to a large extent, to project design, varied communication within and between the NRIs, and between the NRIs and AIT. In terms of individual technologies, points worthy of note can be summarised as follows.

Solar Photovoltaic

The focus placed on the adaptive research of accessories for solar PV is very relevant since the production of solar modules is excluded in the mid term in most developing countries, both for technological and economic reasons, e.g. the limited market which inhibits benefit from economies of scale.

Given the lifetime of the programme, the five NRIs involved in this research and AIT have achieved the main objectives despite some shortcomings. More than 70 solar home systems were installed in Bangladesh, Cambodia, Laos, Nepal and Vietnam. The number of direct beneficiaries is estimated at 375. In addition, two promising low wattage income-generating activities, PV operated sewing machine and DC (direct current) drilling, were experimented with in Bangladesh.

With respect to *adaptive research*, the focus was on the improvement of PV accessories such as charge controllers, regulators, converters, inverters and improved direct current ballast. The methodology and field tests carried out by the NRIs, particularly in Bangladesh by Grameen Shakti (GS) and the Centre for Mass Education in Science (CMES) and Nepal by the Centre of Renewable Energy (CRE) comply with the standards for such experiments. Significant technical improvements were made although additional research is needed, particularly in the case of inverters developed by Solarlab in Vietnam. It appears, especially in the case of Bangladesh, that the products developed can be cost-effective compared with imported products. Nevertheless, further monitoring of the costs and the performance is needed before more definite conclusions can be drawn.

In Nepal, the major PV users and the applications are well described. The main problems at the sites visited were identified. It appears that the problems are very diverse. It will be useful to identify common problems, if any, in order to design a strategy for such problems in the future.

Most NRIs have carried out good quality and well targeted *training courses*. However the impact of these courses has not been fully assessed. A follow-up of the trainees will contribute to finding if the training courses have led to their mastering of the key aspects of adaptive research and to an increase in the awareness of Renewable Energy Technologies (RETs) in general.

With respect to *dissemination*, Bangladesh especially, but also Vietnam and Nepal has carried out some activities in this field. However in Cambodia and Laos, PV technology is relatively new and there is little local expertise available. Due to the lack of research capabilities (including personnel and equipment), adaptive

research could not be carried out as planned. With a PV market still under-developed, and with no past experience, suitable dissemination strategies could not be formulated. Hence PV activities were confined to installing various demonstration systems in the country. Nevertheless this must be considered as an important step towards a strategy aiming at the development of solar photovoltaics in these two countries.

A further difficulty was that the effective time for the NRIs to implement the whole programme was limited to some eighteen months.

Solar Drying

Solar drying is relevant both as a sustainable method of food preservation and also in the promotion of rural enterprises. It is an attractive technology because of its relative simplicity. Solar dryers were classified, drying practices and different solar dryers used in the region were studied. In the field of research and demonstration, solar dryers were adapted to the conditions prevailing in each country. Existing solar dryers were suitably modified to enhance their performance and reliability. The performance of dryers was recorded and monitored, although in the case of Nepal, due to time constraints and the weather, insufficient testing on the various dryers has been undertaken.

In total, five solar dryers and one hybrid solar/biomass dryer were manufactured and tested by the NRIs. The hybrid dryer in the Philippines and the solar rack dryer in Nepal, in particular, performed well.

In **Cambodia**, ITC (Institut de Technologie du Cambodge) has achieved its objectives in creating solar dryer prototypes, disseminating this knowledge and tackling training courses. A solar cabinet dryer and solar chimney were developed and tested. The technology appeared to perform well when used to dry rice and fruit. The market research is limited but this appears to be due to the lack of any previous experience or manufacturing capability in solar dryers in Cambodia, lack of government interest, and no clear industrial use for dryers.

In **Nepal**, three technologies were identified as being appropriate; the rack and cabinet dryer for both domestic and industrial use and the solar tunnel for industrial and commercial use. Cabinet, rack and tunnel type dryers were adapted and tested. The results were encouraging for all except the cabinet dryer which did not perform well during cloudy days. The main objectives have been achieved, although more testing is needed before a marketable product is produced. This is recognised by the NRI and proposals made to continue with this aspect of the research during the second phase. The use of the solar tunnel is also questionable at the moment, given its size and the problems of transport in Nepal, and these aspects are also to be tackled. Attempts at dissemination are encouraging.

In the **Philippines** a hybrid solar biomass drying system for a ceramic factory was designed and fabricated. This is running successfully although more testing is

needed for a complete evaluation. The successful dissemination of this solar drier is largely due to the identification of a need and a solvent customer before the technology was fully developed. The clear meeting of a specific need is a positive aspect of this research in particular.

Biomass Briquetting

The refinement of biomass to form a more concentrated fuel in the form of briquettes has great potential for utilising agricultural and process wastes. Technologies for briquetting biomass exist but there are significant technical and economic problems which this project has attempted to address.

At AIT, energy consumption of the briquetting machine tested was reduced by 12% when processing rice husk and 16% when processing sawdust by the use of preheating. In **Vietnam** adaptive research was carried out on two briquetting machines and improvements were made to the screw and to the process of preheating the biomass before briquetting. In **Bangladesh**, the screw life has been increased from 2 hours to 19 hours and energy consumption reduced by up to 21% by the use of preheating.

These quantitative results show that significant improvements have been achieved in the field of research and demonstration, but problems with the technology continue to prevent its widespread dissemination. However a clearer understanding of those problems, has been a major outcome of this research as well as significant progress in overcoming them. More work is needed, and in the light of the experience gained further research in the area has been proposed. The identification of beneficiaries and an appropriate method to disseminate the technology are the two areas where further improvement is needed.

Both AIT and the NRIs identified screw wear and die heating as appropriate areas for adaptive research. Electrical energy consumption per kilogramme of briquette was found to reduce significantly on preheating the raw material, according to research conducted at AIT. At NRI level, research conducted has been thorough, within the constraints encountered. Adaptive research has been interpreted quite narrowly, however, and this has not enabled a more basic look at the technology to be undertaken.

It is estimated by the **Bangladesh** NRI that there is potential for 15 000 briquetting machines in that country. A screw-press type briquetting machine was tested and measurable improvements made. Energy efficiency has been improved by up to 20%.

In **Vietnam**, a machine was imported from Thailand and tested. Shortcomings with the machine and its components were quickly identified. A second machine, from within Vietnam, was then tested but it too did not function properly. Some adaptation of the technology has taken place, but there is still considerable room for improvement.

The acknowledgement of the shortcomings encountered has been positive since it will lead to better project design and focuses efforts in areas of need; this has been done by both NRIs involved. The potential for biomass briquetting is large but a cost-effective technical solution is essential before the full potential can be realised. The projects carried out have contributed to the technology, but maybe a more fundamental look at the problem and the technological capability of the areas where biomass can be converted to briquettes is needed.

Some areas worthy of note are the marketing activities undertaken in Vietnam, which were tackled well with the target beneficiaries identified clearly. Given further development of the technology this work will be useful. Some of the materials research in Bangladesh, although perhaps too advanced to be of direct use in the field, has added to the research capacity of the NRI and led to a greater understanding of the problem.

Improved institutional Stoves

The main objectives of biomass institutional stoves, which were design, manufacture and testing, were achieved. Design details of improved stoves for burning biomass briquettes were developed at AIT and sent to NRIs. The first phase did not include the dissemination of institutional stoves. However, a prototype of the two-stage top-down burning stove was sent to the Institute of Energy for dissemination in Vietnam. Further, Bangladesh and Vietnam have developed briquette-burning domestic stoves for dissemination in their countries.

Biomass Gasifier:

In the case of the gasifier, the main objective was limited to establishing design parameters. The feasibility of producing gas of low tar content through multi-stage gasification of sawdust briquettes and wood was investigated. The dissemination was planned to be carried out during the second phase. There is also no analysis of the capability needed to manufacture the technology. If this technology is to be successfully disseminated, this aspect needs to be considered at an early stage.

PHASE II 1999-2001

Proposals of phase II were submitted after a thorough process. Outlines were submitted to SIDA and assessed by the evaluators before the workshop held in Bangkok in October 1998. The evaluation of these outlines and the analysis by the NRIs and AIT during the same workshop showed that the proposals were rather technology driven and the link with phase I was not explicitly defined. Lessons were drawn and it was agreed to focus the programme for the second phase on the three key technology areas already investigated in phase I, namely solar photovoltaic, solar drying and biomass briquetting.

In addition, the lessons from the evaluation (mainly dissemination and identification

of beneficiaries) were incorporated into the proposals submitted in phase II. All the proposals were developed after thorough discussions between the NRIs interested in a particular technology. A logical framework analysis was also included in all the revised draft proposals. The current proposals submitted for the second phase are of a good standard despite a few shortcomings, particularly monitoring aspects, which should be addressed during the first regional workshop to finalise the document.

CHAPTER 1 - THE PURPOSE OF SERVICES

The purpose of the services is the evaluation of a two year programme co-ordinated by the Asian Institute of Technology (AIT) and involving twelve National Research Institutions (NRIs) from six Asian countries, namely Bangladesh, Cambodia, Laos, Nepal, Philippines and Vietnam. There are two main reasons for this evaluation:

- a) to assess how far the programme has been able to fulfil the research, dissemination and capacity strengthening objectives and tasks set out in the revised proposal (January 1997 document), and
- b) to assess the new draft application¹ submitted by AIT to SIDA for the second phase to be carried out between 1999-2001

CHAPTER 2- THE TEAM

The evaluation was carried out by two international experts on energy, Dr Smail Khennas team leader from Intermediate Technology Development Group (ITDG) and Dr Teresa Anderson from Intermediate Technology Consultants (ITC). The evaluation has also benefited from valuable inputs made by Simon Dunnnett, energy researcher at ITDG and Dr Rona Wilkinson, energy and environment projects manager at ITC.

CHAPTER 3- METHODS USED AND CONTENT

The evaluation was based on a desk study of the final reports and, where available, progress reports. It incorporates the results of interviews and a workshop held in Bangkok in October 1998. The comments are based on this material and other experiences worldwide. The activities and outputs produced by the programme are assessed against the objectives and tasks contained in the "Revised Research Programme". The report also includes the evaluation of the proposals submitted for the second phase.

The main findings and the issues contained in the terms of reference are addressed in Chapter 4. This chapter comprises four sections. For each section, the evaluation report highlights the key points which are relevant in each country or across countries, the points which deserve further clarification and what the evaluators consider are the missing points which may need to be addressed in the next research programme. The first section will try to find out:

- a) the extent to which the programme is relevant to the promotion of the provision of energy sources in the rural areas of the region, and

¹ Renewable Energy Technologies in Asia: a regional research and dissemination programme, phase II Jan 1999-2001, August 1998.

b) the degree of achievement of the programme's overall objectives and specific tasks listed in the revised research programme. The overall performance will be assessed against the three key objectives set out in the proposal: adaptive research, demonstration and marketing, training and dissemination

In section 2 the quality of outputs produced by the programme are assessed, along with the ability of NRIs to carrying out support activities, the extent to which the technology has been mastered, and its dissemination, particularly training courses and the understanding of the macro-environment necessary to disseminate renewable energy technologies (RETs). This section also includes the modes of dissemination of the results and the range of targeted recipients.

The third section is devoted to the relationships between AIT and the NRIs and tries to find out to which extent AIT's research and support has been beneficial to the NRIs.

The fourth section will look at the cost effectiveness of the programme

CHAPTER 4- MAIN FINDINGS

This chapter will follow the terms of reference of the contract agreed between SIDA and ITDG. The same structure will be used for each technology area.

1. Relevance and overall performance

1.1. Promotion of the provision of energy sources in the rural areas of the region

The programme covers two renewable energy sources (solar and biomass) encompassing five technology areas: solar PV, solar drying, biomass briquetting, biomass gasifier and institutional stoves. The last two technologies were studied only by AIT.

These technologies cover both domestic and productive end uses, which may contribute, if widely disseminated to a significant improvement in the provision of energy services in the rural areas of the six countries. The huge need for electricity for both domestic and productive end uses, energy for drying and cooking are indicators of the popular demand for this type of services.

