EIE-06-256 REEPRO

Intelligent Energy Europe

Promotion of the Efficient Use of Renewable Energies in Developing Countries

Publishable Report

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Content

Foreword

Renewable Energies are the Future

Dear Reader,

Many things are changing in this world. The global resources of fossil energy are diminishing at a rapid pace and consequently the price of energy is increasing. The only way out of this economical problem is the consistent usage of free energy found in our own area. The usage of solar energy in its direct form like photovoltaics and indirect forms like bioenergy and wind or water is one of the key motivations for a local sustainable energy supply.

The best news about using solar energy in all of its forms is that the value generation is undertaken locally and all that is required is local staff and experts to implement most of these projects. Knowledge about the technology and the experience in implementation is the key to the projects.

This set of training material developed within the REEPRO project aims to empower the users with the necessary knowledge to implement solar energy projects in all forms. Regardless of whether you use the training kits for self studies or educational purposes. The aim of the EU-financed REEPRO project is to fuel the local knowledge for a sustainable energy revolution.

Yours truly,

Dr. Jan Kai Dobelmann

Dipl. Ing. Antje Klauss-Vorreiter

Acknowledgments

The REEPRO team would like to thank the European Commission and all the sponsors and partners, who helped us to complete the REEPRO project successfully. To express our deep appreciation we designated one chapter of this report to presenting the partners and sponsors of the REEPRO project.

Partner Countries

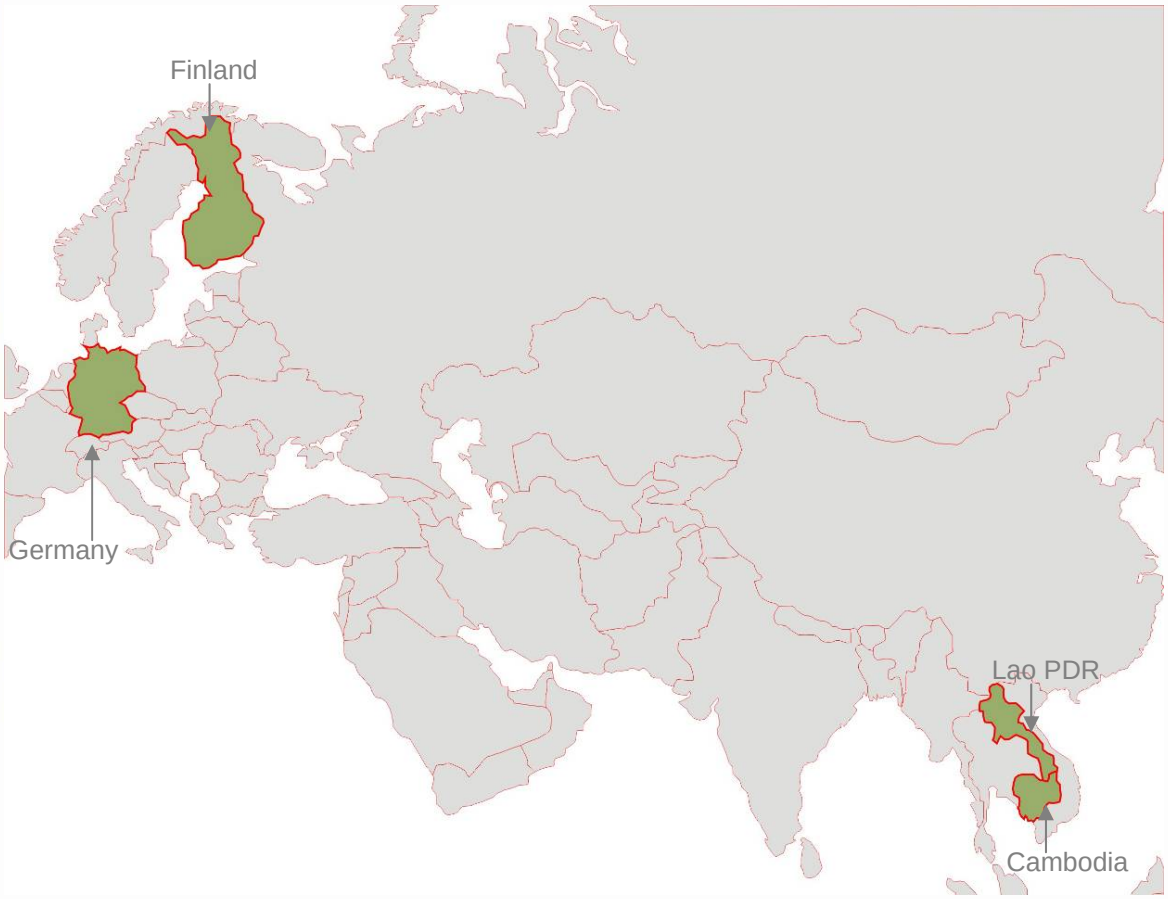

Figure 1: Location of partner countries

Figure 2: UNESCO World heritage Angkor Wat, Cambodia

Figure 3: Pratuxai (Arc de triumph), Vientiane, Lao PDR

Partner Remarks

Dr. Kai Dobelmann, DGS Vice-president and Head of the REEPRO project

The REEPRO project has been a great success story for renewable energy in Asia. During the course of the project the team was able to achieve a movement within the target countries. Due to the wide integration of stakeholders many similar actions and follow-up activities have been generated on the local level both by government actors and entrepreneurs.

Dipl. Ing. Antje Klauss-Vorreiter, DGS Vice-president and project manager of the REEPRO project

The REEPRO team consisted of great people, who became friends during the 3-year project. The joint development of the renewable energy training kits was an ambitious task, which the team implemented successfully. Within the REEPRO project the first renewable energy training material sets were developed and distributed in both countries. Those books, slides, handouts, videos and so on are a great basis for further training and educational activities and thus for the renewable electrifications in both countries.

Dr. Jyrki Luukkanen, Professor at Turku School of Economics, Finland Futures Research Centre

The involvement of the people in the project has been great. It has ensured the success of the project and has helped in reaching the targets. The wide variety of expertise and points of view have provided a basis for multiple and fruitful dis-cussions, which have helped in understanding the complex issues related to the development of renewable energy.

REEPRO demonstrated that modernisation and energy supply in developing countries can successfully build on and integrate Energy Efficiency and Renewable Energy policies and technologies, which were developed in the context of the decentralisation of the EU's energy infrastructure. At the same time REEPRO raised the awareness of the potential co-operation opportunities with EU SMEs in the renewable energy sectors.

Dr. Uwe Weber, Managing Director of EFEC

3 years of REEPRO project implementation has helped all stakeholders to know the importance not only of knowing how to install hardware but also the importance of operation and maintenance in order to run the equipment economically and sustainably. That which people have been trained and learned from the project, they will distribute directly and indirectly to many other people in their environment. I am sure the output and outcome of the project are more then we expected.

Dipl. Ing. Chau Kim Heng, Director of COMPEED

The REEPRO project has been a greatly success-ful renewable energy project in developing coun-tries. During the 3-year project, we were able to achieve training kits, training courses and REEPRO textbooks. More and more, ITC has set up solar equipment, LeXsolar, mini solar panels and solar hot water. This equipment is useful for ITC students to do their experiments and ITC will become the first Cambodia Research centre in the field of energy in the country.

Dr. Norith Phol, Deputy Director of ITC

REEPRO was among the first of such projects that have been conducted in Lao PDR. Local counterparts could learn how to prepare the training materials and how to transfer knowledge the local stakeholders. Obtained skills and experiences will serve as the basis for further promotion of renewable energy in our country.

Prof. Dr. Khamphone Nanthavong, NUOL

Mr. Khampha Keomanichanh, Vice-director of CDEA

The REEPRO project gave me a lot of experience that I can use for sustainable community devel-opment. The team consisted of great people that I will never forget the rest of my life. The time has passed, the project is over, my friends left, but the lessons learned from the REEPRO project will stay with the Lao people in rural areas and assist them in developing their livelyhood. Please keep in touch; do not forget CDEA.

Mr. Rithy Uch, COMPED Program Officer

The REEPRO project has introduced advanced knowledge in renewable energy into Cambodia and adapted it into applicable and appropriate options for various stakeholders from grass-root to high levels in the society.

The REEPRO team has been building up capacity dealing with renewable energy project manage-ment and implementation including social and international network set-up, finding the common goals and sharing for social, environmental and sustainable benefits of renewable energy to curb climate change.

Mr. Phok Chrin, Lecturer of Energy and Electrical Engineering Department, ITC

The REEPRO project provided the great opportunity for people in rural area to enjoy the benefits of using renewable energy and it's potential. Within the 3-year project we shared experiences on renewable energy and lessons learnt from the project, the REEPRO team developed training kits, textbooks, posters and booklets, which were implemented successfully. These great results will provide a sustainable programme for both Cambodia and Laos.

The REEPRO Project – Brief description

The "REEPRO - Promotion of the Efficient Use of Renewable Energy in Developing Countries" project was a co-operation project between three European, three Lao and two Cambodian partners headed by the German Solar Energy Association (DGS e.V.). The project received funding from the European Commission within the Intelligent Energy Europe COOPENER Programme. REEPRO was a three-year project, which started in January 2007 and lasted until December 2009. The European partners German Solar Energy Association DGS e.V., European Forum for Economic Co-operation and the Finland Futures Research Centre, Turku School of Economics advised the Asian partners Cambodian Education and Waste Management Organisation, Institute of Technology of Cambodia, National University of Laos, Lao Technology Research Institute and the Lao Community Development and Environment Association in developing and implementing the REEPRO training.

The REEPRO project was motivated by the fact that poor households in developing countries often lack access to basic energy services. The REEPRO approach is the provision of energy services to those currently unserved or underserved with higher quality energy services on the basis of an introduction of renewable energy and energy efficiency. Therefore, the REEPRO team developed an extensive training and information campaign, which was implemented in the REEPRO target countries Laos and Cambodia. The training courses target politicians, engineers, technicians and community stakeholders to overcome barriers for renewable energy sources (RES) utilisation. Typical problems are the lack of technological knowledge and awareness of RES financing options and models.

Background

Legal Framework in Laos

Since the early 1980s, the government of Lao PDR has embarked on a programme of legislative structure regulation in order to create an environment favourable to the promotion of socio-economic development. There is currently no legislation dealing specifically with renewable energy production. Nevertheless, the Electricity Law (1997) provides a solid basis to formulate specific legislation on renewable energy, especially under those laws dealing with Rural Electrification. In addition, the Power Sector Policy Statement emphasizes the use of local resources for small-scale hydropower, solar, wind, thermal, coal, biogas and biomass to produce energy in local and rural areas while supporting the development of rural livelihoods in remote areas.

With the "National Environmental Strategy for 2001-2020" the Lao government set among its objectives to strengthen environmental protection, to provide 90% of the country's households with electricity by 2020 and to promote the application of new renewable energy resources. The government established an off-grid programme intending to supply rural areas without road access, and designed grid extension electrification plans to supply urban and rural areas with road access. In the context of rural electrification, the government focuses on mini or micro-hydroelectric generating stations with a mini-grid connection to serve one or several villages located nearby and solar home systems for individual households or pico-hydro stations serving several households in unconnected clusters.

Within the scope of the second stakeholder dialogue "Biomass and Solar Energy Potential and Feasibility in Lao PDR" organised by DGS and CDEA as a part of the Asia Pro Eco Project "Diagnostic Study on Renewable Energy Potential and Feasibility in Southeast Asia", the clear statement of the participants (key persons from the government, NGO's, companies, farmers and international organisations) was that the main obstacle for a successful implementation of RE in Laos is the lack of education, training, awareness, and promotion campaigns.

Legal Framework in Cambodia

Currently the situation for many rural communities in Cambodia is characterised by energy poverty and stagnation. Energy prices in Cambodia are extremely high at between 0.50 to 1 US $ per kWh, far from an affordable reality for the rural poor. The development of energy services based on locally available renewable energy resources (RES) instead of expensive fossil fuels could lead to affordable energy prices.

The Renewable Electricity Action Plan (REAP) of the Cambodian Government provides the framework for supporting small-scale electricity generation by local communities. According to Cambodia's leading proponent from REAP, Dr. Sat Samy, Director of the Department of Energy and Technique in the Ministry of Industry, Mines and Energy, "Promoting renewable energy technologies to produce electricity can boost the rural electrification efforts to help us achieve the goal....[to] provide a safe reliable supply of electricity to 70 percent of the population by the year 2030." The REEPRO project supports the Cambodian government in achieving this aim.

