Diagnostic Study on Renewable Energy Potential and Feasibility in Southeast Asia

TECHNICAL PART OF THE FINAL REPORT

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I Introduction

I.1 Main activities that have been implemented

Rising oil prices have received much public attention in recent months. The impact of higher prices disproportionately affects developing countries in Southeast Asia constrained by their reliance on oil imports and limited budgets. On the other hand, Southeast Asian countries have abundance of two renewable energy sources – sun and biomass. Sunlight used in PV solar systems is an efficient source of electricity and biomass from agricultural crops can be converted into biogas, electricity and fertilizer.

In the frame of the Asia Pro Eco APE project ("Diagnostic Study on Renewable Energy Potential and Feasibility in Southeast Asia"), PV, solar and biomass strategies were developed. Target was the development of renewable energy sources (RES) basing on solar energy and biomass to provide the Lao population with reliable energy services. Complete chains of PV and biomass energy generation from input over suitable technologies to the demand and marketing of the final products were evaluated from the economical, technical, social and legislative point of view. The findings of this evaluation are presented in the studies on solar and biomass energy potential and feasibility in Lao PDR and in Thailand.

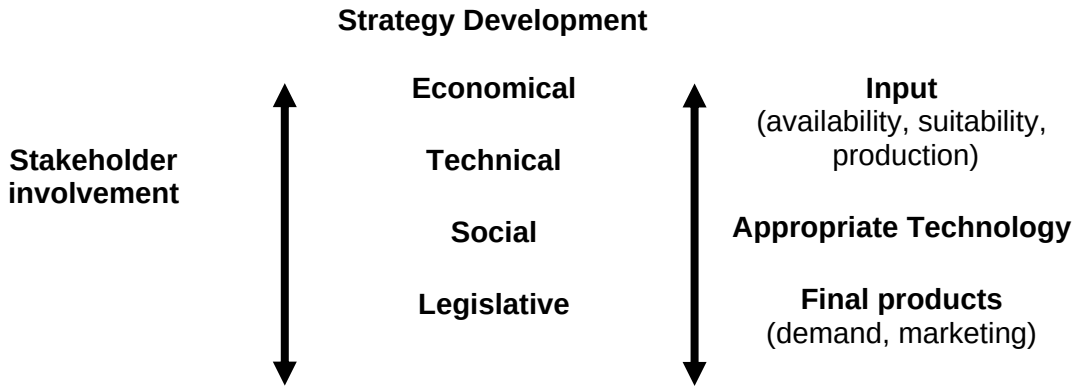


Figure 1: Approach of the strategy development

The study is the final result of the European Commission funded Asia Pro Eco Project "Diagnostic Study on Renewable Energy Potential and Feasibility in Southeast Asia". This project was implemented by the Deutsche Gesellschaft für Sonnenergie e.V. (DGS) in partnership with the Wageningen University in The Netherlands, the Thai Renewable Energy and Environmental Centre (REEC), the Lao Renewable Energy for Sustainable Development Association (RESDALAO), the Lao Community Development and Environment Association (CDEA) and the National University of Laos (NUOL).

Based on the findings of the various reports completed in this diagnostic study and from comments made during the stakeholder workshops, the project partners developed the final studies. As such, both, biomass and PV solar energy production chains (Input-Technology-Product) were analysed in the frame of the 15 months project from September 2005 to November 2006.

The Biomass Chain

The analysis of the biomass chain focused on the availability, suitability and production possibilities of input materials. In addition to technical data collection on wasted biomass, a research was carried out on the wider social and economic potential of biomass cultivation for energy production. Suitable energy crops were identified, cultivated and their biogas yield analysed in laboratory digestion trials. Appropriate technologies for biomass treatment were identified based on the research, pilot and full-scale projects in Laos and an evaluation completed on the transfer possibility of European technologies.