1.1.1 Solar photovoltaic

The low rate of rural electrification and the distance from the grid of rural populations makes decentralised energy options a sensible alternative. The decrease in prices and the increase in the energy efficiency of solar PV systems have dramatically improved the cost effectiveness of solar systems over the last decade.

The focus on the adaptive research of accessories for solar PV is very relevant since the production of the solar modules is excluded in the mid term in most developing countries, both for technological and economic reasons - chiefly the small market which limits the economies of scale.

1.1.2 Solar drying

Solar drying is relevant as a sustainable method of food preservation and also in the promotion of rural enterprises

The three countries selected for promoting the dissemination are all at different stages in solar dryer use and production. **Cambodia** has the lowest energy consumption and GDP. Their use for solar drying is primarily limited to domestic farmers at the moment, for rice drying. **Nepal** has some experience of using solar drying practices, for food preservation, both for domestic requirements but also on an entrepreneurial scale and for exporting.

The **Philippines** has the highest energy consumption and GDP of the three countries involved in solar drying projects. The Philippines is interested in using solar drying to improve the quality and output of their ceramic industries.

1.1.3 Biomass briquetting

Biomass use at present is mostly limited to direct burning, which does not exploit the full potential of the fuel due to inefficient combustion technologies and the relative unsuitability of the raw material for this purpose. Biomass briquetting in **Bangladesh** is identified as a relatively recent phenomenon, but the exact extent of the spread of the technology is not indicated due to lack of recorded data. Several regions are highlighted as having an, albeit inefficient, briquetting industry. Given that the raw material exists in sufficient quantity to be processed more efficiently, the more widespread production of biomass briquettes could provide an energy-intensive alternative to existing supplies of fuel.

The technology to briquette biomass waste has been in evidence in **Vietnam** for some years, although production costs have proved prohibitive. Only a small proportion (20-25%) of agricultural residues is used.

1.2. Degree of achieving the programme's overall objectives

1.2.1 Solar photovoltaic

By and large the first two objectives, adaptive research on one hand and training and demonstration on the other hand, have been achieved. However, dissemination remains an objective which has only been partially achieved in Vietnam, Laos, Cambodia and Nepal. In Bangladesh, there is a clear and sound strategy and this country shows better results with respect to

dissemination. There seems to be some confusion between dissemination and training. Training should be understood as an activity to disseminate PVs and not an objective. There are at least four main reasons, which can explain the discrepancy between targets and achievements:

- a) at the methodological level, it is not very clear who the ultimate beneficiaries are. NRIs are certainly among the beneficiaries. However, the recipients of the technology (communities, villages) are not mentioned,
- b) the lack of expertise in the field of marketing and dissemination, especially in Laos and Cambodia.
- c) the project design did not include a clear strategy concerning the dissemination of the research results. Targets have been set without planning the matching resources to reach this objective, and
- d) the unequal level of development of the PV sector according to the different countries is another reason explaining the gap between the potential and actual results in the dissemination field.

1.2.2 Solar drying

In **Cambodia** ITC (Institute of Technology, Cambodia) have achieved the overall objectives in creating solar dryer prototypes and disseminating this knowledge and tackling training courses. The market research is limited but this appears to be due to the lack of any previous experience or manufacturing capability in solar dryers in Cambodia; lack of government interest, and no clear industrial use for dryers. At the moment it would appear that natural sun drying is adequate for domestic needs.

The overall objectives in **Nepal** have been achieved although more testing is needed before a marketable product is achieved. The use of the solar tunnel is also questionable at the moment given its size and the problems of transport in Nepal. More thought to the market strategy, which is very technology led at the moment, is needed. RECAST (Research Centre for Applied Science and Technology) also experienced administrative problems that hindered the timescale of the project.

The project in the **Philippines** was the only one with a specified end-use. All the objectives were achieved, although it was recognized that more testing would need to be done. The approach taken was market led, with a clearly identified end product. The requirements of the factory which was used as a demonstration project, were carefully considered. The results were widely disseminated.

1.2.3 Biomass briquetting

In **Bangladesh** the objectives seem to have constrained the project to limited research into too few aspects of one type of machine. This may have been the correct course to take, but alternative machine configurations, for example, are not

examined. This has led to some constructive research in one area but the full potential of the technology has not been explored.

It is estimated by the Bangladesh NRI that there is potential for 15 000 briquetting machines in that country. A screw-press type briquetting machine was tested and measurable improvements made. Energy efficiency has been improved by up to 20%. The project in Bangladesh, however, appears to have been technology-driven. The question of whether the output of the machines, the briquettes, are a suitable fuel for household use is only addressed at the end of the report, when it is discovered that they are not suited to the conventional type of stoves. Initial market research would have identified this fact and could have led to alternative machine design. It is also unclear how the training programme, although quite extensive, actually relates to the subsequent activities of the participants.

The technology to briquette biomass waste has been in evidence in Vietnam for some years, although production costs have proved prohibitive. Only a small proportion (20-25%) of agricultural residues is used. The weakness of the present technology is highlighted by the frustrations encountered by the project team.

A machine was imported from Thailand and tested. Shortcomings with the machine and its components were quickly identified. A second machine, from within Vietnam, was then tested but it too did not function properly. Some adaptation of the technology has taken place, but there is still considerable room for improvement. Awareness of the technical limitations is evident. Little mention is made of improved stove design.

The demonstration and marketing aspects are well tackled, with much thought given to the needs of the users and manufacturers. Again, the limitations of present technology are acknowledged, and the failure to develop the machine further within the time constraints has limited the marketing possibilities.

Much of the work undertaken in the area of training and dissemination is of good quality and is relevant to the objectives laid out, but the poor nature of the technology is again a constraint.

1.2.4 Improved institutional stoves.

The overall objective was to design, fabricate and test a number of biomass fired stoves suitable for institutional kitchens or traditional cottage industries.

A very useful literature review is provided by AIT. It is worth noting that Bellerive Foundation in Kenya has also developed wood burning institutional stoves. It would have been useful to look at the literature on institutional stoves in East Africa.

Although largely accepted, it was relevant to describe the procedures used to carry out the efficiency tests. Indeed very often different parameters might be used.

The overall objectives to design, manufacture and test institutional stoves were achieved. However with respect to dissemination, additional aspects are to be taken into consideration :

- **efficiency:** it appears that these stoves have a higher efficiency than traditional stoves. However within the five models tested the gap in terms of energy efficiency is relatively large between 15 % and 29 %. Given the fact that all the stoves are smokeless, the tendency might be to choose the high-energy efficiency model.
- **End users.** the type of end users or beneficiaries may differ according to the type of stove. Apart from brick stove and gasifier stove, the institutional end users are not specified for the other four models.
- **Cost effectiveness:** it is important to provide some elements on the respective costs of each model and the conditions for local manufacturing. Indeed an important parameter with respect to sustainability lies in the affordability of the model and local maintenance factors.

1.2.5 Biomass gasifier

The overall objective was to investigate the feasibility of producing gas of low tar content through multi-stage gasification of sawdust briquettes and wood. A comprehensive literature review is presented indicating the level of current technology and identifying development areas.

The work as a whole has contributed to the development of the technology and has fulfilled the objectives set out. However, there is no study presented of the cost implications and no recommendations made to undertake such a study. There is also no analysis of the capability needed to manufacture the technology. If this technology is to be successfully disseminated this aspect needs to be considered at an early stage.

1.3 Degree of achievement of specific objectives

1.3.1 Solar photovoltaic

The key specific objectives were on adaptive research, demonstration and implementation of solar home systems (SHS) and, dissemination.

In the field of adaptive research, the production of PV accessories and tests

undertaken by Grameen Shakti (GS) and the Centre for Mass Education in Science (CMES) in Bangladesh seems successful for the different components. However the strategies for a wider dissemination are not developed. For example if a partnership is envisaged, what type of partnership etc.? Batteries are an important component in the systems. It is striking that all batteries tested were working properly including reconditioned batteries. In the absence of data concerning the lifetime of each battery and the respective costs, it is rather difficult to provide guidance for choosing a specific option.

The findings show that good quality products and accessories were developed by the NRIs in Bangladesh. Apparently the costs of charge controllers, compact fluorescent lamps (CFL) and other accessories made by GS are very low compared with those manufactured locally (Rahimafrooz) or imported from China (Alpan). However at this stage, it seems premature to draw definite conclusions with respect to the cost-effectiveness of the products developed by GS. A follow-up during the second phase should provide more credible results based on a longer period of experimentation and dissemination.

In many countries, the sharp fluctuations of the exchange rates have put into question the sustainability of a PV industry based on imported components. In this respect it would have been useful to find out what components are imported and the associated costs including for the products and accessories manufactured locally. The low cost of the solar lantern seems attractive all the more that it was manufactured using components available on the local market.

Some technical results and tests are not commented upon. For example the number of failures for CFL manufactured by GS and tested in the field seems relatively high. In order to give more relevance to the results, comparison with the average norms for this type of equipment should have been provided.

The report produced by Centre of Renewable Energy (Nepal) on the "status of PV technology in Nepal" gives a very good picture of the PV situation in this country. The different applications of solar PV are well described and broken down by sectors. Three key findings are to be highlighted:

- PV applications for telecommunications implemented under the Nepalese Telecommunications Centre are performing satisfactorily. This is certainly due to the high standards of PV systems required by this sector given its strategic role .
- PV water systems installed under the Agricultural Development Bank of Nepal (ADBN) are not performing well due to technical problems (inverters/pumps) and management problems. It seems that the lack of involvement of the beneficiaries had a negative impact on the good functioning of these systems.
- Approximately 2 000 solar home systems (SHS) have been installed between late 1993 and mid 1998 thanks to a governmental subsidy which accounts for 50 to 75 % of the SHS.

With respect to the problems associated with PV accessories (charge controller, DC lights and DC-DC converters) the report gives a fairly good analysis of the problems and suggests some recommendations to overcome them. It appears that there is a need to develop better components which meet the requirements of remote PV domestic systems although, it seems that DC lights produced in Nepal are of a good quality. The report includes some important recommendations. However the key recommendations could have been detailed further to give some guidance for their implementation.

The project team in **Cambodia** did not find any problem with the installation of the pilot project and the technical recommendations for the different components (lights, poles, batteries etc.) are very relevant. However, activities linked to the adaptation and manufacturing of accessories, test identification of local manufacturers, formulation of marketing strategy and dissemination were not carried out. This is certainly due to the lack of sufficient qualified skills and the level of development of solar PV in this country. As a result the project lacks a realistic plan of the activities likely to be implemented and targets were set at a level which is beyond the human and financial resources available in this country. Nevertheless, it is worth highlighting that the results achieved, given all the constraints faced by this country, are encouraging.

Overall the main achievements by the Science and Technology Organisation (STENO) in **Laos** are in the field of adaptive research, i.e. the improvement of existing designs of PV accessories particularly the DC ballast and a Led indicator to monitor the charge of the battery. The dissemination activities were limited to raising the awareness about RETs of senior officers and policy makers involved directly or indirectly in the energy field. It does not seem realistic in the near future to consider the marketing of PV technology as it was specified in the report produced by Laos. Building up local capabilities remain a priority. In this respect, inputs from other NRIs, Solarlab in **Vietnam** and CRE in **Nepal**, have contributed towards this objective.

1.3.2 Solar drying

In **Cambodia** the objectives under the project were to:

Conduct adaptive research on solar dryers for local products

Two designs were developed at ITC: a basic cabinet dryer and a solar chimney. Both were designed taking into account local requirements, which are specifically for rice drying.

Fabricate the prototypes

The prototypes were made at ITC but it was recognized that all the materials could be obtained locally. Testing was also carried out on the two designs over a period of 16 days, using different products, in the rainy and dry seasons. A comparison between the improved performance of the dryers compared to natural sun drying was also given.

Assess renewable energy resources in Cambodia

No figures were given as to the potential for solar power or statistics regarding solar radiation in Cambodia, but this could be due to a lack of available records.

Study Government policy on energy and fiscal incentives for solar drying

The Government does not seem to regard it as appropriate at the moment so no policies were discussed.