Inefficient use of Fossil Fuels

Presently, out-dated diesel generators are the main electricity sources in rural areas in Laos and Cambodia. They are used to run battery charging stations (Figure 6), village grids or single applications such as rice mills (Figure 5). Those systems are inefficient and expensive. Diesel costs are constantly rising; in 2007, one litre of diesel cost 0.90 US$ and in July 2008 it had already reached 1.2 US$. Aside from the high price the high environmental damages (green house gas emissions, dust) from using diesel in inefficient generators is an enormous problem. The use of diesel generators to feed electrical village grids is very common in Cambodia. Rural Energy enterprises offer diesel-based electricity for a cost ranging from 0.50 US$ to 1.00 US$ per kWh. Many households cannot afford these high electricity prices.

Figure 4: Village grid generator for 250 households, Cambodia

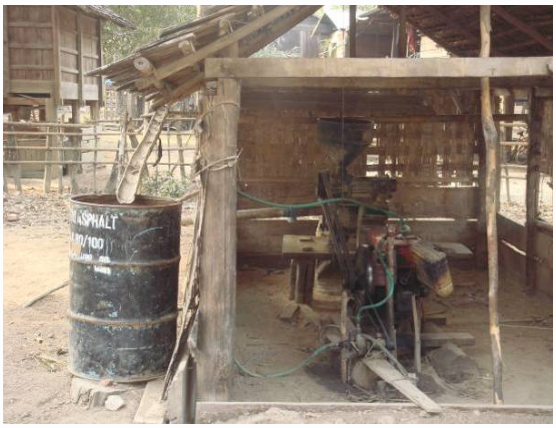

Figure 5: Rice mill generator, Laos

Car batteries are another common source of electricity. Batteries are charged at central battery charging stations, once again mainly operated with diesel generators. Figure 6 shows a battery charging station and its price list in Cambodia. The charging of one 120 Ah battery costs 2000 RIEL (0.50 US$). The charging stations are situated at central locations in the villages or districts inducing additional costs for the transport of the batteries from home to the charging station and vice versa. Hence, the average cost ranges between 0.50 to 1.50 US$ per charging. Typical batteries can operate lamps, CD-players, radios and TVs 3 hours a day for one week.

Renewable Energy – The solution for efficient rural electrification

One possibility for overcoming the energy deficits in the rural areas of Laos and Cambodia is the local use of renewable energy sources (RES). The use of locally available RES such as the sun and biomass can bring a multitude of benefits for the region. These include: independence from grid connection and imported fossil fuels, generation of new jobs in the energy sector, availability of clean energy, improvement of the quality of life and consequently a reduction of rural migration.

Figure 6:Battery charging station, Cambodia

Figure 7: Price list, Cambodia

The governments of both countries already recognised the potential of renewable energy and support its use as described above. However, the main obstacle for the sustainable implementation of renewable energy in Laos and Cambodia is the limited knowledge and awareness of all stakeholders ranging from engineers to villagers. Not only the rural population, but also technicians, engineers, and experts are unaware of the existing funding programmes and of the potential of RES, and all lack its economic understanding. They only see that the first investment in renewable energy (RE) technologies is often higher than in conventional, energy fossil technologies. Comparing the investment plus the operation costs to get a real feasibility picture is rarely considered. Another problem is the incorrect installation and the lack of maintenance for applied RE technologies. Solar home systems are very often completely or partly shaded, dirty or installed facing the wrong direction. Small-scale biogas plants are often operated ineffectively and are sometimes even out of order. Installers and users are not aware of the correct installation and operation. There is a lack of knowledge concerning the negative influences of shading, dust and of the incorrect installation on the efficiency of PV modules. Solar systems can suffer a great deal of power reduction if shaded. A solar system with a mere 10% of its module area covered by shading from leaves or other obstructions will suffer a power loss of up to 90%.

Objectives

The REEPRO project was motivated by the fact that poor households in Developing Countries often lack access to basic energy services. The REEPRO project should lead to the provision of energy services to those unserved or underserved by higher quality energy services based on the introduction of renewable energy and energy efficiency.

Therefore, the REEPRO team performed an extensive training and information campaign in the target countries Laos and Cambodia. These training courses targeted politicians, engineers, technicians and community stakeholders to overcome barriers to renewable energy sources (RES) utilisation. The problems are characterised by lack of technological knowledge and awareness of RES financing options and models.

Training kits including textbooks, teaching material and teaching descriptions were developed for Bio energy, Solar Thermal and Photovoltaic.

The local training kits are structured into 3 levels according the 3 target groups:

Level 1 – **Renewable energy experts** (RES)

Level 2 – **Technicians**

Level 3 – **Community stakeholders**.

Trainers of each level were trained and training courses for each level performed. The project team selected 7 communities in Cambodia and 5 in Laos for the implementation of the Level 2 and 3 training programmes. Those communities were encouraged to develop and implement RES showcases – pilot applications of renewable energy technologies. Figure 8 shows the distribution of the pilot sites in Cambodia.

Level 1

Covered the whole country. Thus Level 1 training courses were offered mainly in the capitals, for participants from all over Laos and Cambodia.

Level 2 and 3

Covered the selected pilot communities. Figure 8 shows the potential distribution of the pilot sites. The Cambodian project communities were Kampong Thom, Kampong Cham, Kandal, Preak Chrey, Svay Rieng, Takeo, the COMPED Training Centre and the ITC Campus. The Lao pilot communities were the Xay and the Hound district in Oudomxay, the Khammuane province, the Saravanh province and the NUOL Campus in Vientiane.

Figure 8: REEPRO showcase communities

Training

The training courses were structured according to the snowball effect as shown in Figure 9. To disseminate the project knowledge, local renewable energy experts including those from the local project partners were initially trained as Level 1 trainers. Afterwards, Level 1 trainers with the partners jointly developed the Level 2 training kit used to train the Level 2 technicians. Then the technicians and trainers with the partners developed the Level 3 training kit used to train the community stakeholders. Level 2 and 3 training courses were only offered in the REEPRO pilot communities and were accompanied by the development of electrification master plans for the respective communities and for the implementation of pilot applications.

Training courses were offered in Lao and Khmer languages for the following 3 levels:

- Level 1 – Renewable energy experts; trainers and multiplier (scientists, engineers, architects, etc.) with a higher education degree as well as local and national government representatives
- Level 2 – Technicians with a basic understanding of engineering subjects
- Level 3 – Community stakeholders often with a very basic education level

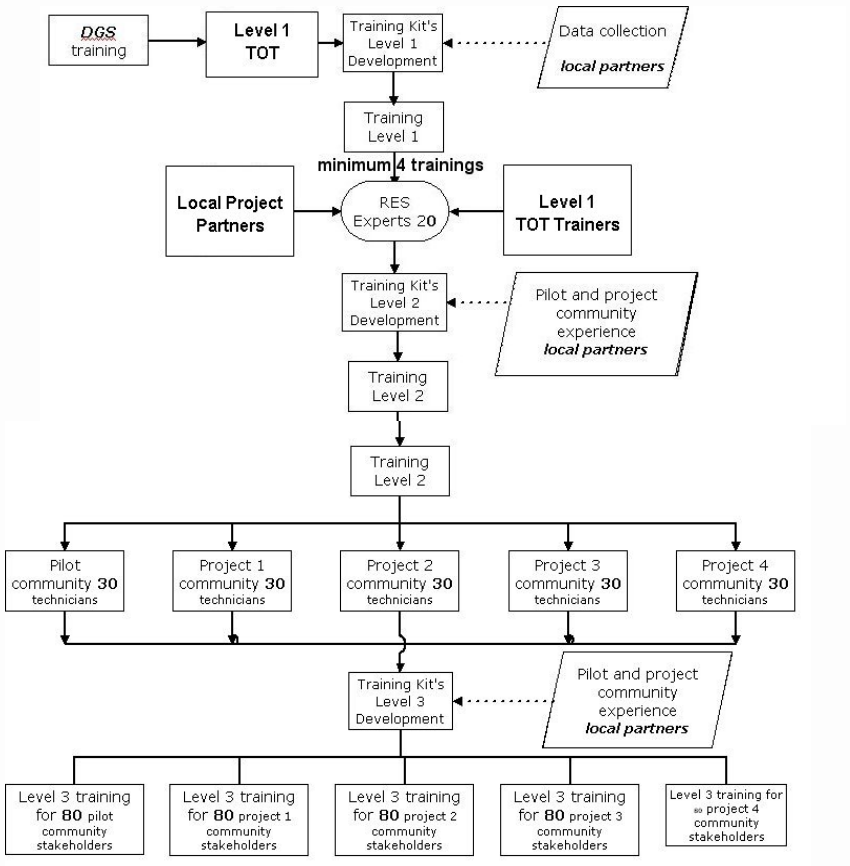

Figure 9:REEPRO project structure (RES-Renewable Energy Source)

Common subjects in the training kits were presented at those 3 levels -taking the knowledge and abilities of the respective target group into consideration. To guarantee this adaptation the target groups were involved in the training kit development level by level as shown below. This structure ensured the development of target group-oriented training kits, the training by local trainers and the dissemination of the project results following the end of the project.

Training Material

The REEPRO team developed training kits for each level, based on the existing DGS photovoltaic, solar thermal and bioenergy guidebooks, training material from the Asian partners and demand surveys performed in the first REEPRO project year. The different local framework conditions, such as educational competence, available and appropriate technologies, economic situation, available biomass, etc., were considered during the preparation of local training kits, especially for the generation of local chapters in training of economic skills. The Level 1 local training kits were developed in English and afterwards translated into Lao and Khmer; this procedure ensured transparency on the detailed content of the local versions' training kits.

Levels 2 and 3 of the training kits were developed in Lao and Khmer with only the final version being translated into English. All first versions of the training kits were further developed based on the experience during its application. The final versions of the training kits were prepared in the last semester of the project. Additionally, all versions of all 3 levels were published on CD.

Table 1:Media and material for the levels

Media	Material
Level 1 -Energy experts, multipliers	
• Lecturers • Workshops • Project work • Practical work & excursions	• Scientific textbooks • Slides with explanatory text for the trainers • Handouts • Videos, practical training equipment • Excel calculation tools for planning and dimensioning RE projects
Level 2 - Technicians	
• Practical work • Lecturers • Excursion	• Technical textbook/manuals with experiences/handouts • Videos • Practical training equipment
Level 3 - Community stakeholders	
• Stakeholder workshops • Coaching • Meetings • Consulting	• Handouts • Posters • Comics • Videos etc.

The training kits were developed based on the demand and abilities of the different levels.

Levels 1 and 2

The training kits are assembled in such a way so that energy experts or REEPRO Level 1 training participants can use the material to perform training by themselves. For example, all slides are accompanied by an explanatory text (show figures 10 and 11), which helps the new lecturers to present the content of the slides during training courses.

Slides with explanatory text for the trainers

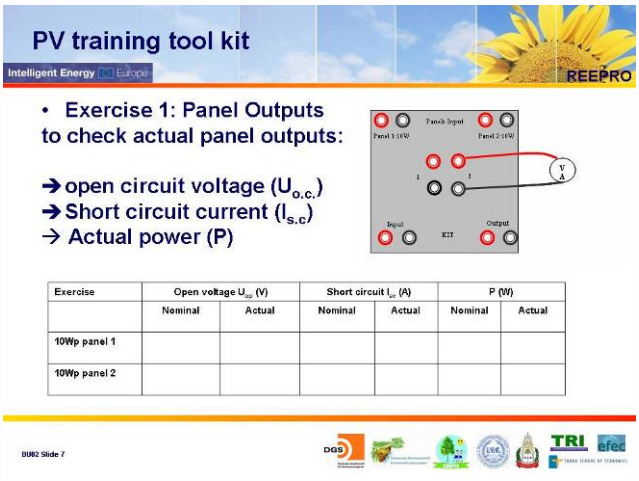

Figure 10: Slide of the practical work module

In this exercise, the trainees are to measure actual open-circuit voltage (V) and short-circuit current (A) of each single module (1 and 2), then to calculate the actual power, and to compare these measured figures with the nominal figures on the label of the module.

Figure 11: Explanatory text for this slide

Fact sheets

The fact sheets provide information on the size and content of the textbooks. Additionally they list the background information to be used for the textbook development. The approach is not “reinventing the wheel” but to use the available sources, to adapt and shorten text. The numbers of textbook pages and slides are reference values, which could be adjusted if agreed between the responsible partner for kit development and review.