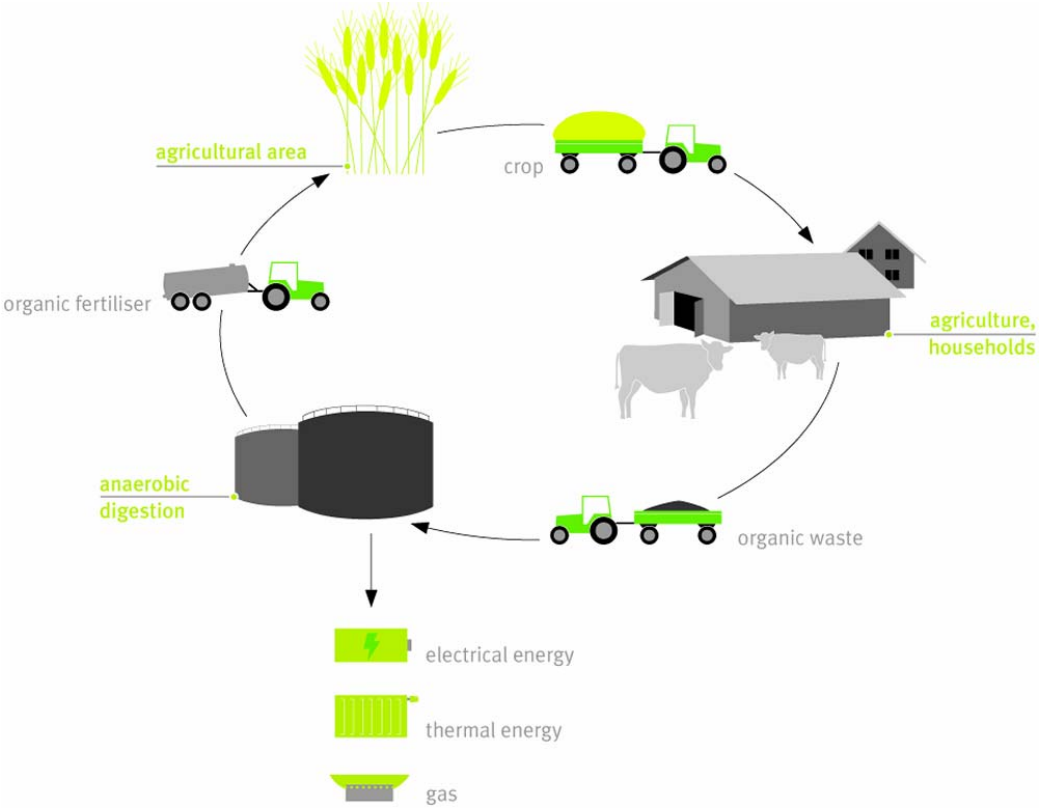


Figure 2: EnergyFarming cycle combining manure and crop treatment © BioVAG

"Energy Crop" is a worldwide nearly unknown term – in Laos and Thailand, too. Regularly, crop is understood as food for human consumption or as fodder in husbandry. The production of energy from crops is a new concept for South East Asia. In the past, energy was produced from crop residues by biogas, gasification or steam route only. No thought was spent about the possibility to cultivate crops directly for energy production. Therefore existing studies about biomass to energy routes are based only on biological waste as agricultural waste, food processing waste or municipal solid waste (MSW) – not on energy crops produced on farms.

The innovative approach of the research performed in the APE project consists in considering the fact that biomass is not only wasted biomass but especially the grown biomass usable as an energy source. This can be combined with PV solar energy production. The EnergyFarming is a relatively new approach in Europe and a totally

innovative approach for South-East Asia. Figure 2 demonstrates the general EnergyFarming cycle.

The PV Chain

The PV solar chain research on monthly, hourly and solar irradiance was carried out to provide detailed data on the PV solar potential. Additionally, information on implemented PV solar systems were collected and evaluated. The project has provided an opportunity to collate, update and store local meteorological data and knowledge to create a secure basis for the planning of PV solar projects in Laos. Appropriate PV technologies and systems were identified based on the research, on pilot and full-scale projects in Laos and an evaluation completed on the transfer possibility of European technologies.