In Nepal, three technologies were identified as being appropriate; the rack and cabinet dryer for domestic and industrial use and the solar tunnel for industrial and commercial use. All three had been used in Nepal but there is a lack of records as to their performance particularly for the rack cabinet dryer.

Conduct adaptive research on solar dryers for local products

The three types were modified by RECAST using their own facilities.

Fabricate improved prototypes and field test.

Three prototypes were designed, fabricated and tests were done. The tests were limited to a couple of days for each design and about 6 products were tested. Products were also left to be sun dried as a comparison but the actual results from these were not given² The test days were also not sunny days so results were not as favourable as expected. RECAST did note that more testing was needed.

Set up demonstration units and monitor

Three units of the three types were set up in different areas, which seemed a reasonable number by which to compare results. A monitoring program has been set up to evaluate the results but they are not yet available.

The solar drying project in the Philippines was a collaboration between the Solar Laboratory and Biomass Laboratory of the University of the Philippines. Its specific objectives were:

Design and fabricate a hybrid solar biomass drying system for a ceramic factory

A continuous flow solar dryer that was already being used in the Philippines for crop drying and a biomass furnace (running off rice hulls) was adapted and fabricated. This is running successfully although more testing is needed for a complete evaluation.

Conduct adaptive research for analysing the performance characteristics and optimisation of the drying system

The dryer was installed in a ceramic factory near the Mount Pinatobo where many displaced people were working. Monitoring of the performance of the hybrid dryer continued throughout the project with modifications being made according to performance. The production of pots increased, as did the quality.

² Tests were not given because of adverse weather conditions during the experimentation.

1.3.3 Biomass briquetting

1.3.3.1 Bangladesh

Conduct survey to identify locally available raw materials needed for briquetting.

The availability of locally available raw materials is ascertained from national statistics. A field survey questionnaire was carried out by BIT (Bangladesh Institute of Technology) staff who visited several saw mills covering approximately a quarter of the country.

Develop appropriate prototype machines by carrying out adaptive research.

A survey identified a number of existing machines in operation. They appear to all operate according to the same principle of using a feed screw to continuously compact and feed the material. A survey conducted identified four areas of improvement of the screw mechanism, although only two are presented in any detail in this report. Again the nature of the survey or any specific methodologies or results are not detailed.

Prototype development concentrates on the improvement of the screw and the pre-heating of the raw material. To this end a large amount of work is described on efforts to improve screw repair technologies. Some work on pre-heating is also described, although tests were not complete at the time of the report completion.

Demonstrate and field-test the prototypes

The various alternatives are tested in the laboratory and the results presented. The testing and screw-repair procedures necessitate the use of the entire machine and to this extent the technology is being demonstrated. Field demonstration at two sites is mentioned, but no data is presented to support the assertion that the machines were working well.

1.3.3.2 Vietnam

Conduct survey to identify locally available raw materials needed for briquetting.

The amount of agricultural residues available is presented. Existing combustion technologies are described as well as modes of transport.

Develop appropriate prototype machines by carrying out adaptive research.

Adaptive research was conducted on a machine imported from Thailand. The basic operating characteristics of the machine were established, but early failure of the feed screw rendered further tests impossible. After manufacturing a replacement, further work was concentrated on pre-heating the waste. This still led to unsatisfactory results, so another machine was tested based on a Bangladeshi prototype. This machine produced more satisfactory results.

Demonstrate and field-test the prototypes

Plans have been made to disseminate the machines, but no concrete results available.

Make suitable strategy to market the technology.

A suitable marketing strategy has been identified as essential for the proper dissemination of this technology. Barriers to dissemination have been identified and several recommendations are made for future action.

Carry out dissemination and training programme.

A proposed training course schedule is presented, as well as a workshop for the dissemination of results to government and local authorities. The purposes of the objective seem to be well understood.

Identify local entrepreneurs/manufacturers for technology transfer and extension works.

Criteria for selecting manufactures are detailed and the resulting list presented, as well as suggestions for end uses. Appropriate sites are also listed, matched against criteria.

Study government policies on energy and fiscal incentives for the promotion of RETs.

A comprehensive summation of policy suggestions is presented because of a lack of availability of appropriate government laws.

2 Research output, capacity strengthening and dissemination of research results

2.1 Quantity and quality of outputs.

Overall the results are satisfactory, particularly in the fields of research, demonstration and training. In General, dissemination of RETs remains an area which has not been investigated in methodological way. For some NRIs, there is not a clear strategy and guidelines for the dissemination of RETs. However reports from the NRIs of Bangladesh, Nepal and the Philippines, provide a strategy and guidelines in the domains of marketing and dissemination. These lessons need to be fully transferred to other NRIs during the second phase.

The final reports of Laos and Cambodia need some editing.

2.1.1 Photovoltaic

Out of the 18 reports produced in the framework of this programme, 8 were devoted to solar photovoltaic involving 5 countries. In general the quality is relatively uneven. Reports produced by CRE in Nepal and GS and CMES in Bangladesh are much more comprehensive. Given the lifetime of the programme, the NRIs and AIT have achieved the main objectives.

More than 70 solar home systems were installed in Bangladesh, Cambodia, Laos, Nepal and Vietnam. The number of direct beneficiaries is estimated at 375. In addition, two promising low wattage income-generating activities (PV operated sewing machine and DC drilling) were experimented with in Bangladesh. The methodology and field tests carried out on PV accessories comply with accepted standards although the non-technical conclusions could have been developed further. The facilities at Solarlab in

Vietnam proved to be of good standard and the training courses effective.

Despite these satisfactory results, some shortcomings and ways to address them might be considered for the second phase. For example, calculations must include all the costs. Cost parameters, the ability of customers to pay and financing options could be developed further.

It is worth highlighting that the findings of the final report on "Marketing of solar PV technology in Nepal" remain vague and do not provide useful guidelines for a development strategy for PV technology in this country. There are some affirmations without an in-depth analysis, such as "In general government subsidy given to solar PV technology used in income generating activities should be higher than the subsidy given to solar PV technology used in enhancing quality of life". Assuming that this appreciation is shared, what are the practical implications of different levels of subsidy granted to a same product?

The study on "Status of PV technology in Nepal" carried out by CRE is fairly comprehensive and reaches the objectives assigned. It is worth noting that telecommunications accounts for 70 % of the current market. Stand alone PV SHS account for only 8 % of the installed capacity; the bulk of the systems were installed over the last 5 years and it is likely that this market will expand. The major PV users, installed capacity and the applications are well described. The main problems for the sites visited were identified. It appears that the problems are very diverse. A matrix encompassing common problems and the solutions may be useful as a first step in designing a strategy to alleviate the main problems.

By contrast the final report of Laos does not show that the activities implemented are contributing towards the objectives defined by the project. Some objectives, in particular dissemination and market PV technology, seem too ambitious. It is worth mentioning though that the results achieved in Laos and Cambodia are promising given the level of the solar PV development in these countries. These results are not reflected enough in the final documents due to some weaknesses in reporting. For example it is frequently referred, in the case of Laos, to reports sent to AIT without including the analysis and key findings in these reports

In Vietnam, comprehensive research has been carried out by Solarlab. Although Solarlab failed to develop a new type of inverter, interesting results were achieved in the improvement of regulators, DC lamps and an adapter for colour TV.

For Bangladesh, it was relatively easy to assess the achievements against the objectives. In general activities listed were implemented and interesting issues were raised with respect to dissemination, particularly the use of micro utilities and alternative financial packages proposed by the users themselves.

2.1.2 Biomass briquetting

The main purpose of this research was to improve the design of a briquetting machine to make it more economical and suitable for use in the rural villages of the developing countries of Asia. This involved concentrating on screw life and heating of the die. Given the stated purpose, perhaps simpler technologies should have been considered at the outset to aid the dissemination of the technology; an inferior biomass briquette produced on a wide scale using a simpler machine could then lead on to the development of more sophisticated technology.

In **Vietnam**, the quality and quantity of the various biomass resources are described, information coming from existing sources and surveys conducted. There is an understanding of the potential of the technology and of its end uses.

For the screw material, Medium Carbon steel (CT45/Russian standard) has been tried by Vietnam. It was found that the increased service life is not justified for the cost of the material. High Carbon steels are less resilient and so tend to break easily under the severe operating conditions of temperature and pressure in the briquetting machine. The cost involved in making the whole screw in alloy steel will not be justified for its service life, and availability is another factor against its use. This was the justification for concentrating on improved surface treatments, particularly in **Bangladesh**, but if the beneficiaries of the technology are to be small entrepreneurs, who can most easily facilitate its widespread dissemination, their ability to afford to utilise the proposed technology is paramount.

Of the two objectives, to develop a longer lasting screw and to examine the effect of pre-heating, only the latter is tackled at any depth. In **Vietnam** one screw is manufactured, which performs better than the selection provided with the imported machine, but no tests are carried out to improve its design. The screw is acknowledged to be the weak link in the machine as a whole, but no alternative designs are suggested. Pre-heating is found to improve the overall energy consumption, but the resulting briquettes are still relatively expensive. The two different machines tested give markedly different results, which would seem to suggest that design improvements are possible. However, within the limits imposed by specific project objectives, alternatives are not investigated. The shortcomings in machine design are acknowledged in the report.

In general, the energy consumption of the briquetting process with raw material pre-heating and die heating with biomass stove, has to be monitored over a longer period in order to have more accurate figures on energy consumption. With longer period of operation, the combined effects of better screw life and lower energy consumption tend to improve the energy consumption figures further. Results from field-testing were not available due to delays.

2.1.3 Solar Drying

In **Nepal** a comprehensive final report was produced, with clear graphical output of the test results and numerous colour photographs showing the installation, running and testing of the solar dryers at the demonstration sites.

In **Cambodia** the section on solar drying in the report was very brief and did little more than detail the activities. The test results were clear with good graphical interpretation. Photographs of the test sites were also produced, although quite hard to view, as they were black and white photocopies.

In the **Philippines** the report was very professional and well laid out. Colour photographs and the contents clearly following the project objectives helped in understanding the output and results from the project.

2.2 Building up capabilities in the NRIs, dissemination and monitoring of renewable energy technologies.

This section assesses the ability of the NRIs to conduct training courses, monitor the dissemination of renewable energy technologies and the impact of macro policies.

2.2.1 Solar photovoltaic

Most NRIs have carried out good quality and well targeted training courses. However the impact of these courses has not been monitored. It is therefore fairly difficult to assess to which extent the training courses have led or contributed to an increase in the awareness of RETs and to their possible wider dissemination.

- a) In the case of **Bangladesh**, 3 training courses were organised by CMES respectively for technicians, entrepreneurs and consumers. The quality of the courses appears to be fairly good. The source book for training is a valuable resource for practitioners. In addition, GS has carried out training on installation and maintenance of PV systems for 130 rural technicians³ who are also working as promoters of the PV technology. GS took the responsibility of providing the training course for entrepreneurs. In the absence of feedback, it is very difficult to find out if the 3 courses have reached all their objectives and to assess their impact.
- b) In **Laos**, a training course on installation and maintenance of SHS was carried out. This course was aimed at technicians and engineers. The course had a practical content and was designed for technicians and engineers. Both the number of people trained and the impact of the course are not described in the final report. However the information is available. This course seems to have reached its main objective i.e. enhancing the capability of local technicians in the maintenance field. It is worth mentioning the production of manuals on the maintenance of PV systems.

³ Interview with Grameen Shakti

Indicators should be defined on the dissemination of the manual and its impact.

- c) Training activities to be conducted by MIME (Ministry of Industry Mines and Energy, **Cambodia**) were not implemented according to the schedule. MIME is planning to carry out these activities by the end of 1998.
- d) Two international training courses were organised by the Solarlab institute of physics in **Vietnam**. Overall 14 participants from 4 countries were trained. It seems that the first course (4 countries and 8 participants) met some problems linked to the uneven skill level of the participants. The second course (6 participants, 2 countries) has a more practical content and seems to have had a much greater and immediate impact. However, an evaluation of the whole training programme is necessary to assess the real impact on the trainees and the dissemination of RETs in this country.
- e) In Bangladesh as far as **dissemination** is concerned, it is worth mentioning at the macro level the reduction and the abolishing of the import tax and VAT on RET.
- f) In Nepal, a governmental subsidy of 50% channeled by the Agricultural Development Bank of Nepal (ADBN) is granted to stand alone PV SHS. The subsidy, which should not exceed 15,000 Rupees per set is even higher in relative terms (75%) for solar PV water pumping system. The report also highlights the constraints and the problems associated with the subsidy.