Excel calculation tools

Excel calculation tools were developed for Level 1 training kits. They can be used to support the training courses with different exercises. These tools are available for the following lessons (show tables 2 and 3):

- Financial analysis
- Project development
- Entrepreneurship
- Tariff system calculation (optional)
- PV systems planning
- SHS sizing

REEPRO Manuals Level 1

Several books for the different levels were developed during the REEPRO project. The final REEPRO training kit set consists of 3 books in English, Lao and Khmer. The Level 1 training kit contains one solar energy, one biomass and one economics for renewable energy book.

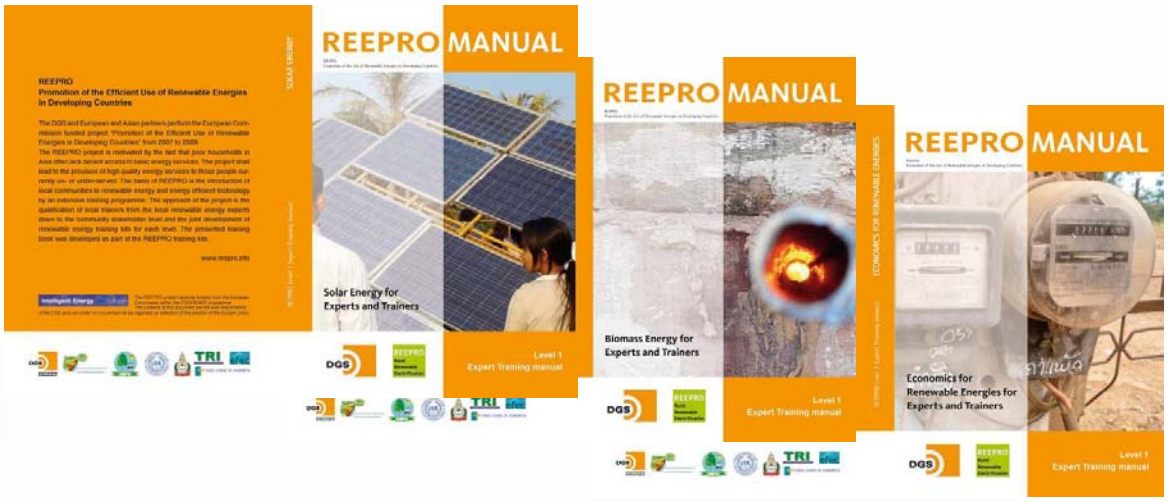

Figure 12: Cover of REEPRO Manuals Level 1

Each of the three books presents the REEPRO project with technical or economical basics and scientific chapters on the respective themes, solar energy, biomass energy and economics.

You can order the REEPRO training manuals using the order form under http://www.reepro.info/2454.0.html or by e-mail reepro@dgs.de. We can provide you the books free of charge but are required to collect a service fee of about 25 EUR.

Table 2: Content of REEPRO Manuals Level 1 for experts and trainers

Solar Energy Manual	Biomass Manual	Economics for REs Manual
Content of English books		
Introduction	Introduction	Introduction
Basics	Basics	Project Development
Power Transmission, Storage	Power Transmission, Storage	Entrepreneurship Development
PV	Biofuel	Performing Financial Analysis
Solar Thermal	Biogas	Business Management for Small Enterprise
Photovoltaic Laos	Gasification	Tariff System Calculation
Photovoltaic Cambodia	Practical Work Rocket Stove	Financing Tools in Cambodia
Practical Work PV Case LexSolar		Financing Tools in Laos
Practical Work Mini SHS		
Content of Khmer books		
Introduction	Introduction	Introduction
Basics	Basics	Project Development
Power Transmission, Storage	Power Transmission, Storage	Entrepreneurship Development
Photovoltaic	Biofuel	Financing Tools in Cambodia
Solar Thermal	Biogas	
Photovoltaic Cambodia	Gasification	
Practical Work Mini- SHS	Practical Work Rocket Stove	
Content of Lao books		
Introduction	Introduction	Introduction
Basics	Basics	Project Development
Power Transmission, Storage	Power Transmission, Storage	Financing Tools in Laos
Photovoltaik	Biofuel	
Solar Thermal	Biogas	
Photovoltaic Laos		
Practical Work PV Case LexSolar		
Practical Work Min- SHS		

REEPRO Manuals Level 2

Figure 13: Covers of REEPRO Manuals Level 2

For Level 2 the different subjects are assembled in one manual covering the subjects' photovoltaic, biogas, gasification (rockets stoves and small-scale gasifiers), improved cooking stoves and renewable energy entrepreneurship.

Table 3: Content of REEPRO Manuals Level 2

REEPRO Handbook English	REEPRO Handbook Lao	REEPRO Handbook Khmer
Content	**Content**	**Content**
Introduction	Photovoltaic	Photovoltaic
Basics	LeXsolar Experiments	LeXsolar Experiments
Power Transmission and Storage	Biogas	Biogas
Photovoltaic	Rocket Stove	Rocket Stove
LeXsolar Experiments	Improved Cooking Stove	Renewable Energy Entrepreneurship
Biogas	Renewable Energy Entrepreneurship	
Rocket Stove		
Rural Gasifier <5 kW		
Improved Cooking Stove		
Renewable Energy Entrepreneurship		

Level 3

For the Level 3 booklets, posters and videos on photovoltaic, biogas and rocket stoves were developed as handouts during the trainings. The main tools during the training courses were the portable and on-site renewable energy technology show cases described below.

Booklets

Figure 14: "Operation and Maintenance of SHS" in English, Khmer and Lao

Figure 15: “Rocket Stoves” explanation, construction and benefits, English

Poster

Figure 16: Benefits Rocket Stove, Khmer

Figure 17: Benefits PV, Lao

You can order the REEPRO slides, videos, booklets and posters by e-mail reepro@dgs.de.

Videos

During the showcase implementation the REEPRO team produced different videos to be used as training materials in the training courses for Level 3 but also in Level 2 and 1.

Figure 18: Rocket Stove Construction in English Part I

Figure 19: Module cable installation

Title	Links
Rocket Stove Construction, English Part I Rocket Stove Construction, English Part II	http://www.youtube.com/watch?v=pX0fmIqdh1s http://www.reepro.info/typo3temp/pics/59463709dc.jpg
Rocket Stove Construction Instruction, Lao	http://www.reepro.info/typo3temp/pics/5731385ab6.jpg
Training on Rocket Stove Production Level 2 and 3, English	http://www.youtube.com/watch?v=MkPg6G8c5Do
Installation of 2,4kWp PV Plant Part I Installation of 2,4kWp PV Plant Part II Installation of 2,4kWp PV Plant Part III Installation of 2,4kWp PV Plant Part IV	http://www.reepro.info/typo3temp/pics/9f04691501.jpg http://www.reepro.info/typo3temp/pics/4fbd617c40.jpg http://www.reepro.info/typo3temp/pics/9b76366ab3.jpg http://www.reepro.info/typo3temp/pics/e7b2775777.jpg
Installation of PV Panels on metal roof Part I Installation of PV Panels on metal roof Part II	http://www.youtube.com/watch?v=eE_7dxcYC-A http://www.youtube.com/watch?v=0Mch_7KF3y8
Explanation of Electrical Installation	http://www.reepro.info/typo3temp/pics/db667694c1.jpg
Roof Transport of PV Modules	http://www.reepro.info/typo3temp/pics/33b0db4bc2.jpg
Roof Mounting of Installation Holders	http://www.reepro.info/typo3temp/pics/205111eea3.jpg
Module Cable Installation	http://www.reepro.info/typo3temp/pics/af5dfcaf18.jpg
Grounding and Battery Installation	http://www.reepro.info/typo3temp/pics/64ee054dd3.jpg

All videos can be watched at http://www.reepro.info/2466.0.html.

Practical training equipment

Two different kinds of showcases were developed and implemented within the REEPRO project. Community showcases – static installations in the pilot and project communities and training showcases – installations and training equipment for practical training.

Community showcases (demonstration plants) using different technologies like biomass and wood gasification, biomass stoves and SHS were planned and installed as a part of the REEPRO project. The REEPRO team and the REEPRO level 1 and 2 trainers supported the pilot communities in developing renewable energy concepts to meet their needs. Twelve communities in Laos and Cambodia were supported to encourage existing or install new renewable energy plants (community showcases). For more information please see: www.reepro.info/2400.0.html.

Nine training showcases covering the subjects biogas, rocket stoves, solar thermal energy and photovoltaic were developed during the REEPRO project and used during the performed training courses.

Training Courses

Level 1 Train the trainer programme

The training started with two parallel 2-week train-the-trainer (TOT) seminars in January 2008 in Cambodia and Laos. 20 RES experts from each country participated in this seminar. Those 40 Level 1 trainers will be involved in the whole project, in the training of further trainers, the training material development and in the development and implementation of the community showcases. These persons will serve as the seeds for further development in their countries' sector. The REEPRO team offers frequent further seminars for these TOT participants.

Level 1 Expert training

For the Level 1 training schedules 2 one-week courses were developed. Every course contains 20 units á 90 minutes, thus 30 hours. The BIOMASS course contains 9 and the SOLAR course 8 different modules, which are listed below.

Additionally, one special 5-day entrepreneurship course was offered in co-operation with the Cambodian - Indian Entrepreneurship Training Centre in Phnom Phnom training course monitoring system

Training Documentation Template

The template was written for the trainers to have assistance with the documentation. The first one contained a summery for the documentation, a list of participants, photo documentation and the results of the questionnaire. This kind of documentation was very considerable thus the REEPRO team decided that future documentations should have a larger scope for more transparency and comparability.

The content of the second training documentation template was a summary sheet, short descriptions of workshop preparations, performance, discussions and documentation. The list of participants and some pictures of the progress remain part of the documentation while the training material used, such as presentations, had to be added.

The template was essential as a guidance for the trainers, who had difficulties with the documentation at the beginning. While the documentation was in progress, the template was a consistent document for the evaluation of the single training courses and the comparison of different events.

Table 4:Level 1 courses BIOMASS

ID	module name	Units
IN	Introduction	0.5
BA	Basics	0.5
PT	Power Transmission, Storage	1.0
BG	Biogas	3.0
BF	Biofuel	0.5
GA	Gasification	0.5
BU	Business (EN, FI, PD)*	4.0
CS	Project (Case Study)	2.0
EW	Excursion/Practical Work	8.0
	Total	**20.0**

Table 5:Level 1 courses SOLAR

ID	module name	Units
IN	Introduction	0.5
BA	Basics	0.5
PT	Power Transmission, Storage	1
PV	PV	3
ST	Solar Thermal	1
BU	Business(EN, FI, PD)*	4
CS	Project (Case Study)	2
EW	Excursion/Practical Work	8
	Total	20

*Entrepreneurship, financing, project development

The TOT participants offered around 8 training courses á 30 hours for 20-30 participants from April 2008 to June 2009. The targeted participants are public and private sector RES experts, officials and politicians from the target countries. The trainees are able to become Level 1 RES trainers or RES consultants.

Laos		
Description	**Location**	**Partici-pants**
Course 1 Hands-on PV and biomass training, 28.-29.04.2008	NUOL campus, Vientiane	20
Course 2 Photovoltaic, 23-27.06.2008	NUOL campus, Vientiane	21
Courses 3 and 4 Combined PV plus BM course, 12-18.01.2009	in co-operation with the vocational training centre at the NUOL campus, Vientiane	45
Total No. of Participants		**96**

Figure 20: Course 1, Acquaintance with manual instruction before starting the experiments

Figure 21: Course 2, Fourth and fifth year students of Mechanical Engineering department participating the training

Cambodia		
Description	**Location**	**Participants**
Course 1 Hands-on PV and biomass training, 25.-26.04.2008	COMPED Training centre	24
Course 2 PV installation, operation and maintenance, 21.-22.06.2008	Kampong Thom orphanage, the Cambodian REEPRO pilot site	26
Course 3 PV course, 5-9.01.2009	ITC campus	31
Course 4 Biomass training with SNV, 17-20.02.2009	COMPED Training centre	33
Total No. of participants		**114**

Figure 22: Course 2, Working on board of SHS

Figure 23: Course 4, Field visit to bio-digester model

The training courses were offered in Lao and Khmer.