The main activities of the project are listed below:

- Ongoing project management by DGS to ensure the target oriented performance of the project
- Pooling of all governmental, non-governmental and private renewable energy stakeholders by organising two participatory stakeholder workshops, one at the beginning and one at the end of the project:
    - Organisation and performance of stakeholder workshops, one in Lao PDR and one in Thailand, in order to present the project, collect information on renewable energy activities in both countries, identify needs and constrains of the different stakeholders and demands.
    - Organisation and performance of a “Study on Solar and Biomass Energy Potential and Feasibility” presentation, one in Lao PDR and one in Thailand respectively, in order to present and discuss the results of the project.
- Establishment of a project homepage in order to spread the project ideas and results. The project homepage was created in an interactive manner in order to include information of the project partners and external participants on decentralised level.
- Data collection and evaluation of present sources for renewable energy in Thailand and Lao PDR.
- Evaluation of the solar energy potential in the different geographical regions of Thailand and Lao PDR.
- Evaluation of biomass to energy potential in Thailand and Lao PDR by data collection and laboratory experiments.
- Evaluation of the potential urban areas to be supplied, especially industrial estates, with renewable biomass energy, photovoltaics and solar thermal energy from urban, sub-urban and rural areas.
    - Performance and evaluation of data survey and questionnaire actions to collect information on the RES potential and demand in selected pilot areas.
- Assessment of existing technologies and legislation in Thailand and Lao PDR.
- Survey on appropriate renewable energy technologies for SEA.

- Carrying out strength, weakness, opportunity and threat (SWOT) analyses considering renewable energy potential, technologies, financing and stakeholder dialogue based upon the collected information.
- Development of one Lao and one Thai country specific "Study on Solar and Biomass Energy Potential and Feasibility", hereinafter called "PV&Biomass Study", consisting of a description of the present situation, a SWOT analyses and strategies for the implementation of solar and biomass energy in Thailand and Lao PDR.

I.2 Main Results Achieved

The main results of the project are:

- Establishment of a project home page as information and communication platform
- Online publication of interim reports on:
  - Laws and Guidelines
  - Energy Sector Data
  - Grid and Feed-In Condition
  - Realized Projects
  - Financing and Funding
  - Research Structure
  - Education Structure
  - Solar Potential
  - Biomass Potential
- Performance of each 3 Stakeholder workshops with 40-60 participants each
- Dissemination of project information by means of flyers, brochures, the project home page and email newsletters.
- Forming of a stakeholder network, outlasting the project period.
- Forming of a European – Asian partnership between the project partners with the aim of further co-operation. (One new joint project started already in January 2007: Promotion of the Efficient Use of Renewable Energies in Developing Countries" (REEPRO), proposal n° EIE-06-256)
- Development of 2 studies "Study on Solar and Biomass Energy Potential and Feasibility in Lao PDR" and "Study on Solar and Biomass Energy Potential and Feasibility in Thailand" as basis for the further development of renewable energy projects in Laos and Thailand.
- Involvement of the local stakeholders in each project activity and thus creation of a strong local ownership of the project results.

I.3 Difficulties encountered

The approach of the project was to develop the studies on solar and biomass energy potential based on mainly external information. Only the biogas potential trials of the selected energy crops were performed by the projects partners. The strong reliance on external sources sometimes was an obstacle for the Asian partners to perform the data collection in an adequate time frame and quality. Encountered difficulties are described below:

Data collection

Difficulties encountered during the project implementation period included data collection in the pilot cities and general data collection for reports. For data collection the local partners often rely on governmental institutions. Especially the Lao partners faced the problem that the bureaucracy often hinders a quick data access which leads to delays in the project implementation, especially the report delivery. But so far this did not disturb the overall on-time project implementation.

Statistics from different sources often gave not the same figures for similar items, e.g. the data on electricity consumption given in different sources were extremely varying. Thus, the electricity data and the total energy consumption had to be adapted for the study development. Anyway, it was assumed that the data on the different sources could be used to give a general picture on the use of those energy sources within the study.

Statistics about different subjects in Thailand scattered in different sources and related departments. Usually, these data are not easy to be reached by the public and the data format and contents were not so accurate. Data which involve number statistics varied slightly. In many data items, numbers were reported differently.

Stakeholder Dialogue

One of the objectives of stakeholder workshops was to make the stakeholders familiar with project activities. After presenting the results they should provide comments and further cooperation. However, those stakeholders were not acquainted to contribute their ideas and giving suggestions. They tend to come for updating knowledge and provide acknowledgement to the project work. In addition, some expect contribution in the form of hard ware. To overcome these barriers, REEC emphasized project objectives during the workshop many times and let them know of the project impact in the form of knowledge base but not providing hard ware to the stakeholders. Personal contacts to them were constantly done. As a result good understanding and cooperation during the workshop program were obtained.