2.2.2 Solar drying

2.2.2.1 Cambodia

Carry out dissemination and training programmes

A course is to be taught at ITC to about 30 final year students in particular departments. They also plan to train about 30 local, rural farmers. No teaching plan or course details were given.

Identify local entrepreneurs and manufacturers for technology transfer and extension.

No details were given but it should be noted that there are no established solar dryer manufacturers in Cambodia at the moment.

Formulate suitable market strategies

A very brief outline plan was drawn up with a series of bullet point areas that should be noted. ITC did not undertake any market research itself, and no costs were supplied.

2.2.2.2 Nepal

Carry out dissemination and training programmes

A three-day intense course for operators and manufacturers in the demonstration areas was established with course details given. The marketing side looked a little weak but the technical and practical aspects looked very thorough. A seminar was given and mass training session (one day) was given to interested parties and an exhibition of the

three solar dryers was held. The dissemination and training program was impressive although no objectives were given or figures as to the success rate of the people trained.

Set up market strategies for solar dryers

This was slightly disappointing. RECAST seems to feel that they are basically a technology centre and that the manufacturers and wholesalers would do the market research. They felt that without further testing they do not have a marketable product. They have devised a marketing strategy but it is not detailed.

Identify local manufacturers and entrepreneurs for technology transfer and extension works.

RECAST feels that there are still problems with the prototype so they are not at the stage to identify such people. Six manufacturers that are already involved with solar drying in Nepal were mentioned but no details given. However some of the training did involve manufacture and fabrication, of personnel employed at the six manufacturing companies.

Study government policies on energy and fiscal incentives for the promotion of solar dryers

There are a number of schemes but consensus of the project is that the subsidies are not clear and that tax exemption is not really appropriate.

2.2.2.3 Philippines

Carry out dissemination and training programme for this technology

A workshop was held for plant manufacturers and managers; details of which were given. Training of the operator of the demonstration hybrid dryer was given which was fairly extensive. A brochure on the product itself was also produced and included with the report.

Demonstrate the commercial viability of the project

A comparison of the hybrid drier with a LPG drier and conventional sun drying was given to show that the hybrid drier was cheaper as well as environmentally superior to using LPG and could produce more pots with less cracks than using the conventional drying method. However the figures or estimates as to the solar potential, when rice hulls would be needed or the number of ceramic factories that could use such technology were given only in the progress reports. It would have been useful to include in the final report the key figures.

2.2.3 Biomass briquetting

Carry out dissemination and training programme.

In **Bangladesh** a training programme is described which involved 23 trainees. There is no indication of whether these trainees continued to work with the technology. No mention is made of any dissemination programme.

In Vietnam a proposed training course schedule is presented, as well as a workshop for the dissemination of results to government and local authorities. The purposes of the objective seem to be well understood. Because of the lack of results from the prototype development and the field-testing stages, a training and dissemination programme were not conducted. However, a training schedule is presented with a dissemination programme.

Identify local entrepreneurs/manufacturers for technology transfer and extension works. Three entrepreneurs are identified in Bangladesh, although further work is expected by another party. In Vietnam, criteria for selecting manufacturers are detailed and the resulting list presented, as well as suggestions for end uses. Appropriate sites are also listed, matched against criteria.

Study government policies on energy and fiscal incentives for the promotion of RETs. This activity was conducted in Vietnam. It is stated that there is a lack of appropriate laws in Vietnam, so none are given. A comprehensive summation of policy suggestions is presented.

2.3 Modes of dissemination of results and their appropriateness including the relevance and range of targeted recipients.

2.3.1 Photovoltaic

The Bangladesh report raised interesting issues, which might be encountered in strategies to disseminate PV systems. It is now acknowledged that grant projects are accompanied with uncertainties, lack of confidence and delays in maintenance after the withdrawal of the donor. However, the purchasing power of very low-income people is still not sufficient to make the product affordable for this category of the population. This is sometimes the case even when systems are partly subsidised and are sold by instalments. The report highlights though that leasing and instalment systems remain the most popular when applied appropriately.

The leasing system deserves more development. It is offered with a 3 months guarantee only. What will happen if there is a breakdown outside the 3 months period of guarantee? The report has mentioned two other options, which may need further developments in the future:

- alternative financial packages proposed by the users themselves and,
- micro utility. Issues such as ownership, funding, guarantee, and maintenance are still to be addressed. The scope of the mini utility must be defined as well. Will its role be limited to the initial beneficiaries or will the micro utility play the classic role of utilities, i.e. meeting the needs of other customers? Such a strategy will imply a different type of structure and organisation.

The section on government policy shows how it is important to involve policy makers. Issues related to taxes, subsidies, even new projects are paramount when industries

are at their early stages of development.

Customer's preferences highlighted in the report seem to confirm that users prefer systems of approximately 50 Wp which can provide services not only for lighting but power to other common appliances such as televisions and fans. They also prefer decentralised systems. Centralised systems must be planned very carefully particularly the management, ownership, maintenance, geographical cover. Any failure is likely to have greater negative impact given the number of beneficiaries compared with decentralised systems.

With respect to *income generating activities*, it is worth mentioning low wattage income generating activities experimented in **Bangladesh**. Further studies to identify this new market are recommended. If such a market for productive end uses proves to be cost effective, the dissemination of PV systems may reach low-income people. The additional cost of the modified equipment should be affordable to low income people otherwise it is likely that this market will remain marginal.

With respect to dissemination in **Vietnam**, the most important achievement is a solar village demonstration site inaugurated in September 1998 in the DogDinh hamlet in DongThap province. Solar electricity is being used in a battery charging centre, post office, for public lighting and a cultural and health centre. Local government officers praised the demonstration site. In addition, a seminar on the 'RET Village' was held in Hochiminh City where four papers were presented by participants from Vietnam, Cambodia and Thailand. The seminar was a good opportunity for sharing experiences and results of the project between the Asian countries involved in the programme.

2.3.2 Solar Drying

In **Nepal** the manufacture, operation and maintenance of the solar dryers were disseminated to a targeted audience of personnel from existing manufacturing companies and operators in the demonstration sites. Widespread dissemination was attempted through an exhibition of the dryers and a mass training session. Feedback and comments from the workshop participants would have been useful. It is highlighted that marketing should be conducted by manufacturers through wholesalers. This assumes that the product is well established and there is an efficient network of the key players.

In **Cambodia** the final report was fairly brief, especially compared to the other reports from Nepal and the Philippines, and there was no mention of the groups at which the dissemination was targeted or what the aims or objectives of the dissemination process were meant to achieve.

In the **Philippines** case, the technology and marketing approach were disseminated through two workshops and papers. No feedback from the workshops was given but the list of activities and topics appeared comprehensive.

A comparison of the different teaching courses and lessons learnt in the three

countries would have stimulated debate and helped in the dissemination.

2.3.3 Biomass briquetting

In **Bangladesh** the need for an alternative to fuelwood is translated as a market existing for biomass briquettes. While this may be the case, this report does not outline why entrepreneurs will be willing to invest in machinery even if it has been improved. An assumption is made that the main limiting factor on the spread of the technology is the possible scarcity of raw material if the machines are too successful. A marketing strategy is alluded to, however, but not presented in this report.

In **Vietnam** an extensive programme to popularise the technology is presented. The inclusion of barriers and difficulties gives this section credibility - the assumption that the technology will automatically be successful is not a pre-text. Efforts to encourage the consumption of the end product as well as incentives to producers are suggested. It is acknowledged that the success of biomass briquettes could depend on an effective and cost-competitive technology, and that the technology is far from perfect at present.

3. Relationships AIT- NRIs

AIT has played a crucial and efficient role in both the management of the project and in providing technical support for the NRIs, particularly in the fields of biomass briquetting and solar drying. This regional collaborative project has facilitated and developed greater cooperation between NRIs and between NRIs and AIT. AIT has produced a comprehensive set of reports to help NRIs address the issues related to adaptive research and training.

3.1 Written and audio-visual outputs

Six final reports and a video relating specifically to solar drying were produced. A comprehensive and impressive list of papers and conference proceeding publications, as a result of the work, was produced. The document called 'country profiles' provides a useful summary of the energy characteristics of the country concerned in the project and brief descriptions of the current activity in the particular RET.

The evaluation of this material will be then assessed, for each technology area, according to their usefulness to NRIs. To which extent the 3 topics addressed by AIT (evaluation of PV accessories and systems available locally, identification of PV systems in the field and possible solutions, preparation of specifications) were useful to the NRIs.

3.1.1 Solar photovoltaic

AIT's study on PV applications in selected countries provides a useful framework view for researches carried out by NRIs. The report gives an interesting view on the status of PV applications in Asia. Interesting data are provided on the price of PV modules and the efficiency. The updated figures show that between 1978 and 1997, the cost

effectiveness of PV modules has dramatically increased. To give more relevance to this report, the following remarks should be taken into consideration.

- a) A table synthesising the status in the four countries using the same indicators (e.g. installed capacity, legislation, etc.) would have allowed to draw easy comparisons
- b) In several instances the relevance of grid connected PV power plants have been mentioned. Given the modularity of PVs and the current cost per Wp, such options do not seem very economic. Further developments seem necessary on this issue.
- c) The study gives a good description on PV accessories and components and the common problems associated with their utilisation. However section 2-3 on the survey of PV accessories and systems commercially available in Asia is the one which seems to be more useful for NRIs and might have been expanded.
- d) It seems obvious that a comprehensive survey of PV manufacturers/suppliers had been carried out given their limited number. Nevertheless for other accessories (batteries, inverters, charge controller etc.) it is very difficult to get an idea of the sample surveyed and its relevance.
- e) Although there was an explicit question on the cost of the various accessories, there is no feedback on these costs. Such information, included in the questionnaire, would have been very useful to assess the possibilities of trade between the different countries.
- f) The possible solutions are not given in enough details so NRIs may be able to use them. Possible guidance on the design of low cost models, e.g the level of reasonable savings that could be achieved, strategies in terms of technology transfer, partnership etc, should have been presented.
- g) In the section on strategies for successful PV programs, the preference of decentralised home systems compared with central PV generators is highlighted. In the strategy 3 components (technical, economical and social) are set out but only the technical component is addressed in the introduction.

3.1.2 Solar drying

Two documents and a video relating specifically to solar drying were produced. Also a comprehensive and impressive list of papers and conference proceeding publications produced as a result of the work was given.

The document, "A Study on Improved Solar Drying for Agricultural Products in Asia", gives a brief explanation of why solar drying is relevant as a RET in Asia, both for the domestic and commercial market. A description of the existing technologies, a review of the status of the technology, relevant applications, associated problems and the institutions involved for solar drying in selected Asian countries is given. Clear diagrams and photographs are included.

One particular technology, the solar tunnel, was then chosen and a qualitative analysis given of the various types around. One design was chosen and adapted at AIT. The fabrication and testing of this solar tunnel dryer was then well described.

The importance of a participatory planning approach was drawn out, to include consumers, end users, and manufacturers but the decision to adapt a technology aimed at a commercial market would seem to exclude countries like Cambodia where the requirement for solar dryers is still for domestic and small scale use.

The activities related to the actual fabrication and construction of the solar dryer have been well documented and carried out. The only criticism would be the lack of reasons given for the choice of dryer chosen for construction and dissemination.

3.1.3 Biomass briquetting

A literature review by AIT describes existing technology and identifies areas for improvement. Tests were conducted to discover the effect of pre-heating the raw material. The effect of altering the production rate was also tested. A biomass stove for die heating is also described and was tested but its efficiency compared to electrical heating was not measured.