Level 2 technician training

The Level 1 trainees from the TOT organised 15 Level 2 courses of 1 to 5 days for 15 to 45 technicians in the geographical areas of the pilot communities from September 2008 to December 2009. The trainees were able to become Level 2 and 3 trainers and to develop and implement RES projects in their communities. The training courses focused on specific subjects, such as:

- Photovoltaic
- Biogas
- Gasification
- Business management

Laos		
Description	**Location**	**Partici-pants**
Course 1 Workshop training on construction of a low-cost small gasifier, 11-14.11.2008	NUOL Campus, Vientiane	27
Courses 2 and 3 Solar photovoltaic, entrepreneur and biomass, 10.-12.03.2009	Oudomkham hotel, Xai district	22
Course 4 Training on renewable energy and biogas plants, 05.11.2009	Mai Village, Xai district	20
Course 5 Photovoltaic and entrepreneur training, 15.-16.05.2009	Forestry Control Office, Parnam village, Mahaxai district, Kham-muan province	15
Courses 6 and 7 Solar PV systems, rocket stove construction and pro-ject development, 21.-23.07.2009	EDL Saravanh Branch's meeting room. Saravanh district	20
Course 8 Low-cost gasifier development, 08.07.2009	Mechanical meeting room,Faculty of Engineering, NUOL, Sokpaluang campus, Vientiane	11
Total No. of Participants		**104**

Figure 24: Course1, Groups' work: mud preparation

Figure 25: Course 5, There were 15 participants attending the training, they were village electricians

Cambodia		
Description	**Location**	**Participants**
Course 1 Introduction to biogas plants construction, operation and maintenance, 29.30.09.2009	Provincial Department of Agriculture, Svay Rieng province	27
Course 2 Introduction to biogas plants construction, operation and maintenance, 01.-02.10.2009	Provincial Department of Agriculture, Kampong Speu province	20
Courses 4 Introduction to photovoltaic, practical work and basic concept of entrepreneurship, 07.05.2009	Kampong Thom Orphanage, Student room	33
Course 5 Introduction to biogas plants construction, operation and maintenance, 07.-08.09.2009	COMPED Training Centre, Choeung Ek, Phnom Penh	34
Course 6 Refreshment course on biogas from biodigester for biodigester construction companies with the integration of entrepreneurship, 03.07.2009	COMPED Training Centre, Choeung Ek, Phnom Penh	21
Course 7 Introduction to biogas plants construction, operation and maintenance, 10.-11.09.2009	COMPED Training Centre, Choeung Ek, Phnom Penh	28
Total No. of Participants		**163**

Figure 26: Course 7, Practiced with standard plan measurement to the demo biogas plant

Figure 27: Course 4, Test output of produced electricity

The Level 2 training courses had a strong focus on practical work and excursions.

Level 3

Laos		
Description	**Location**	**Participants**
Course 1 Introduction to renewable energy, 15.-22.03.2009	Phoutoom village, Phose Zone, Houn District	33
Course 2 Introduction to renewable energy, 16.03.2009	Khongmuang village, Houn district	40
Course 3 Introduction to renewable energy, 17.03.2009	Tanglon village, Houn district	39
Course 4 Introduction to renewable energy, 18.03.2009	Phouse village, Houn District	36
Course 5 Introduction to renewable energy, 19.03.2009	Nampak village, Houn district	42
Course 6 Introduction to renewable energy, 20.03.2009	Phoukhoi village, Houn district	31
Course 7 Introduction to renewable energy, 21.03.2009	Tangya village, Houn district	42
Course 8 Introduction to renewable energy, 22.03.2009	Longkhou village, Houn district	32
Course 9 Introduction to renewable energy, biogas plants, 6.-14.11.2009	Mai Village, Xai district, Oudom-xay Province	20
Course 10 Introduction to renewable energy, 17.05.2009	Phoxai village, Mahaxai district, Khammuan provincet	42
Courses 11 Solar PV systems	Nakhok village, Saravan District,	22
Courses 12 Rocket stove construction	Nakhok village, Saravan District,	22
Total No. of participants		**401**

Figure 28: Course 5, Participants were very interested to see how wonder energy could use, and its benefit

Figure 29: Course 8, Participant had really interested making of brick for constructing the rocket stove

Cambodia		
Description	**Location**	**No. of Partici-pants**
Course 1: Training on solar home system installation, operation and maintenance, 19.09.2008	Kampong Thom Orphanage	33
Course 2: Introduction to renewable energy and biogas to rural people living along the Vietnam Cambodia border, 08.02.2009	Prek Chrey village, Kandal Province	37
Course 3: Introduction and benefit of biogas plants, operation and maintenance, 15.07.2009	Chan Trea District, Chres Com-mune, Svay Rieng province	16
Course 4: Introduction to PV, operation and mainte-nance, 03.08.2009	Salar Nº5, Kampong Chhnang district, Kampong Chhnang Province	20
Course 5: Training on photovoltaic, 06.05.2009	Kampong Thom Orphanage	22
Course 6: Introduction to the energy crisis in the world and higher demand of energy for subsistence as well as benefit of the biodigester and achievement of NBP, 05.05.2009	Kampong Thom Orphanage	45
Course 7: Introduction to PV, operation and mainte-nance, 03.08.2009	Kor Village, Kampong Chhnang district, Kampong Chhnang province	21
Course 8: Introduction and benefit of biogas plants, operation and maintenance, 16.07.2009	Svay Rompear Commune, Svay Teap district, Svay Rieng province	53
Course 9: Introduction to PV, operation and mainte-nance, 14.09.2009	Thmor Et Commune, Kampong Chhnang province	14
Course 10: Introduction and benefit of biogas plants, operation and maintenance, 17.07.2009	Laberk Commune, Romeas Hek district, Svay Rieng prov-ince	40
Course 11: Introduction to solar energy with PV tool kit., 22.06.2009	Royal University of Agriculture	43
Course 12: Introduction and benefit of biogas plants, operation and maintenance, 28.07.2009	Prey Kabaskor Village, Prey Kabas district, Takeo province	33
Course 13: Introduction and benefit of biogas plants, operation and maintenance	Prey Prom Village, Prey Kabas district, Takeo province, 29.09.2009	37
Total No. of Participants		**407**

The Level 3 training courses targeted the rural community stakeholders and thus provided very basic information. Most of the training courses were performed with local partners, which facilitated the planning of the trainings.

The reports for all of the training courses are available under: http://www.reepro.info/2498.0.html

Training monitoring system

In order to achieve efficient documentation the REEPRO team developed a training monitoring system. This includes the preparation tools for the planning, performance, documentation and evaluation of REEPRO trainings. During the project progress the REEPRO team developed an event checklist, an evaluation questionnaire and a template for the training documentation. All three were helpful tools for organisers, trainers and REEPRO project leaders.

Event Checklist

For better organisation and function of training courses the REEPRO team developed a check-list. This list contains the fundamental points that are important for the training progress.

The list is structured as follows:

1. Before an event

This point contains the selection of the date of the event, the invitation of the consultant, the schedule, press releases, preparation of distribution materials, lists of participants, accommodations etc.

2. During the event

The second point should remind the trainer of tasks for a correct documentation of the training. Amongst others it contains the point to check the completeness of the list of participants and to take notes on discussions and questions.

3. After the event

The third point includes the refurbishment and documentation of the training and a look forward to the next training course.

Evaluation Questionnaire

At the 4th project meeting in September 2008 the team decided to develop a questionnaire to evaluate trainings. The objective of the questionnaire is the ongoing improvement of the training courses.

Questions 1 to 5 ask general information about the person such as sex, age and education. Questions 6 to 14 ask about the relevance for their work, the practical and theoretical involvement, a self estimation of learned lessons and future application. Furthermore questions on the quality of training materials and which other topics the participants had wished for the training complete the questionnaire.

With the collected feedback the training approach shifted from theoretical to more practical work. For Level 3 training courses the team decided to carry out a question period at the end of each training, since reading and filling out questionnaires is not an appropriate task for the rural people.

The figure below shows an example for the evaluation of questionnaires distributed at Level 2 course 1, Training on biomass September 29th - 30th, 2009 in Svai Rieng.

Figure 30: Expectations

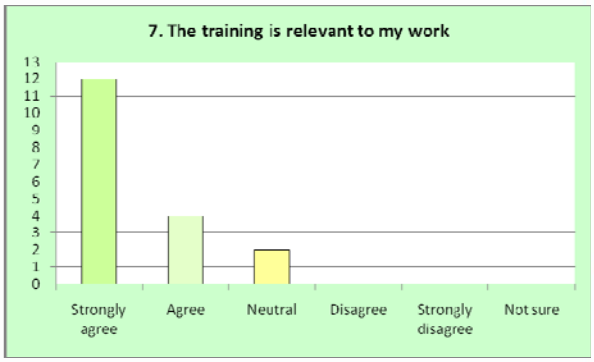

Figure 31: Relevancy for work

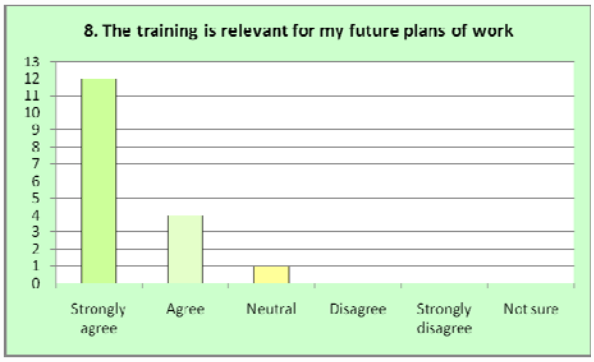

Figure 32: Relevancy for future work

Figure 33: Practical training

Community Showcases

Within the REEPRO project it was planned to build and operate community showcases with different thematic areas like biomass and wood gasification, biomass stoves, solar home systems, solar hot water systems, solar cookers and others. The intention was to establish – within the overall framework of community training – live showcases, which are the results of practical training activities. They in turn complement the theoretical lessons within the community and technician training courses, which further enables project replication.

Thus two different kinds of showcases were developed and implemented within the REEPRO project. Community showcases – static installations in the pilot and project communities and training showcases – installations and training equipment for practical training.

On-site community showcases

Community showcases with different thematic areas like biomass and wood gasification, biomass stoves and SHS were planned and installed within the REEPRO project. The REEPRO team and the REEPRO Level 1 and 2 trainers supported the pilot communities in developing renewable energy concepts for their demand.

The following communities were encouraged to implement or to install renewable energy systems (community showcases):

REEPRO communities in Laos

- Xay district – Implementation of 4 family biodigesters
- Hound district – Encouragement to use SHS
- Ban Man – Encouragement to use SHS
- Saravanh province – Encouragement to use SHS
- NUOL Campus, Vientiane – Implementation of a SHS and a wood / gas gasifier

For more information please visit the REEPRO webpage: www.reepro.info/2387.0.html

REEPRO communities in Cambodia

- Orphanage - Implementation of a SHS
- Kampong Chhnang – Encouragement to operate a solar battery charging station
- Preak Chrey – Development of concepts for the implementation of SHS
- Svay Rieng province – Encouragement to implement and operate family biodigesters within the framework of the National Biodigester Programme
- COMPED Training Centre - Implementation of a SHS and family biodigester
- Takeo province – Encouragement to implement and operate family biodigesters within the framework of the National Biodigester Programme
- ITC Campus - Implementation of a SHS and a solar water heating system

For more information please visit the REEPRO webpage: www.reepro.info/2400.0.html. Here you can find detailed information and fact sheets for each showcase. The two pilot showcases will be exemplified in the report below.