Biogas trials

Another difficulty was the inexperience of the NUOL staff in performing biogas trials according international standards. Therefore, there were many inaccuracies incurred within the biogas tests i.e.:

- Each material was only tested for digestion for one time in single digester, no data of parallel trials were obtained to compare with;
- Biogas outputs of inoculum were not tested in multiple trials and therefore, unable to be excluded from the recorded results;
- Gas analysis was not done during the testing times (the gas components were analyzed several weeks later).

This, the results of the Laos test can not really be considered as basis for further calculation though the performed work made the Lao team familiar with international standards and enabled them to perform further research in this field subsequently the reported project.

In Thailand REEC had to design all test units and to built them. These work needed extra time to obtain a adequate and accurate test system. The research results then came out early July 2006. Therefore, extra time to prepare related reports was needed. Extension of the project a few months allowed REEC to accomplish those reports.

II Implementation of Activities versus Work Plan and Logical Framework

The project could be implemented according the task list, beside negligible delays which were reported in the quarterly updates. The task list was the main project management tool and was developed based on the project contract between the DGS and the European Commission. This contract included the detailed project description and the logical frame work. The implementation of the different tasks is described in this chapter.

II.1 Task A Project Management

II.1.1 Task A1 Kick-Off Meeting (5.-6.9.05)

The project started with the preparation and performance of the kick-off meeting in Laos from September 5th to 6th, 2005. The overall project management and the performance of the following seven main project tasks were discussed in the frame of the kick-off meeting:

- A - Project Management,
- B - Stakeholder Workshops (WS),
- C - Homepage and Data Base,
- D - Data Collection,
- E - Laboratory Analysis,
- F - Technology Survey and
- G - PV&Biomass Study development).

Every main task was divided in sub tasks. One project partner was responsible for performance of every subtask and one for the approval, co-ordinated by the DGS project manager Antje Klauß-Vorreiter.

The minutes of the kick off meeting are attached in Appendix 2.

II.1.2 Task A2 Project manual

The project manual was developed by the DGS developed by the DGS according the schedule and distributed to all project partners. The project manual compiled the following information and was the main management working tool of the partners.

Part 1 - Communication

- Partners (tasks and contacts)
- Communication flow and responsibilities

Part 2 - Templates

- Reports
- Payment request
- Titles of files
- Papers and documents

- Reports
- Minutes of meeting

Part 3 – Schedule and deadlines

- Schedule
- Deadlines for all reports and works

The manual is attached as Appendix 11.

II.1.3 Task A3 Mid-term meeting (20.4-21.4.06)

The second project meeting in April 2006 in Thailand gave the partnership the chance to present and discuss all work and results from the data collection and laboratory analysis work. The partnership discussed general strategies for the final studies on solar and biomass energy potential and feasibility in Lao PDR and Thailand and performed a first SWOT analysis.

During the visit of the European partners DGS and WU April Asia, they met several representatives from third organisations e.g. Palang Thai, DEDE, Promotion of Renewable Energy Technologies: Action Plan for the Development of the Market in Thailand, Joint Graduate School of Energy &. Environment KMITT in Thailand and Sunlabob Ltd., Ministry of Industry and Handicraft, SNV, world bank, European commission, and gtz in Laos. In interesting discussions DGS could present the interim result of the reported project and collect relevant information on the activities of those organisations. DGS could also convince the representatives of those organisations to review and comment the draft of the study on solar and biomass energy potential and feasibility. Further integration of these organisations in the stakeholder workshops was also agreed. A dissemination agreement was conducted in which the representatives of the mentioned organisations accepted to disseminate the results in their respective houses.

The minutes of the mid-term meeting are attached in Appendix 3.

II.1.4 Task A4 Final meeting (20.-21.07.06)

The final project meeting in July 2006 in Laos gave the partnership the chance to jointly discuss the first draft of the final study and to develop discussion papers for the workshops of the second stakeholder workshop.

The minutes of the final-term meeting are attached in Appendix 4.