The specific objectives outlined in the report includes only one of the specific objectives stated in the Revised Research Programme document, i.e. development of an improved briquetting system by incorporating raw material preheating. The performance of the hardened screw is described in the literature review, but it appears no tests on its performance were carried out. Certainly, there is a discrepancy between claimed performance in the literature and the experience of the NRIs but this may be the result of insufficient time to run tests. Since the life of the screw appears to be the main contributor, in the field at least, more research in this area is desirable, especially since the powder-coating processes described to improve surface hardness may not be available universally. The piston-type machine is described and it is suggested that wear and breakage's are common. At some stage, improvements to this type of machine may need to be investigated.

The improvements in electrical energy consumption due to pre-heating of the biomass are significant and could contribute to the development of the technology, but the cost of the additional equipment is not given.

The study into raw material pre-heating seems to have been conducted well, but this aspect of the research was also easy to conduct in the NRIs (in part due to information supplied by AIT). In the case of Vietnam, particular problems were caused by screw failure, leading to a lack of results - more data on this aspect would have been useful from AIT. If the aim is to disseminate this machinery to the extent where it can make a contribution towards a sustainable energy supply, the practical problems associated with screw wear seem to be of prime importance, and a comprehensive study into appropriate materials would have been helpful.

There is mention in the Vietnam report of service and advice provided by AIT, but little mention in the Bangladesh report. Extensive testing has been carried out by the Bangladeshi project on screw coatings and less on the dissemination of the technology, while the Vietnam team seem to have paid a lot of attention to the marketing aspects while not contributing significantly to the technology. There appears to have been contact between the Vietnamese and the Bangladeshi teams and a sharing of information and technology thanks to the co-ordination from AIT.

There also appears to be discrepancies in specific energy consumption recorded between the two NRIs. A comparison of results by AIT was not undertaken, so lessons learnt are not commonly available due to insufficient time to collect results over a long period.

3. 2 Training programme

3.2.1 Solar photovoltaic

AIT has co-ordinated three training courses⁴ respectively on PV technology and its maintenance in Vietnam, PV charge controller and maintenance in Vietnam and PV charge controller in Nepal. Participants appear to have benefited a great deal from the three courses, which were focused on practical and crucial problems related to the development of the PV industry in developing countries. In addition, the production and dissemination of the manuals will certainly contribute to strengthen the technology transfer. Assessment of the impact of the training courses and the dissemination of the manual to other audiences, particularly in Africa and Latin America, might be considered by AIT.

3.2.2 Solar drying

A one-month special training course for researchers was held on solar drying for one participant from each country. The course was aimed at the design and construction of solar dryers.

The training courses were a valuable part of the AIT activities, but a thorough assessment cannot be carried out, as details of the course were not given. It would have been useful to have feedback from the countries involved concerning the content, relevance and use of the course.

In solar drying one workshop was held to discuss objectives, methodologies and expected results from solar drying projects. The participants were from the 3 countries. A review workshop was held later on.

The video and construction manual for the AIT solar dryer was sent to each NRI in Nepal, Cambodia and the Philippines. It would have been however useful to have the

4 Programme described under training courses carried by NRIs, see also table in annex.

feedback from the NRIs.

3.2.3 Biomass Briquetting

A one-month training course was conducted by AIT for one participant from the NRIs (Bangladesh and Vietnam) involved in this research.

3.3 Expert support from AIT

3.3.1 Solar photovoltaic

The review workshop organised by AIT is certainly an important step in the monitoring process and the quality assurance of the programme. AIT has made valuable inputs and suggestions for the methodologies.

Direct exchanges between countries working on the same technological is a relevant channel to share lessons learnt not only on the technology but also on other key aspects such as training and dissemination. It would have been useful to synthesize the impact of inter-country visits organised by AIT.

Given its reputation, AIT has certainly played an important role in reviewing material produced by NRIs. AIT's contribution, particularly with respect to the 3 manuals, could be detailed further. In addition, it would be useful to set out strategies to disseminate of the manuals.

3.3.2 Solar drying

A construction manual and video were produced by AIT to show the fabrication, operation and maintenance of the solar tunnel dryer. This is a clear document giving the technical specifications, costs associated with building the dryer, and an indication of the load that can be dried. A step by step guide gives comprehensive instructions as to the construction of the dryer, with photographs at relevant stages. The accompanying video needs to be viewed in conjunction with the manual but is a good visual aid.

3.3.3 Biomass Briquetting

The literature review provided by AIT appears to have been helpful, and results obtained from their experiments served as a useful benchmark for NRI experiments in the area of biomass pre-heating. The facilities available seem to be of a good standard.

4- Cost effectiveness

The budget seems reasonable given the international dimension of this project, the number of countries involved, the time scale, the technology areas addressed, the field work, and the research, demonstration and training activities implemented by AIT and

NRIs.

The distribution of the budget between the NRIs and the institution responsible for the overall co-ordination and the quality assurance seems also in line with similar programmes carried out worldwide. Although the final actual figures were not available, according to the provisional figures there is not a major discrepancy between the planned budget and expenditures.

SIDA's support to AIT is broken down according to the main items. It is recommended to follow the same procedures for the NRIs.

The initial budget included support for Bhutan. However the organisations contacted in Bhutan did not demonstrate any interest in the programme. The planned budget for Bhutan was therefore reallocated to other NRIs after consultation with SIDA.

CHAPTER 5: RENEWABLE ENERGY TECHNOLOGIES IN ASIA, PHASE II

Proposals of phase II were submitted after a thorough process encompassing three stages.

1) The first stage was limited to the development of project ideas and preliminary proposals submitted to SIDA and assessed by the evaluators before the workshop held in Bangkok in October 1998. The NRIs submitted outlines and projects ideas in four technology areas: gasifier engine systems, biomass-fuelled dryers, solar biomass fuelled dryers, and PV diesel hybrid systems⁵.

2) The evaluation of phase I and the analysis by the NRIs and AIT during the workshop showed that the proposals were rather technology driven and the link with phase I was not explicitly defined. Considering this, it was agreed to focus the programme for the second phase on the three key technology areas already investigated in phase I, namely solar photovoltaic, solar drying and biomass briquetting.

The evaluation of the preliminary proposal was completed by the methodological input on to the logical framework analysis and the presentation of SIDA's values. The analysis of stage 1 and SIDA's methodological input contributed to refocus phase II of the programme and led to proposals closely related to the first phase which built upon the lessons drawn from this phase. This meant that the gasifier engine system, which was not developed during the first phase, was dropped. The PV diesel hybrid system, which included a non-renewable energy, was also dropped. The three technology areas selected were those identified in phase I. In addition, the lessons from the evaluation (mainly dissemination and identification of beneficiaries) were incorporated into the proposals submitted in phase II. All the proposals were developed after thorough discussions between the NRIs interested in a particular technology. A logical

5 See in annex 1 : Evaluation of preliminary outlines submitted by the NRIs.

framework analysis was also included in all the revised draft proposals.

3) The third stage was devoted to the finalisation by the NRIs of the revised proposals developed and discussed during the workshop.

During the first phase, local expertise was built through technology development in adaptive research and training. After being thoroughly discussed and dramatically improved, the proposals submitted for the second phase are a logical continuation of phase I and build on the results achieved during this period.

The proposals submitted are an important step towards the sustainability of the whole programme, in particular the dissemination of the results of adaptive research and building up local capabilities in NRIs, especially countries such as Laos and Cambodia which were hard hit by internal conflicts.

All proposals are accompanied by bar charts and logical frameworks. However the verifiable indicators are not quantified. Although it seems difficult at this stage to provide realistic indicators, it is highly recommended to carry out this exercise during the first regional workshop scheduled for the first quarter of 1999. Indicators should be carefully defined not only to facilitate the evaluation process but also to allow the project teams to set targets to be monitored and possibly amended.

Although the proposals are very comprehensive, the following points deserve to be taken into consideration and might be addressed during the first regional workshop

5.1- Photovoltaic

- It is particularly important to show very clearly the added value of the adaptive research on selected PV systems and accessories to be carried out in phase II in comparison with the results achieved during the first phase.
- Batteries are an important component of the solar PV system both for the costs involved and the environmental dimension. The issue of battery disposal should be addressed and the comparison between automotive batteries and other batteries (such as solar batteries) should include the environmental dimension.

5.2- Drying Systems for Rural and Urban Poor

The success of the programme depends to a large extent on the second output - market assessment for the commercialization of renewable energy based drying systems. The development and demonstration output should be closely linked to this to ensure that technologies developed are relevant. The demonstration and dissemination outputs should also be more closely linked to the market survey - demonstration should not only show that the technology works but that the products are marketable in the local economy.

5.3- Biomass briquetting

The aim of improving the briquetting system by developing its separate elements builds to an extent on the results of phase I. With this respect the screw design should be given a high priority in general.

It is recommended to investigate the machines already in operation, especially in Bangladesh (estimated at 1 000) and Vietnam. Presumably, valuable lessons from the operation of these machines could be learnt.

Indications should be provided that, even if successful, ceramic coating of the screw is a technology which will be widely available in all or some of the NRIs.

A case against developing alternative machine configurations should be made to justify the technological choice taken by the project.

5.4- Budget

Although the budget is in line with similar international projects, the most important components can be further broken down particularly the equipment and consumable. For example in the case of solar drying activity 1d accounts for more than 36 % of the total budget of the Philippines and Nepal.

In the case of photovoltaics, activities 2 (procurement of PV systems) and 5 (adaptive research on selected PV systems and accessories) account for more than 32 % for each of the NRI involved in this research.

Breakdown of Photovoltaic budget according to main components (SEK)

NRIs	GS and CMES	MIME	CRE Nepal	STENO	Solarlab
Procurement of PV systems and installation	280,000 (22 %)	140,000 (22.1%)	140,000 (22.1%)	170,000 (20.4%)	170,000 (20.4%)
Adaptive research	149,300 (11.8%)	95,650 (15.1%)	74,600 (11.8%)	135,480 (16.3%)	135,480 (16.3%)
Total Budget	1,265,000	632,500	632,500	832,999	832,999

CHAPTER 6 CONCLUSIONS - RECOMMENDATIONS

The conclusions-recommendations are classified into:

- specific recommendations which apply to the three main technologies investigated, i.e. solar photovoltaic, solar drying and biomass briquetting,
- recommendations which apply to the overall programme, and
- general recommendations for the second phase

1- Conclusions recommendations by technology area

Photovoltaic

The low rate of rural electrification combined with the low density of populations living in rural areas and the distance from the grid make decentralised energy options, and solar photovoltaics in particular, a credible alternative option. The decrease in prices and the increase in the energy efficiency of solar PV systems have dramatically improved the cost-effectiveness of solar systems over the last decade.

The focus on the adaptive research of accessories for solar PV and training were very relevant since the production of the solar modules is excluded in the mid term in most developing countries, both for technological and economic reasons, chiefly the limited market which can benefit from economies of scale.

During phase I a significant number of solar home systems were installed. The performance and the costs of solar PV accessories (mainly batteries, converters, inverters, charge controllers) have improved. Low wattage income generating devices such as PV operated sewing machines and drills were developed. It is worth mentioning that if the market for productive end uses proves to be cost effective, the dissemination of PV systems may reach low-income people.

The key recommendations concerning solar PV are:

- a) Small scale productive PV applications should be investigated further and in particular the dissemination of income generating applications (PV sewing and drilling appliances) demonstrated during phase 1.
- b) The Bangladesh report produced by Grameen Shakti has mentioned two options in the dissemination field, which may need further developments:
 - alternative financial packages proposed by the users themselves, and
 - the use of micro utilities.
- c) The comparison between the different types of batteries and the respective costs-benefits should be investigated in a more systematic way.
- d) Further adaptive research is needed on DC lamps.

- e) The facilities at Solarlab in Vietnam proved to be of good standard and the training courses effective. During the second phase, Solarlab' support to Laos and Cambodia in particular should be increased.
- f) Adapted and improved accessories (batteries, inverters etc.) developed during phase I should be further demonstrated and disseminated.
- g) Environmental aspects linked to battery disposal should be addressed.

Biomass Briquetting

The refinement of biomass in a more concentrated fuel in the form of briquettes has great potential for utilising agricultural and process wastes. Technologies for briquetting biomass exist but there are significant technical and economic problems which this project has attempted to address.