Pilot showcase Xay district, Laos

Type of Equipment: (check the type)	PV		Solar Thermal		Biomass to Energy
					✓
Name:	**Biogas Plants in Xay District, Oudomxay Province**				
Location of the equipment:	Mai village, Xay district, Oudomxay province				
Year of purchase:	2009				
Operator: (Name and address)	CEDEA office in Xay district, Oudomxay province, Bane Thinh: group number 9, house number: 155				
Planner: (Name and address)	CDEA office, Bane Phoxay, group number 11, house number 171 P.O.Box: 3413 Vientiane Capital. Tel / Fax: (865) 21 415105; Mobile (856) 20 2222187				
Detailed description of the installation:	8 biodigesters with a digester volume of 4 m³ each The biogas model constructed in Lao PDR was adapted from German and Chinese technology and is comparable to the Indian Deenbandhu and Nepalese model. The components of a domestic Biogas system include the six main parts of the biodigester: (1) Inlet (mixing chamber) for a cattle-dung-fed plant and maturation pond for swine manure (2) Digester (digestion chamber) (3) Gas holder (storage chamber) (4) Outlet (displacement chamber) (5) Gas conveyance system (6) Slurry compost pit(s). [Bajgain 1994] The digester is made out of bricks and cement, the tubings are made out of PVC tubes. Each digester is equipped with one burner.				
Generated Energy service: (check the energy type)	electricity	heat	gas	light	
			✓	✓	
Power output of installation: (kWel, m³ biogas, kW th, etc.)	Total number of biogas plants: 8. 4m³; every day each digester is fed with about 20kg cow dung and produces 1-2 m³ biogas, which can be be used about 2-3 hours. => 8 to 16 m³ biogas/day or 2920 to 5840m³ biogas/year				
Financing* (check the financing type)	private investment	loan	donation	grant	
				✓	
Investment costs in US$*	2,498,500 LAK (216.90 EUR) per plant				
Maintenance costs in US$*					
Savings US$ per month	USD 7.35 within 2 years therefore establishing community development funds in the village.				
Energy sale income in US$*					

Pictures

Figure 34: Meeting with villagers during the family selection

Figure 34: Training on biogas plant building and maintenance

Figure 35:Site selection

Figure 36: Biogas plant building

Pilot showcase Kampong Thom, Cambodia

The REEPRO team selected the Kampong Thom Orphanage as a REEPRO pilot community based on the project side survey.

The Kampong Thom Orphanage Centre was chosen as the first community showcase and obtained several solar home systems to generate electricity. The orphanage is located in Kampong Thom provincial town along the national road 6 only 2 km from the provincial town. Kampong Thom is 170 km away from Phnom Penh. The centre is connected to the provincial electricity grid which provides electricity for the consumption of the whole centre, but unfortunately this electricity grid is not stable and unreliable. The centre frequently faces power outages during in the evening when the students need light for their evening class. Another problem the orphanage has to face is the high price for electricity, which is 0.7 USD/kWh and expected to rise to 0.75 USD/kWh.

The orphanage was presented to the REEPRO team by the German-speaking catholic community St. Elisabeth in Singapore, which has been supporting the orphanage for a long time. In December 2007 a joint workshop between the REEPRO team and the representatives of the orphanage and the German-speaking catholic community St. Elisabeth was performed to discuss the joint activities in Kampong Thom.

Type of equipment:	PV	Solar Thermal	Biomass to Energy		
	✓				
Name:	**4 Solar Home Systems at Kampong Thom Orphanage**				
Location of the equipment:	Kampong Thom provincial town, Ackarleak commune, Stung Sen district, Kampong Thom province				
Year of purchase:	2008				
Operator:	Director Sean Cheah, Kampong Thom Orphanage				
Planner:	ITC, Pochentong Blvd, Toul kok district, Phnom Penh COMPED, Dangkor district, Phnom Penh				
Detailed description of the installation:	At the Kampong Thom Orphanage Centre 4 Solar Home Systems (SHS) were constructed in June 2008. One solar generator had a peak power of 0.7 kWp and can produce up to 2,000 Wh on a daily average. Each of the SHS consist of 4 Sharp 24V 175Wp solar panels, 1 Victron inverter C 24/1200, 12 batteries OPzV 420Ah/2V, 1 charge controller Phocos CX40 12/24V, cables etc. Solar modules are very important to support the training courses level 1 to 3 carried out at the Orphanage. They are used for practical training on installation, operation and maintenance. Aside from this the 4 SHS serve different houses at the orphanage and provide electricity for light in the evening hours, e.g. for evening classes, or to run televisions and fans.				
Generated energy service:	electricity	heat	gas	light	
	✓				
Power output of installation: (kWel, m³ biogas, kW th, etc.)	on average 53 kWh per system and month 4x53kWHh = 212 kWh				
Financing	private investment	loan	donation	grant	
			✓		
Investment costs in US$*	42.850				
Maintenance costs in US$*	600 USD				
Savings US$ per month	140 USD per month				
Energy sale income in US$*	0.00				
Comments	The system does not reach the estimated 66 kWh per system and month during first 8 months of operation. The performance will be evaluated and improved. For the first 8 months, only system number 4 (House 10 and 11) reached 66kWh for one month (October 2008). In July, Dr. Kai and Dr. Matthias came to check the performance of the system. It could be due to the limitations of Mr. Chea for using the PV system. He does not allow the children to use much more energy during the day time. We had already informed him of using solar energy. According to Mr. Ramin, the PV system currently yields an averaged energy output of around 56kWh per month				

Pictures

Figure 37: Installation on the office roof

Figure 38: Installation of inverter and charge controller

Figure 39: Moved panel from its first position to a shadow-free location

Figure 40: Batteries inside box and solar board above

Show case Hound district, Lao PDR

Solar energy is available in Hound District where solar home systems were installed previously, but not by CDEA. It was found that most of the households were not maintaining the equipment properly, and thus not using the available solar energy to its full potential. In this regard, the idea of renewable energies was not completely new to local villagers. However, it was decided that training would help expand and improve the use of renewable energies in these areas.

CDEA provided training in 8 villages. The exact number of households with existing solar home systems is unknown. A total of 295 participants attended the 8 training sessions, where each was conducted in a separate village.

Target villages in Hound District were chosen by REEPRO for training to improve upon the existing renewable energy infrastructure.

Type of equipment:	PV		Solar Thermal		Biomass to Energy
	✓				✓
Name:	**Installation of Photo Voltage (PV) System Unit for Khongmuang Health Post, Phousea zone, Hound District – Oudomxay Province**				
Location of the equipment:	Various villages, Hound district, Oudomxay province				
Year of purchase:	2009				
Operator:	Villagers in the Hound district				
Planner:	CDEA office, Bane phoxay, group number 11, house number 171 P.O.Box: 3413 Vientiane Capital. Tel / Fax: (865) 21 415105; Mobile (856) 20 2222187				
Detailed description of the installation:	Antje Klauß-Vorreiter: CDEA provided training for households in the Hound district to promote renewable energy activities. Specifically, two technologies were promoted in the training sessions which were the maintenance of PV equipment and the local production of rocket stoves. 275 solar home systems were installed previously by various other NGOs. However, it was found that the equipment was not maintained properly to make full use of the available solar potential. CDEA explained how a solar PV panel works, how much energy could be produced in a given day and the proper maintenance practices to achieve this including the upkeep of system, batteries and solar panels. Further, CDEA explained the benefits of using a rocket stove and the types of fuel that can be used in it. In addition, the REEPRO team supported the Phousea zone, one of the 10 villages in the Hound district, to develop an electrification concept for their post health centre. It was planned to equip the centre with a 100 Wp solar home system for lighting and a 150 SHS for the operation of a solar fridge for vaccine cooling. A detailed design was prepared but the installation has not yet been implemented.				
Generated energy service:	electricity	heat	gas	light	training
	✓				✓
Power output of installation: (kWel, m³ biogas, kW th, etc.)	Encouraged PV installations: 8110 Wp, 84 x 50Wp, 9 x 30Wp and 182 x 20 Wp Power Output of those systems: Before the training: about 8,000 kWh After the training: about 10,500 kWh Increase: about 2,500 kWh				
Financing	private investment	loan	donation	grant	
			✓		
Savings US$ per month	Exact value not calculated. Saving from fire wood: 10m3/year /family x 12$/m3 = 120$/year or 10$/month /family or 80$/8h/h Saving from time instead of collection fire wood in a year: 50 days collection fire wood in a year x 4$ as labor cost/day = 200$/year or 16.67$/month/family.				
Comments	CDEA's involvement was for the sole purpose of training. No hardware was installed. But the performance of the existing systems could be increased by training the villagers in operation and maintenance.				

Pictures

Figure 41: " Takein" used mostly at night

Figure 42: Rice mill engine used for sawing, lighting and entertaining

Figure 43: SHS in Phousea

Showcase Saravanah province, Lao PDR

The REEPRO team contacted department of energy and mines for selection of the right location for promotion of rocket stoves production and use. The Nakhong villages' group, which is located about 6 km from the Saravanh provicial centre. The main occupation and also the main source of income is brick production. The village is located in the buffer zone between the city and the rural area, and is facing some shortage in wood supply, because a lot of wood is used for bricks burning. Thus the village was chosen as appropriate site for promoting use and production of efficient stoves, such rocket stoves.

Saravane is a Centre of Southern provinces and still among the poor provinces of Lao PDR. Province is facing problems in achieving 90% electrification rate and poverty eradication by 2020, as planned by GoL. Rocket stoves were chosen for promotion in the target area because of its simple construction but rather high efficiency (up to 33%). In Lao PDR there is still high share of wooden fuel use in domestic energy balance. The rocket stoves were proved for use in many developing countries in Africa.

Type of equipment:	PV	Solar Thermal	Biomass to Energy		
			✓		
Name:	**Multi-purpose Brick Mold for Rocket Stoves Production**				
Location of the equipment:	Ban Nakhong village, Meangg Saravanh, Saravanh province. Lao PDR				
Year of purchase:	July 2009				
Operator:	Mr. Khamlae Chanthaboune, Chairman of Village group Nakhong. Saravanh District, Saravanh province. Lao PDR				
Planner:	Thongxay Bounthisavath, Deputy Director. Department of Energy and Mines, Saravanh province.				
Detailed description of the installation:	Two sets of brick moulds (one metallic and another wooden) were given to the village group for promoting the production of rocket stoves in this area. The multi-purpose mould was designed and fabricated by a group of students of ME/FE/NUOL. The mould is used for making bricks of different shapes and sizes, and therefore can help production of different modification of rocket stoves. The mould is characterised by simplicity and flexibility in use. Besides, the mould can also be reproduced by anyone who is willing to deal with rocket stove making, out of either metal or wooden materials.				
Generated energy service:	electricity	heat	gas	light	
		✓			
Financing:	private investment	loan	donation	grant	
			✓		
Investment costs in US$*	30 US$ for a metallic mould and 10 US$ for a wooden one				
Maintenance costs in US$*	None				

Pictures

Figure 44: Rectangular-trapezium brick

Figure 45: Villagers learning how to use the mould

Figure 46: Level 1 trainer introducing brick mold to levels 2-3 trainees

Figure 47: Level 2 trainer showing villagers (Level 3) how to assemble the rocket stove

Showcase Nuol Campus, Lao PDR

Faculty of Engineering's Sokpaluang campus is located in the Sisattanak inside of Vientiane capital. FE is among the largest faculties of NUOL with total number of students around 6500 (2008-09 academic year). The Mechanical engineering department is one of 7 departments of FE, the only where offered most components of renewable energy technologies. The department's laboratories are not up to date and lacking of research and training facility on renewable energy.

FE/NUOL is the most important engineering EDUCATION provider in Lao PDR and will establish energy study program in near future. Furthermore FE is in process of formulating of RE research and development Centre. Staffs and students are encouraged to carry out more research activities.