Problems with the technology continue to prevent its widespread dissemination, but a clearer understanding of those problems has been a major outcome of this research as well as significant progress in overcoming them. In particular, development of the screw in the Bangladesh NRI has improved performance, but not sufficiently. More work is needed, and in the light of the experience gained further research in the area has been proposed. A more fundamental look at both the technology and the market is necessary.

There have been improvements in the performance in two aspects of one type of machine, screw wear and die heating, although there is still considerable room to adapt and develop the technology further. The improved designs are not yet ready for dissemination.

The marketing of biomass briquetting machines depends upon further development of the technology to further reduce costs. Marketing programmes presented by the NRIs were variable in quality. The Vietnam NRI produced impressive plans to market and disseminate the technology but had less success in improving the machines under test.

The key recommendations concerning biomass briquetting are:

- a) The operation of existing machines in widespread operation in the NRIs should be more rigorously studied.
- b) Future research should continue with the existing design of machine using results of tests that were not ready to be included in the final reports. The key component in this type of machine is the screw the cost of which needs to be reduced.
- c) More attention should be paid to adapting the briquettes to the stoves, not the other way round. Alternatively, appropriate and cheap stove design should be a priority.

- d) Alternative machine configurations need to be considered. Designs incorporating pistons may wear less frequently; hand compactors, which may give an inferior but more accessible technology, also need to be considered.
- e) The energy cost of die heating should be investigated further to ensure that there is a positive energy balance in the system.

Solar Drying

Solar drying is an attractive technology because of its simplicity, but its success depends on the correct market conditions. More testing is needed to make solar dryers marketable and more research in the area is proposed. Both the technical and practical aspects were carried out in a thorough and professional way.

Adaptive research has been conducted successfully in the fields of solar drying, where six designs were tested by the NRIs. Results show improvements on previous designs, although there are still questions concerning their marketability. In Nepal, information concerning the quantity of produce wasted, and therefore the potential savings possible through using dryers, was not available. In general, knowledge of the technology has increased as a result of this research. However, due to time constraints insufficient testing has been carried out in Cambodia, particularly in comparison with natural solar drying. The overall cost-effectiveness of the dryers is therefore difficult to calculate.

The solar drying programme has been demonstrated with varying success in the various countries through exhibitions, workshops, papers and training. Marketing has been limited with insufficient market research having been undertaken.

Although in its early stages, in the sense that costs have not been reduced sufficiently, dissemination and training programmes developed for the solar drying programme were well constructed, more particularly in the Philippines. Given further development of the technology, the marketing structure has been well prepared.

The recommendations for future work on solar dryers are:

- a) More attention should be paid to the market requirement for dryers i.e. for preservation or adding value.
- b) Beneficiaries should be clearly identified from market research.
- c) Cost reductions need to take place.
- d) More rigorous testing is needed in all weathers and more comprehensive comparisons made with natural drying particularly in Nepal.
- e) Dissemination of the technology needs to be more effective and wider, with

reference to best practice.

- f) The mechanisms and the level of subsidy for solar dryers should be further investigated in Nepal.

2- Overall programme

- a) A wider dissemination of the results could be considered. For example additional publications could be produced. A synthesis of the results in the form of a booklet aimed at policy makers and development organisations will give much more visibility to the programme and more impact to the work already achieved.
- b) In the six countries the respective governments play a crucial role in the generation and distribution of energy. Financial incentives such as subsidies, tax benefits or soft loans are provided only in some countries. It is therefore important to involve or raise the awareness of the policy makers in the field of RET. A seminar targeting this specific audience may be planned at the end of the second phase.
- c) Environmental aspects could be highlighted further and the gender issue should be considered.
- d) Increased support might be considered in favour of Cambodia and Laos given the level of the development in these two countries.
- e) Concerning the planning and project design of the second phase⁶:
- the design of the second phase should be based in a more systematic way on results and lessons drawn from phase I,
 - target groups should be clearly identified in the new programme and the benefits highlights,
 - logical framework analysis should be used to design the new programme and specific projects. Measurable and verifiable indicators should be used.
 - cost effectiveness should be included in the projects and comparative analysis carried out over the life cycle, and
 - training courses should include methodology to carry out impact assessment.
- f) Concerning results dissemination
- dissemination strategies should be included in the new programme, and
 - targets groups should be identified for dissemination of manuals, booklets and other written and audio-visual outputs.

⁶ These recommendations were formulated before the workshop held in Bangkok in October 1998. Most of them were taken into consideration in the revised proposals submitted for the second phase.

g) Concerning the budget

- AIT managed effectively the overall programme. Some marginal problems were encountered at the beginning with respect to the delays in transferring the funds. Lessons were drawn and AIT took the appropriate measures to speed up the transfer. Some problems remain but they are due to internal procedures to each country and little can be done by AIT.
- The budget seems reasonable given the international dimension of this project, the number of countries involved, the time scale, the technology areas addressed and the research and demonstration work carried by AIT and the NRIs.
- The distribution between the NRIs and the institution responsible for the overall co-ordination and the quality assurance seems also in line with similar programmes carried out worldwide.

The main recommendations are related to:

- breaking down the budget according to the main components not only for AIT but also for the NRIs.
- the particular situation of Bangladesh for which it is suggested that AIT send beforehand a letter of intention to the central governmental body dealing with NGOs. Such a measure will speed up access to the funds for the NRIs working in Bangladesh.

3- Phase II

The proposals submitted for the second phase are logical continuations of phase I and build on the results achieved during this period. During the first phase, local expertise was built through technology development in adaptive research and training mainly on solar photovoltaic, solar drying and biomass briquetting.

The implementation of the second phase will be an important step towards the sustainability of the whole programme and, in particular, the dissemination of the results on adaptive research and building up local capabilities in NRIs. It is therefore recommended that SIDA not only maintain its support to the second phase but also consider a higher level of support given the duration of the second phase (3 years instead of two in phase I) and more emphasis on dissemination activities.

Annex 1 Evaluation of preliminary outlines submitted by the NRIs

To assess the new programme, it is particularly important to find out whether the programme has reached its key objectives and to which extent additional activities related to the previous phase may strengthen further the overall programme. Although the outlines include one of the technologies previously investigated (solar PV) the programme submitted is addressing new demonstration projects. There is a tendency to give to the new programme too much weight on research-demonstration at the cost of marketing, training and dissemination.

Indeed as it stands the initial outlines are rather a demonstration project whereas the issues listed in the programme and the workplan suggest that dissemination in the mid term (3-5 years) is a major objective. If this objective is to be confirmed, the programme should include the following aspects:

1- Gasifier-engine system

In terms of relevance, the gasification of biomass could provide an important fuel for engine applications. The Gasifier engine system has the advantage of offering a clean energy providing that the constraint of the tar content is solved. Some models recently developed suggest that there are good prospects that this objective can be reached.

Although it seems obvious, it should be made clear that there is a biomass resource accessible at affordable cost (including transportation costs) in areas where the technology will be disseminated.

This condition implies that the project should provide indications on the physical potential in relation with the demand and the market.

It does not seem sound to determine the economic feasibility only at the final stage of the project. At the inception, indicators on the pre-feasibility of such a project and the associated provisional costs seem to be necessary. Existing literature suggests that such indicators can be provided. Of course these provisional costs will be based on assumptions which should be explicitly highlighted in the logical framework.

The marketing strategy must be detailed and included in the project design e.g. who the beneficiaries are, how the project will be working with the manufacturers, whether there is a sufficient market for several manufacturers etc. A range of gasifier-engine capacities is targeted in the proposal, but no specific sizes are mentioned. It is unclear who will benefit from the technology other than AIT and the NRIs involved, i.e. who will the technology be disseminated to?

The project design (see suggested model in annex for discussion according to SIDA format) should encompass all the key aspects above and include the verifiable indicators such as number of pilot plants developed, number of beneficiaries (e.g. number of entrepreneurs etc.), target costs, quantitative information for dissemination,

number and type of training courses, publications and respective target groups such as manuals for practitioners, booklet for policy makers and development organisations etc. The budget and the human resources must also be included in the logical framework.

2 - Biomass-Fueled Dryer

The need for a reliable and affordable drying technology is desirable, especially in areas where simple solar drying may not be sufficient. Of the methods currently available, those that avoid the use of heat exchangers by using the exhaust gasses directly offer potential.

The proposed project is intended to develop a gasifier stove developed during the first phase of the RET's Asia project, which shows promise due to the clean nature of the exhaust gasses. Although this route will lead to a useful progression in technological development, there is doubt as to its appropriateness for two reasons:

1. The project proposal itself identifies several projects worldwide that harness similar technologies already, and
2. There is no clear description of a need identified by end-users, rather than by researchers.

The overall RETS programme is aimed at the practical implementation of technologies at a level where they can be effectively utilised and disseminated. While it is possible that the technology described in this proposal may be successful after development, the chances for a wide dissemination are reduced by the technology-led nature of the proposal.

The tasks to be carried out by AIT do not include at an early stage an economic analysis of present technologies. The results of such an analysis could inform the choice of technology at an early stage.

The last task to be carried out by the NRIs is to "disseminate by organising national workshops". Perhaps the organisation of similar workshops at the project's inception could provide valuable inputs to the design process.

3- Solar-Biomass Hybrid Dryer

The solar biomass hybrid dryer is an attractive technology option as it combines two renewable energy sources to improve the reliability and the cost effectiveness of the system. However it does rely on an appropriate biomass fuel source being available within easy access and acceptable cost.

The proposal is very technology led whereas more importance should be placed on the market and rural needs. Overall a more participative planning approach should be considered.

The example of the solar hybrid dryer that was demonstrated in the Philippines in the first part of the project proved to be successful and to provide positive benefit to the ceramic industry. However this was a clear case of there being a strong market demand for the project, a very specific end use, and an infrastructure that could support it.

Will the AIT design take any kind of biomass? Will it be transferable? Nepal has already noted the problems with the transport of the solar tunnel to remote places.

The original report of the solar dryers in Cambodia suggest that a careful study needs to be undertaken to determine whether there is really a market or need for a hybrid dryer.

The Philippines has already installed and are evaluating and monitoring their hybrid dryer.

The second stage proposes the following tasks:

- a survey of the characteristics of the drying process using various agriculture products and testing the performance of the tunnel dryer
- design of a solar biomass hybrid dryer
- testing, monitoring and evaluation of hybrid dryer on selected demonstration sites
- cost/benefit analysis of test sites
- develop dissemination strategy

A market survey of the opportunity and requirements in each country with regard to solar drying should also be conducted.

4- PV- diesel hybrid power system

The same methodological remark on the project design applies to this project. With respect to the relevance of the project, the environmental and technical reasons such as the modularity are very sound and justify a research-demonstration dissemination project on this technology.

However, apart from the environmental dimension which is particularly important, the project must demonstrate that it is cost effective (environmental savings included) or at least not prohibitive to introduce PV-diesel hybrid system. Indeed the potential beneficiaries will be much more inclined to adopt such systems if the additional investment is paid back by the fuel savings and/or if the service they used to receive improves dramatically. This is not obvious. It is a research hypothesis that deserves further investigation. In the report it is rightly quoted (ADB, 1996) that "**for a particular supply capacity**, a hybrid system can reduce the cost of investment for a solar alone system and the extra investment on additional systems may offset the investment on the additional PV panels and battery". The project should try to determine whether there is a niche in terms of size for the PV-diesel hybrid power system

In the case of limited supply of power for example home systems (say around 50 W)

the additional investment might be seen as prohibitive compared with the income of the household and the improvement in the service provided.

In the case of higher supply (say some hundreds Watts), the additional investment for a solar back up might be too high given the capacity required. The project should provide additional information on the range of capacity targeted and the end uses likely to be met by the hybrid PV-diesel system.

The report put the emphasis on the existence of a few installations in Thailand and Indonesia and the lack or the absence of information on these systems. A preliminary step of this project should be an evaluation of these installations and a literature review of other installations. A report must be produced and submitted to SIDA after some 6 months on the feasibility of such a project. The report may include the following topics:

- Target groups
- Technical aspect
- Environmental dimension (savings),
- Additional costs incurred,
- Degree of improvement of the service,
- Maintenance aspects and possible involvement of local manufacturers.