Type of equipment:	PV	Solar Thermal	Biomass to Energy		
	✓				
Name:	**REEPRO-DGS SolarSchool**				
Location of the equipment:	ICI training centre				
Year of purchase:	2009				
Operator:	Solar Energy Laboratory, Mechanical Engineering Department, Faculty of Engineering (NUOL). Sokpluang campus. Watnak. Vientiane capital, Lao PDR				
Planner:	Dr Khamphone Nanthavong, Mechanical Engineering Department, Faculty of Engineering (NUOL). Sokpluang campus. Watnak. Vientiane capital, Lao PDR				
Detailed description of the installation:	The following different renewable energy applications are installed at the REEPRO SolarSchool 1) Solar home system: 1x55Wp panel (contributed by Mechanical Engineering, Faculty of Engineering, NUOL), 1xPhocos charge controller, 1x300W inverter; 1x33Ah deep cycle battery and SHS accessories (socket, saving lamp); support structure and wiring are contributions of the ME/FE and ICI project. 2) 4x10Wp solar panels with control box (the box costs 120 US$, and was donated by Sunlabob Rural energy system Co.LTD). With this set students or any trainees can perform different exercises on solar panel characteristics studies, panel connections and studies on PV systems 3) Rural gasifier: REEPRO trainees level 1 participated in the construction of low-cost gasifiers by using locally-available, cheap construction materials. Some trainees from level 1 and ME students joined the experience workshop on modification of low-cost gasifiers. Now the study on construction of the low-cost gasifier is still going on with funding from the ICI project for sustainable energy futures between Finland Future Research centre (Turku School of Economics, Finland) and the Faculty of Engineering (NUOL). The low-cost gasifier will be a benefit for rural electrification in remote areas where quick growing trees or agriculture residues are available. In addition, it can also supply thermal energy to small rural food processing or cottage industries, where wood is still the main source of energy. 4) Rocket stove workshop: the rocket stove mould was modified by ME students. The new mould can be used for making different sizes and shapes of bricks for rocket stoves. It can also be easily reproduced and used, even by unskilled people, and therefore quickly helps distributing efficient stoves to more and more people in the country.				
Generated energy service:	electricity	heat	gas	light	
	✓			✓	

Power output of installation: (kWel, m³ biogas, kW th, etc.)	1) 55Wp SHS Average Panel generation factor in VTE is 4.7*75%=3.54 Wh/Wp. The annual electric energy produced by this system will be 3.54Wh/Wp *55Wp*365 days/year ~ 72 kWh/year 2) 40 Wp SHS: annual electricity production: 52 kWh/year 3) 5kW Rural gasifier: under development 4) The rocket stove's efficiency is around 33% compared to 11% of a three-stone stove. The average wood consumption in rural households in Laos is around 1 m3/person/year for three-stone stoves. If they used rocket stoves, they would save 2/3 (or 0.66 m3/ person/year) of consumed wood annually. This means significantly lightening labour of women and children. 1 m3 of wood costs around 100,000-150,000 LAK (12-18 US$) depending on location and season			
Financing:	private investment	loan	donation	grant
			✓	✓
Investment costs in US$	~ 350 US$ 1) 55Wp SHS: 275$ (panel) + 45($) battery+ 60$(inverter) + 40 $(controller) + 30 accessories + 30$ (support structure)= 480 $ 2) 40 Wp SHS: 310 US$ (4x10Wp panels) + 85 (controller box including box, controller and 33 Ah deep cycle battery) + 50$ (accessories and structure) = 445$ 4) Rocket stove workshop (30$ for a wooden mould and 45$ for a metallic one			
Maintenance costs in US$*	2 US$/year for SHS (maintenance free deep cycle battery)			
Comments	These systems are used as a demonstration of solar PV systems within the training centre only. The generated energy has not yet been utilised.			

Pictures

Figure 48: Panel's installation and wiring

Showcase Kampong Chhnang province, Cambodia

In cooperation with LOCAB, Salar No5 village is selected as a project community for PV battery charging station, which is located in Kampong Chhnang city. There are around 100 households living scatter in the area. It is one of the 5 stations supported by on the UNDP programme for charging batteries using PV systems in Kampong Chhnang province.

Type of equipment:	PV	Solar Thermal	Biomass to Energy		
	✓				
Name:	Salar Nº5				
Location of the equipment:	Salar Nº5, Kampong Chhnang Province				
Year of purchase:	2009				
Operator:	LOCAB (Local Capacity Building) Salar Nº5, Kampong Chhnang Province				
Planner:	LOCAB #A1, next to western fence of University of Letters and Human Sciences, Phnom Penh				
Detailed description of the installation:	For the solar battery charging station in Kampong Chhnang, the electricity will be produced by two 24V batteries. The combination of PV panels is series for 24V and then parallel to the series to fit with the batteries with the monitoring of charge controller. Power meter is also installed. The diesel genset is set to run temporarily during the time, for instance, when there is not enough energy from the PV or during peak loads. Solar modules are very important to support training courses for Level 2 and 3 done at the station. They're used for practical training on installation, operation and maintenance for the operators and students. In addition, it should provide some background knowledge on the benefit of charging batteries from solar energy for the community level.				
Generated energy service:	electricity	heat	gas	light	
	✓				
Power output of installation: (kWel, m³ biogas, kW th, etc.)	48Ah; 24V				
Financing:	private investment	loan	donation	grant	
				✓	
Investment costs in US$*	USD 8,900				
Maintenance costs in US$*	USD 50-100/month				
Savings US$ per month	USD 75				
Energy sale income in US$*	USD 5/day				
Comments	The standing pole should be strong enough against the wind and also should not have trees nearby and be cleaned at regular intervals.				

Pictures

Figure 49: PV Panel

Figure 50: Charge controller

Figure 51: Charge controller and Batteries

Figure 52: Batteries charging

Showcase Prek Chrey, Cambodia

The REEPRO team visited three areas in Prek Chrey to look for the pilot community and project community for the REEPRO project. Relevant data on the battery charging station were collected for the feasibility study of using Solar PV for charging the batteries. The health centre is located about 1 km from the charging station. The study was done by ITC for the capacity needed.

In Khnar Taing Yu Village, there is a charging battery station which uses small generator of capacity of 5.5 kW. This small Genset is operates almost everyday for charging battery with 10 hours a day. This station is located Kandal Province along the Bassac River nearby Cambodia-Vietnam border. The road is in good condition from Phnom Penh to Check point and about 3km by board from the check point. The centre is in the remote area there is no electricity grid for providing the consumption of the population who live in that area. In the centre, they use small generator for light or charging battery which very difficult to keep the medical in cool condition.

Health Centre (in Khmer, Mondul Sokhakpheab) is located Kandal Province along the Bassac River nearby Cambodia-Vietnam border. The road is in good condition from Phnom Penh to Check point and about 3km by board from the check point. The centre is in the remote area there is no electricity grid for providing the consumption of the population who live in that area. In the centre, they use small generator for light or charging battery which very difficult to keep the medical in cool condition.

Prek Chrey primary/secondary school is located in Kandal Province along the Bassac River nearby Cambodia-Vietnam border. The road is in good condition from Phnom Penh to Check point and about 3km by board from the check point. The centre is in the remote area, there is no electricity grid for providing the consumption of the population who live in that area. In school, there is no electricity for lighting or using. They use small generator for light or charging battery which very difficult to keep the medical in cool condition.

Type of equipment:	PV	Solar Thermal	Biomass to Energy		
	✓				
Name:	**Interethnic Peace Centre (Solar Battery Charging Station)**				
Location of the equipment:	Prek Chrey community, Koh Thom district, Kandal province, Cambodia				
Year of purchase:	2009				
Operator:	- currently no operator				
Planner:	ITC, Pochentong Blvd, Toul kok district, Phnom Penh COMPED, Dangkor district, Phnom Penh Khmer Community Development (KCD)				
Detailed description of the installation:	- up tp this date no components have been installed				
Generated energy service:	electricity	heat	gas	light	
	✓				
Power output of installation: (kWel, m³ biogas, kW th, etc.)	- no data available				
Financing:	private investment	loan	donation	grant	
Comments:	- up to this date the showcase has no financial support				

Pictures

Figure 53: Battery Charging Station in Prek Chrey

Figure 54: Prek Chrey Health Centre

Showcase Svay Rieng, Cambodia

During the project survey, it found that within Svay Rumpea commune, Svay Tiep district, Svay Rieng province, there are 15 biodigester plants dispersing in the area. One prominent farmer, who has the biodigester plant of 4m^3 was selected as a case study in Srma village, Svay Rumpea commune, Svay Tiep district, Svay Rieng province because the householder has mixed farming system and multiple cropping.

A show case within Svay Rumpea commune, Svay Tiep district, Svay Rieng province was selected because it should be an existing model for the others in order to promote more biodigester construction by showing many benefits given by biogas plant solving with the constrains the farmers are facing at the moment. As the mater of fact, it is due to:

- Firewood which is the only energy source in the area is becoming a scare resource; and
- Harmful environmental awareness about the chemical fertilizer and farm soil quality is becoming infertile

Most important points are:

- Because micro-financing channel is already existing in the area and it is under the coverage province of NBP, which is leading in the construction of biogas plant in Cambodia;
- Good management, responsibility and personal characteristics of the operators of the biogas plant;
- NBP masons are locally available for the construction; and last but not least,
- Accessible infrastructure to the case study site

These all points mentioned above are contributing REEPRO and NBP cooperate smoothly in case of providing training and practice by making use of the showcase promoting and extension of biogas application.

<table>
<tr><td rowspan="2">Type of equipment:</td><td>PV</td><td>Solar Thermal</td><td>Biomass to Energy</td></tr>
<tr><td></td><td></td><td>✓</td></tr>
<tr><td>Name:</td><td colspan="3">Farmer’s biodigester plant</td></tr>
<tr><td>Location of the equipment:</td><td colspan="3">Sromor village, Svay Rompea commune, Svay Teab district, Svay Rieng province</td></tr>
<tr><td>Year of purchase:</td><td colspan="3">2006</td></tr>
<tr><td>Operator:</td><td colspan="3">Pa Sarat
Sromor village, Svay Rompea commune, Svay Teab district, Svay Rieng province</td></tr>
<tr><td>Planner:</td><td colspan="3">Ngoun Sam Ann, NBP construction company with the supervision of Pa Sophy, Svay Rieng province</td></tr>
<tr><td>Detailed description of the installation:</td><td colspan="3">It is a 4m^3 NBP biodigester plant with the following characteristics:
Storage capacity of the modified plant is 50%, the original model had only 30% per day. The farmer will have enough gas for cooking
Hydraulic retention time is up to 40 days depending on the climate in Cambodia
Location and size of outlet have been modified to simplify the outflow of the digester by means of gas pressure and gravity
Simplified manhole for entering during maintenance
Inside of dome (gas storage) will be spread with cement-acrylic emulsion
Inlet was modified in order to reduce construction costs
Thickness of wall was modified based on the construction materials available at the market in Cambodia
The outside wall plaster is as thin as possible to reduce the construction costs.</td></tr>
<tr><td rowspan="2">Generated energy service:</td><td>electricity</td><td>heat</td><td>gas</td><td>light</td><td></td></tr>
<tr><td></td><td></td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Power output of installation: (kWel, m³ biogas, kW th, etc.)</td><td colspan="3">1.2 m^3/day</td></tr>
<tr><td rowspan="2">Financing:</td><td>private investment</td><td>loan</td><td>donation</td><td>grant</td></tr>
<tr><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Investment costs in US$*</td><td colspan="3">USD 400</td></tr>
<tr><td>Maintenance costs in US$*</td><td colspan="3">0</td></tr>
<tr><td>Savings US$ per month</td><td colspan="3">Fuel wood: 6Kg/day costs USD 9/month
Charcoal: 2Kg/day costs USD 4.5/month
Kerosene: 0.7l/day costs USD 13.8/month</td></tr>
<tr><td>Energy sale income in US$*</td><td colspan="3">No</td></tr>
</table>

Pictures

Figure 55: One biodigester in Sromor village

Show case COMPED training centre, Cambodia

COMPED Training centre constructed two biogas plants 4m^3 for train to the participants and demonstrate with a model one next to the complete plant. COMPED has invited farmers, masons, teachers, authorities and other participants related to the biogas training courses.

The case study was selected in the frame of REEPRO project in line with NBP cooperation. The training was given for the farmers, biogas owners, teachers and authorities on the background of REEPRO project in Cambodia and Lao and the training content focussing on Biogas Plant Operation and Maintenance, Slurry Extension. The participants are very happy to absorb the knowledge and understanding news technical of biogas plants. COMPED training centre also welcome to the visitor from other institution for visit and learn about biogas plant operation and maintenance.

Type of equipment:	PV	Solar Thermal	Biomass to Energy		
			✓		
Name:	**COMPED**				
Location of the equipment:	COMPED training centre, Dang Kor district, Phnom Penh				
Year of purchase:	2009				
Operator:	Mr. Chhun Thoeun, staff at COMPED training centre				
Planner:	COMPED, Dangkor district, Phnom Penh				
Detailed description of the installation:	It is a biodigester constructed by the NBP (National Biodigester Programme) in Cambodia. There are two plants, one of which is for displaying the function and benefit of biodigester for cooking and lighting for a family living at COMPED training centre, and another one is a cross section view of the biodigester for showing visitors the inside view of the plant from inlet to outlet This equipment is mainly for training display for the 3 levels of the REEPRO project and other relevant visitors. It is useful for training so that COMPED can not only teach the theoretical knowledge of biodigesters but participants can also learn about the application, function and process of the biodigester.				
Generated energy service:	electricity	heat	gas	light	
			✓		
Power output of installation: (kWel, m³ biogas, kW th, etc.)	4 m3 biogas				
Financing:	private investment	loan	donation	grant	
Investment costs in US$*	2623.68 USD				
Maintenance costs in US$*	95.08 USD				
Savings US$ per month	- Fuel wood: 6kg/day, USD 9/month - Charcoal: 2kg/day, USD 4,5/month - Kerosene 0.7l/day, USD 13.8/month				
Energy sale income in US$*	0				
Comments	COMPED biogas plant for training and model presentation of NBP designed biodigester plant				

Pictures

Figure 56: Construction of biodigester plant and cross section at the COMPED training centre

Showcase Takeo, Cambodia

A case study within Prey Kabas commune, Prey Kabas district, Takeo province was selected because it should be an existing model for the others in order to promote more biodigester construction by showing many benefits given by biogas plant solving with the constrains the farmers are facing at the moment. As the mater of fact, it is due to:

- Firewood which is the only energy source in the area is becoming a scare resource; and
- Harmful environmental awareness about the chemical fertilizer and farm soil quality is becoming infertile

Most important points are:

- Because micro-financing channel is already existing in the area and it is under the coverage province of NBP, which is leading in the construction of biogas plant in Cambodia;
- Good management, responsibility and personal characteristics of the operators of the biogas plant;
- NBP masons are locally available for the construction; and last but not least,
- Accessible infrastructure to the case study site

These all points mentioned above are contributing REEPRO and NBP cooperate smoothly in case of providing training and practice by making use of the showcase promoting and extension of biogas application.

Type of Equipment:	PV	Solar Thermal	Biomass to Energy		
			✓		
Name:	Farmer's biodigester plant				
Location of the equipment:	Prey Prom village, Pro Kabas commune, Prey Kabas District Takeo province				
Year of purchase:	2008				
Operator:	Tot Son Prey Prom village, Pro Kabas commune, Prey Kabas district Takeo province				
Planner:	Samrith Kim, NBP construction company with the supervision of Kheang Vannthy, Takeo province				
Detailed description of the installation:	It is a 4m^3 NBP biodigester plant with the following characteristics: • Storage capacity of the modified plant is 50%, the original model had only 30% per day. The farmer will have enough gas for cooking • Hydraulic retention time is up to 40 days depending on the climate in Cambodia • Location and size of outlet have been modified to simplify the outflow of the digester by means of gas pressure and gravity • Simplified manhole for entering during maintenance • Inside of dome (gas storage) will be spread with cement-acrylic emulsion • Inlet was modified in order to reduce construction costs • Thickness of wall was modified based on the construction materials available at the market in Cambodia • The outside wall plaster is as thin as possible to reduce the construction costs.				
Generated energy service: (check the energy type)	electricity	heat	gas	light	
			✓	✓	
Power output of installation: (kWel, m³ biogas, kW th, etc.)	1.2 m^3/day				
Financing:	private investment	loan	donation	grant	
	✓	✓			
Investment costs in US$*	USD 400				
Maintenance costs in US$*	0				
Savings US$ per month	•Fuel wood: 6Kg/day costs USD 9/month •Charcoal: 2Kg/day costs USD 4.5/month •Kerosene: 0.7l/day costs USD 13.8/month				
Energy sale income in US$*	No				

Pictures

Figure 57: Construction and use of biodigester

Showcase ITC Campus, Cambodia

The showcase implementation is under the frame work of REEPRO because ITC offers the Technicians and Engineer every year. The renewable energy is subject to climate change where the students start their careers after completing the degree at university. The Lab facilities of renewable energy are solar PV, Solar dryer and solar Hot water.

Type of equipment:	PV	Solar Thermal	Biomass to Energy		
	✓				
Name:	**Solar home system**				
Location of the equipment:	Fixed stand for training show installed at ITC, Department GEE				
Year of purchase:	2008				
Operator:	ITC staff at laboratory ITC for Electrical and Energy Engineering.				
Planner:	ITC, Pochentong Blvd, Toul kok district, Phnom Penh				
Detailed description of the installation:	A 12V solar home system was installed at ITC. This system consists of two PV modules with a maximum output capacity of 150Wp (2x75Wp). A 70Ah-battery is used to store energy that is used for lamps and fans when there is no sunlight or during the night. A charge controller with a capacity of 12A is used for overcharge protection or overload protection of the batteries. The inverter converts the DC current to AC current, which can produce a maximum output of 300W. The installation of SHS at ITC was done by the trainees of the Level 1 course 4. The solar panels are installed on the roof of ITC and attached to a fixed stand. The DC cable from the solar panel to charge controller is about 7m long. The battery is placed near the charge controller. The inverter connects to the DC load port of the charge controller. A DC voltmeter, AC voltmeter and AC Ampere meter are used to measure current and voltage.				
Generated energy service:	electricity	heat	gas	light	
	✓			✓	
Power output of installation: (kWel, m³ biogas, kW th, etc.)	150Wp				
Financing:	private investment	loan	donation	grant	
				✓	
Investment costs in US$*	1220USD				
Maintenance costs in US$*	ITC has to replace the battery every 3 years, which costs 100USD				
Savings*	At ITC it is mainly used for experimental work only not for daily applications.				
Energy sale income in US$*	N/A				
Comments	This system is used for the experimental set up for the students at ITC each year in the field of renewable energy.				

Pictures

Figure 58: Solar panel with a capacity of 150Wp (each panel 75Wp)

Figure 59
12/24V Charge controller of 12A with a DC volt-meter

Figure 60: Batteries with 70Ah

Figure 61: 300W Inverter, with a AC volt-meter and a AC Ampere meter

Type of equipment:	PV	Solar Thermal (Hot Water)	Biomass to Energy		
		✓			
Name:	**Solar hot water**				
Location of the equipment:	Fixed stand for training shows which is installed at ITC, Department GEE				
Year of purchase:	2009				
Operator:	ITC staff working at laboratory ITC for Electrical and Energy Engineering.				
Planner:	ITC, Pochentong Blvd, Toul kok district, Phnom Penh				
Detailed description of the installation:	A solar hot water system was installed at ITC. This system consists of absorber, tube, and water tank with a storage capacity of 150l. The storage tank is used for storing hot water. The absorber is used to absorb the heat from the sun and transfer the heat to the inside of storage tank It is a glazed flat plate absorber that consists of a plastic absorber in a flat rectangular housing. The collector is provided with a transparent cover on the upper surface. Two pipe connections for the supply and return of the heat transfer medium are fitted, usually to the side of the collector. On one side of the absorber pipe is connected to cool water at the lower part of the storage tank and the other side is connected to the top. The hot water circulates in the absorber and transfers the heat to the storage tank. This is the first time that ITC has built solar hot water systems by using black plastic absorber. The heat exchanger is also good enough to do the experiments. In the next step, we would like to make the absorber out of metal since metal can exchange the heat faster than plastic.				
Generated energy service:	electricity	heat	gas	light	
		✓			
Power output of installation: (kWel, m³ biogas, kW th, etc.)	150L				
Financing:	private investment	loan	donation	grant	
			✓		
Investment costs in US$*	500US$				
Comments	This equipment is used for student experiments only				

Pictures

Figure 62: Solar absorber, from the front side

Figure 63: Rear view of the solar absorber

Figure 64: Top view of the solar absorber

Figure 65: The storage tank with a capacity of 150L

Type of equipment:	PV				
Name:	**Direct-solar box dryer**				
Location of the equipment:	Fixed stand for training shows installed at ITC, Department GEE				
Year of purchase:	2009				
Operator:	ITC staff working at laboratory ITC for Electrical and Energy Engineering.				
Planner:	ITC, Pochentong Blvd, Toul kok district, Phnom Penh				
Detailed description of the installation:	A direct-solar box-type solar dryer suitable for household drying of agricultural products has been developed at ITC. The dryer can dry 4-5 kg of fish, bananas, as well as all kinds of vegetables at a temperature of about 35-58 °C in a single batch.The performance of the box dryer was evaluated using an evaluation procedure for solar dryers, which was also developed at ITC. A comparison of the test results with a solar cabinet dryer indicate superior performance of the dryer, taking into considering not only the thermal performance but also factors such as loading/unloading convenience, operation and maintenance, quality of dried products, floor area requirement for dryer installation and cost of dryer.				
Generated energy service:	electricity	heat	gas	light	
		✓			
Power output of installation: (kWel, m³ biogas, kW th, etc.)	Can dry 4-5kg of fish, banana and all kinds of vegetables in a single batch				
Financing:	private investment	loan	donation	grant	
Investment costs in US$*	300US$				
Comments	This equipment is used for student experiments only				

Pictures

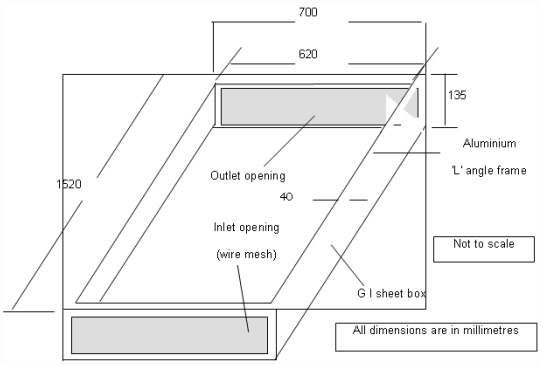

Figure 66: System sizing

Figure 67:Solar dryer box

Mobile solar home system

The mobile PV system is a solar home system with a capacity of 80Wp. This mobile system consists of two PV panels (40Wp each), a 10A charge controller, two batteries parallel connected with a capacity of 96Ah and the electric appliances (lamps, VCD player, TV). This solar home system is designed for the 12V DC voltage system. It is installed at COMPED training centre Phnom Penh.

The purpose of having this mobile system is for both Level 2 and Level 3 training. In case Level 2 the installation will be done by the trainees after completing their theory. Hence they will know how the system works and how to operate the system. However, we will install the whole system for Level 3 training and explain to them how each component functions. Finally, we will show them how much we earn from solar power and that it is a clean source of energy.

Figure 68: Mini solar home system

Figure 69: PV teaching course

Mini Solar Home System

The mini SHS set is comprised of 4x 10Wp standard poly-crystalline solar modules, 4x 5Wp standard mono-crystalline solar modules, 1xcharging controller (CX10 phocos), 1x 33Ah sealed battery, 1x DC socket, 1x 300W power inverter, panel frame stand, modules' connection board, 2x multi-meters and some connection cables.

The set is used for practical exercises on SHS, such (1) solar modules' installation, (2) SHS sizing, installation, operation and maintenance at Nuol campus.

Rocket stove production tools

The tool set is comprised of 2 x multi-purpose brick moulds (wooden, and metallic respectively); 1x full set of rocket stove components and 2x assembled rocket stoves. The set is for training on rocket stove production and assembly in the Hound district. The wooden mould can easily be made by trainees themselves after the training while metallic ones can be fabricated at any rural workshop.

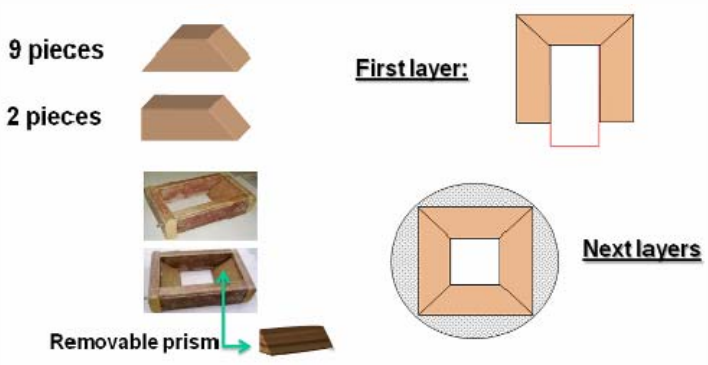

Figure 70: Training showcase - Practical training equipment rocket stove

LeXsolar-experiment kit (REEPRO set)

The LeXsolar-experiment kit offers the possibility to learn the functionality and achieve an understanding of solar energy systems. Several training courses showed that the LeXsolar-experiment kit led to a better understanding by the participants than learning theoretically.

The basis of the LeXsolar-experiment system is the LeXsolar main board, onto which up to three solar LeXsolar plug-in modules can simulteneously be plugged in. Depending on how the modules are plugged in, it is possible to create a parallel or a series connection. Components of the LeXsolar-experiment kit are 1 main bord, 1 connection circuit plate, 4 solar plug-in modules, 4 banana plug cables, 5 multimeters, 1 resister and 1 diode module and a loud speaker (see the end of the data sheet).