Annex 2: Adaptive research: key achievements

PHOTOVOLTAICS	SOLAR DRYING	BIOMASS
• Self-consumption of Charge Controllers evaluated. • Low-voltage disconnect, re-connect range, over-voltage disconnect/full charge resumption range evaluated for Charge Controllers. • Over-charge protection circuitry analysed. • Lux output of DC lamps measured; ON/OFF cycle test on DC lamps conducted. • Lux vs Voltage and operating Voltage of DC lamps determined. • Radio frequency interference of DC lamps analysed. • Efficiency & output voltage at load and no-load conditions of converters analysed	• Solar dryers adapted to individual country and application requirements have been fabricated and demonstrated in the respective countries. • Performance of the dryers monitored and recorded. • Existing solar dryers for drying fruits & vegetables were suitably modified to reduce cost and to enhance performance, reliability and ease of handling.	• Enhancing screw life by hard-facing techniques (screw life increased from 3 hours to 25 hours). • Energy consumption reduced by biomass pre-heating and die heating. Screw profile analysed for optimum briquette production. • Research on developing improved briquette burning stoves conducted. • Briquette/wood gasifier developed for clean gas production. • Biomass pre-heater for briquetting machine. • Biomass die-heating stove to replace electric heaters. • Briquette/wood gasifier for clean gas production.
STENO: Improved DC Ballast. Deep discharge protection for battery	RECAST: Modified Cabinet & Tunnel Dryers	VIETNAM: Briquetting technology introduced and demonstrated
Solarlab: Intelligent Regulator Improved DC lamp assembly	UP: An industrial scale solar-biomass dryer	BANGLADESH: Demonstrated improved screws and reduced energy consumption.
CRE: Various components/sub-systems	ITC	AIT
	• Many Dryers for agro products • A modified tunnel dryer based on Hohenheim Dryer. • A PV-driven and hybrid system.	• Improved briquette-burning stoves developed and demonstrated to NRIs for fabrication and dissemination. • Improved institutional stoves using briquettes as fuel developed and demonstrated by the NRIs. • Improved biomass briquetting and

Annex 3 Building up local capabilities : summary of training courses

Country And course title	Target group	Number of trainees	Written output (manual etc.)	Comments
Bangladesh(CMES,GS) 1- General training Solar PV 2- PV maintenance 3-Individual consumer training PV 4- Operation and maintenance of briquetting machine	Senior Technical Teachers of CMES Technicians Consumers in pilot area and consumers of micro utility Potential machine operators	17 130 Not given 23	Source book for trainers and practitioners. To be published by CMES	
Laos Installation and maintenance of solar PV systems	Technicians and engineers	14 (Progress report, not given in final report)	Manuals in local language.	
Vietnam 1- International training course on solar technology (ITCS) 2- ITCS on making and repairing solar regulator 3- Operation of biomass briquetting machine	Engineers. Engineers Operators of rice milling machines, potential operators, managers	8 from 4 countries 6 from 2 countries 15-16		Sharp differences in Basic level of trainees . Training planned but not executed
Cambodia (MIME)	Basic maintenance	Not given	-	By end 98
Nepal	Entrepreneurs, technicians, users	Not given		

Cambodia (SD) General training	final year school students and teachers in food technology, energy, agriculture, chemical engineering	30	not specified-	Content seems too wide
General training Training Programme:	farmers in certain areas	30	not specified	Little information No details about content
Nepal 1. Operation and maintenance for solar tunnel, solar rack and solar cabinet.	Operators at the demonstration sites	12	Operator manual	One day seminar
2. Fabrication of solar tunnel, solar rack and solar cabinet.	workers at the existing manufacturing companies	8	fabrication manual	
1. Mass Training Course on the solar drying of fruit and vegetables	Women Self Help Society		NA	
4.Seminar on Government policy on RETs and marketing strategies of solar dryer	Key personnel from relevant institutions in Nepal	14	NA	
5. Environment awareness Fair	General public		NA	
Philippines (SD) 1.Workshop on performance, economics and use of the hybrid solar-biomass ceramic dryer	Managers	15	Brochure published on the hybrid dryer	Held in August 98, therefore not included in the final report
2- Operations and maintenance hybrid dryer	operators of the dryer at the targeted ceramic factory	7	Paper published in the Agricultural Mechanization in Asia, Africa and Latin America	

Annex 4 Reports submitted by AIT and NRIs

A. RETs in Asia Programme – 1st Phase

1. Revised Research Programme
2. Country Profile

B. Final Reports of AIT Activities

1. An Experimental Study of Briquette/Wood Gasification
2. An Experimental Study of Improved Biomass Briquetting
3. An Experimental Study of Institutional Biomass Stoves
4. A Study on Improved Solar Drying of Agricultural Products in Asia
5. AIT Solar Tunnel Dryer – Construction Manual & Video
6. A Study on Photovoltaics Applications in Selected Asian Countries

C. Final Report of NRIs

C.1) Photovoltaics

1. Final Report on the R&D on the Fabrication and Adaptation of Appropriate Accessories Used in Small Solar PV System for Rural Electrification and Marketing and Maintenance Strategy for the System – CMES, Bangladesh
2. Final Report – Grameen Shakti, Bangladesh
3. Final Report – Demonstration and Promotion of PV and Solar Drying System in Cambodia, MIME & ITC, Cambodia
4. Demonstration and Promotion of Solar PV Systems in Lao PDR – STENO, Lao PDR
5. Final Report on PV Technology in Nepal – CRE, Nepal
6. Final Report on Marketing of Solar PV Technology in Nepal – CRE, Nepal
7. Final Report on Adaptive Research to Rectify/Improve the Existing Design of Various Accessories/BOS Used in Solar PV Home Systems in Nepal – CRE, Nepal
8. An Evaluation of RETs Village Project in Vietnam – Solar Laboratory, Vietnam

C.2) Solar Drying

1. Solar Dryer Adaptation in Nepal – Final Report – RECAST, Nepal
2. Development of a Hybrid Solar-Biomass System for Ceramic Drying Applications – UP, Philippines

C.3) Biomass Briquetting

1. Final Report on Pilot Project on Briquetting of Biomass Fuels: Manufacturing and Marketing – BIT, Bangladesh
2. Pilot Project on Briquetting of Biomass Fuel in Vietnam – Final Report – Institute of Energy, Vietnam

D. Proposal for 2nd Phase

RETs in Asia Programme 2nd Phase Proposal

Annex 5: Review and Formulation Workshop of RENEWABLE ENERGY TECHNOLOGIES IN ASIA: A Regional Research and Dissemination Programme

12 – 17 October 1998 –

12 October 1998 (Monday)	
08:00 – 08:15	Opening Ceremony
0815 – 0845	Presentation on the key achievements of RETs in Asia Programme by Dr S Kumar
0845 – 1015	Presentation of the accomplishments of NRIs & AIT – Photovoltaics/Part 1 – 3 NRIs Discussion & Comments
1015 – 1045	COFFEE BREAK
1045 – 1215	Presentation of the accomplishments of NRIs & AIT – Photovoltaics/Part II – 2 NRIs & AIT
1215 – 1315	LUNCH
1315 – 1515	Presentation of the accomplishments of NRIs & AIT – Solar Drying (3 NRIs & AIT) Discussion & Comments
1515 – 1545	COFFEE BREAK
1545 – 1715	Presentation of the accomplishments of NRIs & AIT – Biomass (2 NRIs & AIT) Discussion & Comments
13 October 1998 (Tuesday)	
0830 – 0945	LFA Presentation by Dr M R Bhagavan
0945 – 1015	Clarification & Discussion
1015 – 1045	COFFEE BREAK
1045 – 1215	Discussion of 2 nd Phase preliminary proposal
	- Photovoltaics (AIT, NRIs & Sida)
	- Solar Drying (AIT, NRIs & Sida)
	- Biomass (AIT, NRIs & Sida)
1245 – 1345	LUNCH
1345 – 1545	Discussion of 2 nd Phase preliminary proposal (cont'd)
	- Photovoltaics (AIT, NRIs & Sida)
	- Solar Drying (AIT, NRIs & Sida)
	- Biomass (AIT, NRIs & Sida)
1545 – 1615	COFFEE BREAK
1615 – 1700	Summary/Conclusion of Day 2
14 October 1998 (Wednesday)	
0830 – 1015	Presentation & discussion of the revised proposal - Photovoltaics
1015 – 1045	COFFEE BREAK
1045 – 1230	Presentation & discussion of the revised proposal – Solar Drying
1230 – 1330	LUNCH
1330 – 1515	Presentation & discussion of the revised proposal – Biomass

15:15 – 15:45	COFFEE BREAK
15:45 – 17:00	Summing up & concluding remarks
15 October 1998 (Thursday)	
	Interview by Dr Smail Khennas with
08:00 – 09:00	Grameen Shakti & CMES, Bangladesh (PV)
09:00 – 10:10	CRE, Nepal (PV)
10:30 – 11:30	Solarlab, Vietnam (PV)
11:40 – 12:40	STENO, Lao PDR (PV)
13:40 – 14:40	MIME, Cambodia (PV)
14:50 – 15:50	ITC, Cambodia (Solar Drying)
16:10 – 17:10	RECAST, Nepal (Solar Drying)
17:20 – 18:20	UP, Philippines (Solar & Biomass Drying)
16 October 1998 (Friday)	
08:15 – 09:15	IE, Vietnam (Biomass Briquetting)
09:30 – 10:30	BIT, Bangladesh (Biomass
10:45 – 11:15	Discussion with prof. Chongrak Polprasert, Dean, SERD/AIT
11:30 – 12:30	Interview by Dr Smail Khennas with Prof. S C Bhattacharya & Dr S Kumar
14:00 – 16:30	Discussion with NRIs
17 October 1998 (Saturday)	
Further Discussions	

Annex 6 Participating institutions and research areas

Overall Co-ordination: AIT

Institution	Photovoltaics	Solar Drying	Biomass Briquetting
Grameen Shakthi			
CMES, Bangladesh			
CRE, Nepal			
Solarlab, Vietnam			
MIME, Cambodia			
STENO, Loa PDR			
RECAST, Nepal			
ITC, Cambodia			
UPERDFI, Philippines			
BIT, Bangladesh			
IoE, Vietnam			

Acronyms

ADBN	Agricultural Development Bank of Nepal
AIT	Asian Institute of Technology
BIT	Bangladesh Institute of Technology
CMES	Centre for Mass Education in Science, Bangladesh
CRE	Centre for Renewable Energy, Nepal
CFL	Compact Fluorescent Lamp
DC	Direct current
GDP	Gross Domestic Product
GS	Grameen Shakti, Bangladesh
IE	Institute of Energy, Vietnam
ITC	Institut de Technologie du Cambodge
LPG	Liquefied Petroleum Gas
MIME	Ministry Industry Mine and Energy, Cambodia
NRI	National Research Institute
PV	Photovoltaic
RE	Renewable Energy
RECAST	Research Centre for Applied Science and Technology, Nepal
RET	Renewable Energy Technology
RRP	Revised Research Proposal
SHS	Solar Home System
SIDA	Swedish International Development Cooperation Agency
STENO	Science, Technology and Environment Organisation, Laos
UP	University of the Philippines
Wp	Watt Peak

CURRICULUM VITAE Dr Smail KHENNAS

DEGREES Ph.D Energy Economics, Institute for Energy and Economic Policies (IEPE), Grenoble University, France, 1976

POSTS HELD

1994-present, Senior Energy Specialist, Intermediate Technology Development Group, ITDG, UK.

1991-1994 Senior Lecturer on Economics and Energy, Algiers University,

Deputy director of the Association for the Promotion of Social Sciences, Algiers.

1985-1990 Coordinator of energy Programmes, ENDA Energy Programme, Senegal

1976-1985 Coordinator of the Energy Programme, Research Centre on Applied Economics, Algiers..

1973-1976 Assistant researcher (Ph.D), IEPE, Grenoble University, France.