These several modules in the training kit enable different experiments: (1) series/parallel connection, (2) dependence of power on solar cells surface, (3) dependence of power on light, (4) diode's character, (5) shadowing on series connectors, (6) shadowing on parallel connectors, (7) solar cells as transmittance measuring devices.

REEPRO project team operates 20 LeXsolar-exeriment kits: 10 NUOL, 5 COMPED and 5 ITC.

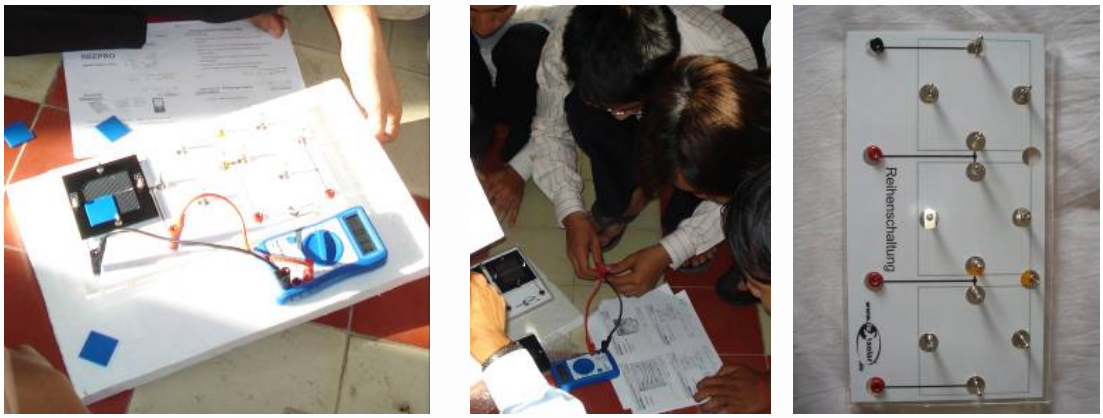

Figure 71: Training showcase - LeXsolar-photovoltaic experiment kit (REEPRO set)

The described compilation of material will allow every trainee to perform training on his or her own. The following table gives an overview of the media and material used for the different levels.

Data sheets on the different developed showcases can be found under: http://www.reepro.info/2454.0.html. The REEPRO manual provides the necessary background information to rebuild the showcases and perform exercises.

Lessons learned

The parallel preparation of text books for different target groups is not very feasible as the authors have to concentrate on two different works at the same time. The subsequent preparation of the books will allow taking into account the feedback of the level 1 trainees for the preparation of the first version of the level 2.

The REEPRO project team overestimated the abilities of the level 1 target group, the experts with an university degree. The content editing workshops showed that the prepared teaching material often was to sophisticated. The participants were not aware about simple basics, like the existence of serial and parallel circuits and the determination of the water content of biomass and some of them even were not able to understand these basics based on the theoretical lecturers only. To overcome this problem, the REEPRO team developed practical experiences to show the trainees these simple basics. Figure 72 shows the 2 used PV teaching cases of which one especially was developed from NUOL and DGS. The whole level 1 training programme was reworked to include enough time for practical exercises and excursions. Additionally, the REEPRO team prepared video documentations of the show case installations.

Figure 72: Practical training equipment SOLAR: REEPRO Mini Solar home system (left), LexSolar PV teaching case (right)

The estimated time for the installation of the show cases was with about 12 month rather short. In some project communities the REEPRO team only could develop electrification concepts but was not able to implement them in the project time frame. It would have made sense to start the work in the communities within the first project year, to have enough time for the selection of the communities and especially the build-up of a network.

Success stories

Rocket stove

The rocket stoves are simple cooking stoves that can be assembled from a few basic components. Considered to be efficient and relatively inexpensive to operate, the rocket stove derives its name from the appearance of the piping that extends horizontally from the main portion of the unit.

Rocket stove has been first times introduced by APROVECHO research centre (Oregon, USA) since 1976.

There are found some problems or obstacles in production of APROVECHO rocket stove in Lao PDR:

- Raw materials availability: there is not always and anywhere available or sufficient sawdust in remote rural area of Lao PDR.
- Construction problems: there is possibility that the short bricks will move into fire hole of the stove due to the pressure from the insulation materials side. The shape and size of fire hole maybe changed when stove is in use for a while.
- There requires two of moulds for preparing two sizes of bricks.
- Stove body is made of mind steel sheet, which is expensive, not always available or affordable for rural people;

Based on above mentioned considerations, we have made the following modifications. The mold was designed for producing multi-shape bricks, see figure 73. The modifications do consider all main technical requirements of APROVECHO rocket prototype, such as fire hole cross section size (10x10 cm) and height (33-35 cm); fuel feeder size (10x11.5 cm).

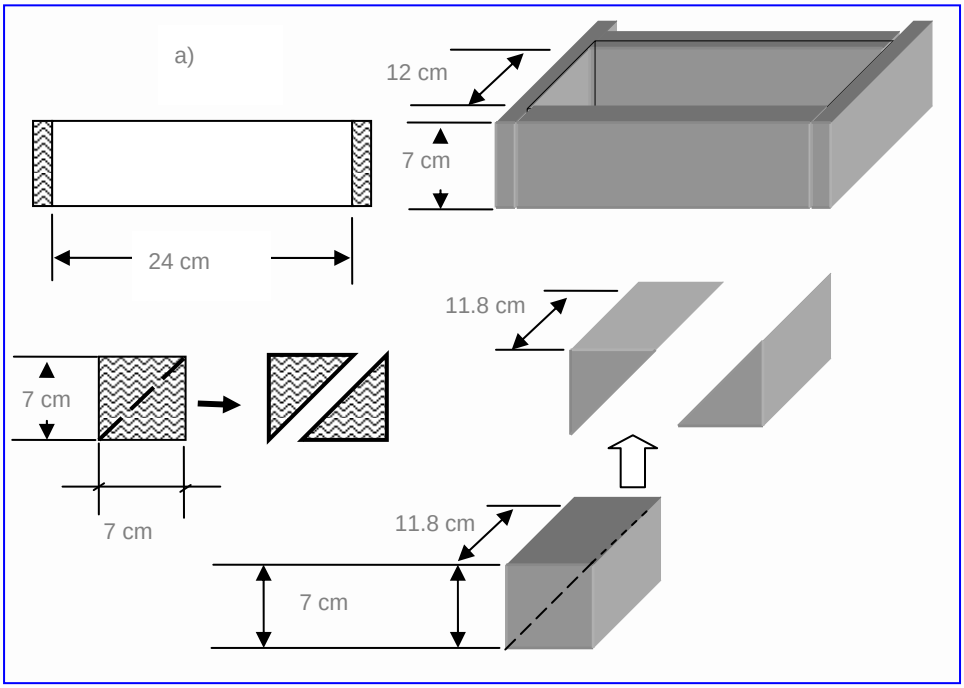

Figure 73:Multi-purpose brick mold

The mold is comprised of:

- Wooden or metallic rectangular mold (a) with internal size of 7x12x24 (in cm) so that produced brick size would be around 6.5x11.5x23 (cm);
- two triangular-shaped pieces (wooden lumbers or metallic) of size 7x7x11.8 (cm)

This mold can produce several brick modifications, including APROVECHO's bricks. These improvements facilitate the production in Laos and Cambodia. Additionally to the low cost rocket stove, one type has production costs of only 1 USD, the NUOL also developed gasification stoves, with a capacity similar to an ordinary household gas stove. In this stove the burning process is regulated with a fan. In several exhibitions the REEPRO team at the National University of Laos presented the different stoves and got plenty of production and training requests.

Biogas showcase Xay district, Oudomxay, Laos

8 bio digesters with a digester volume of 4 m³ each could be installed in the Lao pilot community Xay district, Oudomxay province. The biogas model constructed in Lao PDR is adapted from German and Chinese technology and is comparable to the Indian Deenbandhu and Nepalese model. The Lao REEPRO partner CDEA supported the Xay district in developing a procedure for the implementation of bio digesters, which included the installation of the first 8 digesters as REEPRO pilot show cases. The installation was applied for funding in the frame of the small facility found of the German embassy in Laos and selected for funding. The construction costs of one digester account to 2.498.500 KIP (216,90 EUR), thus the construction of the 8 digesters cost 19.988.000 KIP (1.735,21 EUR).






The total cost of biogas plant is about 3,000,000 kip each (included labour and material cost); 50% of total cost (1,500,000 kip) each of the 8 farmers, which were selected to participate in the pilot programme, will pay back. This payback will be used to establish a community development

fund in the village. The other 50% the project will donate to the members as they participate in the project as pilot families. The duration of paying back is 2 years. With the community development fund further members can borrow for caring out the activities such as biogas building, animal raising, toilet building or house repair. The interest rate for such micro credits will be 1%. Thus the REEPRO project not only supported the villages in installing renewable energy technology but also to build up a sustainable structure for the development of their villages.

SolarSchool inauguration

The DGS **- D**eutsche **G**esellschaft für **S**onnenenergie e.V. (German Solar Energy Society) is the largest and leading scientific and technical organisation for solar based renewable energy such as solar energy and biomass in Germany. The DGS has a network of 36 local and 5 regional offices throughout Germany with over 3,000 individual and corporate members.

The DGS has a strong base in education, standardisation and conception of regional energy concepts. As the national section of the International Solar Energy Society (ISES) the organisation is active in international cooperation for education and standardisation of renewable energy installations. The DGS is strongly committed to education. The DGS developed multilingual bioenergy, solar thermal and photovoltaic guidebooks (English, Spanish, Portuguese, German, Italian). The DGS coordinates eight German DGS SolarSchools, which offer training courses on photovoltaic, solar thermal and biomass energy. Since 1996 hundreds of engineers, architects, craftsmen and interested citizens have been taking part in the SolarSchool courses in Germany. Today the successful training concept is also being transferred to third countries. In 2004 one SolarSchool was opened in Taiwan, in 2007 in Macedonia and in 2009 one school per country in Ethiopia, Laos and Cambodia.

Figure 74: Hands-on training in the SolarSchools Weimar and Phnom Penh

The REEPRO renewable energy training programme and material is the basis for the operation of renewable energy training centres in Laos and Cambodia. In November 2009 two DGS SolarSchools (renewable energy training centres) were opened, one in Laos at the National University of Laos and one in Cambodia at the COMPED training centre. Those DGS SolarSchools will continue with the REEPRO training programme. Additionally, the REEPRO courses and material can be used to perform training courses world-wide.

The SolarSchools offer courses for all 3 REEPRO levels.

Contact for SolarSchool Laos

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Contact for SolarSchool Cambodia

Mr. Chau Kim Heng, staff@comped-cam.org

Contact for REEPRO training courses world-wide

Mrs. Antje Klauß-Vorreiter, Dr. Kai Dobelmann: reepro@dgs.de

Partner

European

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Co-operation

The Lao and Cambodian partners contacted the local partner of the EACI COOPENER projects:

RESIREA - Renewable Energy Sustainable Programs for Intelligent Rural Electrification and Poverty Alleviation and

CAP REDEO - CAPacity and institutional strengthening for Rural Electrification and development, Decentralised Energy Options.

In stead of the planned Coopener round tables several individual meetings were performed to ensure the exchange between the programmes.

Mr. Catherine Bourg, project officer of the RESIREA project at FONDEM contacted the DGS to discuss collaboration possibilities. DGS and FODEM already agreed to jointly organise the final stakeholder meeting in November 2009 and to discuss organisation of Level 2 and/or 3 REEPRO training courses for the community stakeholders involved in the RESIREA project.

Donors

Schwab GmbH
Strasse Bahnhofsplatz 3
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http://www.Schwab-GmbH.com

Hersteller von Schwimmbadabsorbern aus Rippenrohren. Komplette Systeme. Handelsname SOLARFLEX.

Wagner & Co Solartechnik GmbH
www.wagner-solar.com

German Solar company

The German-speaking Catholic Community St. Elisabeth Singapur
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Campaign Partner of Sustainable Energy Europe 2005-2008

REEPRO is an official partner of the Sustainable Energy Europe campaign: a European campaign to raise awareness and change the landscape of energy; an initiative of the European Commission, Directorate General for Energy and Transport.

We are proud to announce that REEPRO was one of the 5 nominees for the Sustainable Energy Europe Award 2008 in the category Co-operation Programmes. Please see the abstract of the programme of the sustainable energy week 2008 and the press relase on the awarding ceremony for more details on the award.
http://www.sustenergy.org/tpl/page.cfm?pageName=home