RECENT PUBLICATIONS

Books and booklets: 8 (below recent publications)

- Energy for the poor, ITDG publications, UK 1998.
- Energy Biomass Guide (co-author), IEPF Quebec, 1994.
- Mineral Resources, Energy and Industrialisation in Africa, CODESRIA book, distributors ABC, Oxford, UK, 1993 (Co-ordinated and edited by S. Khennas).
- The Energy Challenge in Mediterranean Countries, L'Harmattan , Paris, 1992

Articles: About 30 (below recent articles)

- *Urban energy: practical and theoretical issues*, Boiling Point, Autumn 1998, issue No 41.
- 1998: *ITDG International programme*, Energia News, Issue 2, May 1998
- 1997 *Routes for commercialization of rural stoves*, Boiling Point, Autumn 1997, issue No 39.
- 1995: *Energy unequal development and environment*, (book chapter), in *Energy and Society*, UNESCO, Editions Publisud Paris.
- 1995 *Household energy and agenda 21*, (co-author) GTZ publications, Germany.

CURRICULUM VITAE Dr Teresa M. ANDERSON

KEY SKILLS: Technical and economic assessment of renewable energy systems

QUALIFICATIONS: PhD Electrical Engineering, University of Edinburgh, 1993

EXPERIENCE

1995 - date **Energy and Environment Programme Manager, Intermediate Technology Consultants**

1993 - 1995 **Energy Systems Group. Research Fellow.**

1993 - 1995 **Edinburgh University Department of Continuing Education**
Lecturer: Renewable Energy Systems

PUBLICATIONS

Anderson TM, Reeves T, *The Role of Co-operatives and Self-Help Organisations in Utility Provision* A position paper for DFID Enterprise Development Division Seminar, commissioned by the Director, December 1997.

Anderson, T., Holland, R., Smith, N. *Low Cost Connection to Electricity Supplies* pp 25 - 29, GED Bulletin No6, December 1996

Anderson, T., Corominas, J., Gerisch, G., Holland, R.E., Peasley, C., Wishart, G. *'A Transferable Approach to Renewable Energy Integration'* Eurosolar Conference on Renewable Energy in Regions and Cities, Ulm, April 1996

Holland, R., Harvey, A., Anderson, T. *'Decentralised Rural Electrification : The Critical Success Factors : Experience of Intermediate Technology'* Ademe Seminar on Rural Electrification, Marrakech, November 1995.

Wallace, A.R., Wilkinson, R.E., Anderson, T.M., Williams, D.A., *'A Knowledge Based System for MiniHydro Assessment in Sri Lanka'* Water Power and Dam Construction Conference, Barcelona, 1995.

Ref. No.

SAREC-1995-0192

**Terms of Reference for the Evaluation of the Sida-supported
"Renewable Energy Technologies in Asia:
A Regional Research and Dissemination Programme
(RETs in Asia)"
at the Asian Institute of Technology (AIT) in Thailand**

1. Background

The AIT submitted a proposal to Sida in February 1996 for support to the above-mentioned Programme for a three year period. This Programme was conceived as a research network involving selected institutions in selected countries from Southeast and South Asia (hereafter referred to as the "region"). Besides providing the network with research leadership, coordination and management, AIT would also be actively involved in performing the research work and in conducting the research training.

Sida approved a grant of SEK 8 million for the period 1 July 1996 - 30 June 1998, under the condition that AIT would submit a revised proposal for Sida's approval, produced on the basis of a regional workshop to be held at AIT in November 1996 with the purpose of furthering developing the initial proposal and finalising the design of the Programme. The revised final proposal was received and approved by Sida in January 1997.

The Programme deals with three renewable energy technologies: photovoltaics (solar cells), solar drying and biomass briquetting. In each of the three technologies, the stated intention of the Programme is to employ an integrated approach to its central aim of promoting the provision of energy services in rural areas of the region. This is meant to be achieved by a combination of adaptive technical research, demonstration, monitoring and dissemination of the adapted technologies, and training of technical personnel and local

small-scale entrepreneurs. The research component is intended to be both the leading and dominant factor in the Programme.

The "RETs in Asia" network comprises 13 national institutions (hereafter referred to as NRIs) from 6 countries: Bangladesh (3 institutions), Cambodia (2), Laos (2), Nepal (2), Philippines (2) and Vietnam (2). In addition to result-oriented research and dissemination, the Programme aims to build up and strengthen research capacity and competence in the 13 NRIs.

2. The purpose of the evaluation

There are two main reasons for the evaluation. First, to assess how far the Programme has been able to fulfill the research, dissemination and capacity strengthening tasks and objectives set out in its January 1997 proposal. Second, in the light of the Programme's performance so far, to assess the new draft application by AIT to Sida for continued support over the next three year period (1999-2001).

3. The Assignment

The evaluation should cover the following aspects.

3.1 Relevance and overall performance

- * The relevance and importance of the Programme to the promotion of the provision of energy services in the rural areas of the region.
- * The degree of success in achieving the Programme's overall objectives and the specific project-wise objectives, as put forward in the Programme's January 1997 proposal.

3.2 Research output, research capacity strengthening and dissemination of research results

- * The quantity and quality of the Programme's output, including research reports and papers.
- * The contribution of the Programme to the building up and strengthening of capacity and competence in the NRIs in conducting research on, and in the dissemination and monitoring of, renewable energy technologies.
- * The modes of dissemination of research results and their appropriateness, including the relevance and range of targeted recipients.

3.3 Capacity and competence harnessed to the Programme

- * The competence of the project leadership at AIT and in the NRIs, to be assessed in relation to their performance within the Programme.
- * The magnitude and quality of the back-up service, in terms of energy expertise as well as managerial and coordinating tasks, provided by AIT to the NRIs.

3.4 Cost-effectiveness

- * The structure and purpose of the major components of the Programme budget, and the relative shares that go to AIT and the NRIs and how these have affected the performance of the Programme as a whole and the achievement project-specific objectives.
- * A broad qualitative appraisal of the relative cost-effectiveness of the Programme in comparison with other regional programmes in Asia or elsewhere, to the extent that information is readily available to the evaluators through published or unpublished sources.

4. The new draft proposal by AIT

The evaluators shall also assess the new draft proposal submitted by AIT to Sida for continued support over the next three year period 1999-2001, paying particular attention to the following aspects: relevance, importance, quality, competence and capacity strengthening in the NRIs, Programme design, feasibility, and the magnitude, structure and appropriateness of the proposed budget.

5. Recommendations by the Evaluators

In addition to their detailed and in-depth assessment of the performance of the Programme so far and the recommendations ensuing therefrom, the evaluators should also present their recommendations on the changes and improvements required in the approach, design and execution of the Programme over the next three year period 1999-2001, with reference to new draft proposal submitted by AIT to Sida.

6. Evaluation Team, Methodology and Time Schedule

The Evaluation Team

The team comprises two international experts:

Dr Smail Khennas
Senior Energy Specialist

Dr Teresa Anderson
Energy and Environment Programme Manager

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Bourton on Dunsmore
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Dr Smail Khennas will act as the team leader.

The Methodology

The evaluators will study the written output produced by the Programme over the period September 1996- July 1998, including the revised final Programme proposal submitted by AIT to Sida in January 1997, and the new draft proposal for continued support to be submitted by AIT to Sida in September 1998. In addition, they will read relevant selected material pertaining to AIT's overall philosophy, approach, structure and management.

The leader of the evaluation team, Dr Smail Khennas, will attend the Programme's review meeting scheduled for the week beginning 12 October 1998 at AIT and conduct in-depth interviews with the Programme and project leaders, as well as the NRI professionals and researchers involved in the Programme. Further, he will also interview selected key figures in AIT leadership.

The Time Schedule

The evaluation will entail a maximum of 8 person-weeks of work, i. e. a total of 8 weeks for the two evaluators together, spread over the period September-November 1998. Dr Khennas will spend about one week at AIT in Thailand (10-18 October 1998). The remaining seven person-weeks will be spent studying the written material and drafting the evaluation report.

The evaluators will submit a single, joint draft evaluation report in English to reach Sida and AIT not later than 5 October 1998. Sida's and AIT's comments on the draft evaluation report will be provided to ITDG at the meeting in AIT during the week starting 12 October 1998 and subsequent comments, if any, will be dispatched by Sida and AIT to reach ITDG in Rugby not later than 22 October 1998. Taking these comments into account, the evaluators will produce the final version of their report and submit it to Sida not later than 16 November 1998.

7. Reporting and Publication

The length of the final report will be at least 20 single-spaced typed pages (approximately 8000 words), but should not exceed 40 pages (16,000 words), excluding annexes. It should lead with a List of Contents (including pagination) and an Executive Summary of not more than four pages (single-spaced, about 1600 words)

Further, the evaluators will submit the following:

- (i) An Abstract of about 200 words covering the subject matter being evaluated, the purpose, approach and methodology of the evaluation, and the major findings of the evaluation;
- (ii) A four page (single spaced, about 1600 words) summary of the evaluation for publication in Sida's "Evaluation Newsletter", according to the enclosed Guidelines;
- (iii) A brief curriculum vitae of each evaluator, not exceeding 150 words per evaluator.

The final version of the single joint report shall be submitted, together with the above-mentioned Abstract, Evaluation Newsletter Summary, and the CVs, on paper and on disk in Word for Windows or WordPerfect for Windows or a compatible format. **All these should be presented in a form that enables publication without further editing.** Subject to decision by Sida, the report will be published and distributed as a publication within the Sida Evaluation Series.

The final responsibility for submitting the evaluation report according to the criteria and format mentioned above rests with the team leader, Dr Smail Khennas.

Sida Evaluations - 1998

- 98/25 Sustainable Dry Forest Management. Sida-supported collaborative research project between Burkina Faso and Sweden. Karin Gerhardt, Kerstin Jonsson, Eva Evers Rosander
Department for Natural Resources and the Environment
- 98/26 International Centre for Research in Agroforestry, ICRAF 1990-1997. Bo Tengnäs, Arne Eriksson, Terry Kantai, Alice Kaudia, Jeff Odera
Department for Natural Resources and the Environment
- 98/27 Cooperative Reform and Development Programme, CRDP in Uganda. Mick Moore, Lindah Mangali, Z Ojoo
Department for Natural Resources and the Environment
- 98/28 Water and Environmental Sanitation Programme, WES in Uganda. Clifford Wang, Eva Poluha, Jerker Thorvaldsson, Sam Mutono
Department for Natural Resources and the Environment
- 98/29 The Nordic Funded Rural Employment Sector Programme in Bangladesh. Claes Lindahl, Julie Catterson, Robert Andersen, Inge-Merete Hirshholmen, Shamima Nasrin, Petra Stark
Department for Natural Resources and the Environment
- 98/30 The Swedish Cooperative Centre's Environment Project in Sri Lanka. David Gibbon, Ananda A Kodituwakku, A Lecamwssam, S C Giriagama
Department for Natural Resources and the Environment
- 98/31 The Impact of the Sida Financed International Training Programme. A case study of the Philippines. Kim Forss, Lars Bjern, Benjamin Milano
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Department for Democracy and Social development
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Department for Africa
- 98/34 Support to Building an Institutional Capacity for Arbitration in Sri Lanka. Claes Lindahl, Gustaf Möller, Sundeep Waslekar
Department for Infrastructure and Economic Cooperation
- 98/35 Three Human Rights Organisations Based in Banjul, Africa. The African Commission on Human and peoples' Rights, The African Centre for Democracy and Human Rights Studies, The African Society of International and Comparative Law. Lennart Wohlgemuth, Jonas Ewald, Bill Yates
Department for Democracy and Social development
- 98/36 The Training of Journalists in Central and Eastern Europe. Tiina Meri, Börje Wallberg
Department for Central and Eastern Europe
- 98/37 Swedish NGO Foundation for Human Rights. Iain Cameron, Kristina Flodman, Anna-Karin Lindblom, Eva Åhlström
Department for Democracy and Social development
- 98/38 Swedish Support to University of Eduardo Mondlane in Mozambique. David Wield, Admir Bay, Silas Gustafsson, Penina Mlama
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