II.1.5 Task A5 Steering Committee (SC)

The steering committee was established during the first project meeting. Kai Dobelmann (DGS), Arthur Mol (WU) and Maydom Chanthanasinh (REDALAO) were members of the committee. The partnership decided that a steering committee with 3 members will be more flexible in its collaboration and decision making than one involving the project heads of each

partner. The steering committee performed 3 project evaluations without identifying any problems or irregularities.

II.1.6 Task A6 Reports

Every project partner prepared and delivered quarterly reports on its project work. Those reports were delivered within 10 days after the end of the quarters from the partners to the DGS. These reports were the basis for the quarterly updates provided by the DGS to the European Commission.

II.1.7 Task A7 Publication

In the frame of the project the following publications were prepared:

Hard copies:

- Project presentation brochures
- Project presentation leaflets
- Project result presentation leaflet

Digital copies, distributed on the project home page and CD's

- Report on the first stakeholder workshop
- Report on the second stakeholder workshop
- Online project presentation (project homepage www.dgs.de/asiaproeco)
- Ongoing updated project progress presentation
- Reports on all collected data of Part I of the study
- Study on Solar and Biomass Energy Potential and Feasibility for Lao PDR
- Study on Solar and Biomass Energy Potential and Feasibility for Thailand

The hard copies are attached in Appendix 5. A compact disk with the final studies is attached in Appendix 6. Other digital reports forming the basis for the final studies can be downloaded from the project home page.

Additionally four project newsletters were distributed to the stakeholder pool. The project was presented in the frame of the international conference ORBIT 2006 in Weimar, Germany (see http://www.orbit2006.de/cms/). The prepared paper "New Strategies for the Implementation of Biomass Energy in Southeast Asia" is attached in Appendix 7.

In January 2006 the first e-mail project newsletter was sent to the stakeholder pool (150 members) and the DGS news-network (6.000 members). The 2nd project newsletter to the stakeholder pool (200 members) and the DGS news-network (6.000 members) was sent in the 3rd project quarter. 50 new stakeholders used the online registration from to register in the stakeholder pool.

II.2 Task B Stakeholder Workshops

Two stakeholder workshops were performed in Lao PDR and Thailand in parallel. The stakeholder workshop documentations are attached in Appendix 8 and Appendix 9.

II.2.1 Task B1 First Stakeholder workshop

The first joint organised and performed project event was the 1st stakeholder workshop which has had a very good resonance in both countries, Laos and Thailand. The Lao Workshop was attended by 44 participants from governmental, NGO and private sector, from international organisations, NPO, R&D and education bodies. 59 participants attended the first day of workshop in Thailand. The participants eagerly participated in the joint discussions which showed the high interest of the contacted stakeholders in the project and the team assembled. Usually in Thailand such projects and discussions structures receive little attention by the joining stakeholders, even when they take place at the same day as the lectures. The key success of the first Thai workshop was the opportunity to introduce the new concept of EnergyFarming. Assurance, experiences of the EU and Germany expertise were the most interesting points for PV technology and quality. CDEA and REEEC organised the workshops (CDEA in Laos; REEC in Thailand) and provided a detailed documentation on the organisation, performance and results of the workshop to the DGS.

Figure 3: First stakeholder workshop in Laos (left) and Thailand (right)

II.2.2 Task B2 Second Stakeholder Workshop

The second Lao stakeholder dialogue on biomass and solar energy potential and feasibility in Lao P.D.R was held at the Science Technology and Environment Agency (STEA) in Vientiane capital from the 19th to 20th of July, 2006. The workshop was attended by 44 participants from public and private sector that shared interests in renewable energies. The project team presented the results of its project work. Attending stakeholders then discussed the preliminary results in four small discussion workshops such as the use of PV solar and biomass in off-grid areas, use of solar and biomass energy in urban areas and policy requirements for the sustainable implementation of renewable energies. In following presentations the discussion groups agreed that Laos has high potential and feasibility of

RE, especially for EnergyFarming. However, for that to happen there are still many short comings to be addressed.

The REEC organised the 2nd Stakeholder dialogue on Biomass and Solar Energy Potential and Feasibility in Bangkok during July 24th to 25th at Rama Garden Hotel Bangkok. The aims of the meeting were to present research results and having group discussion in promoting research results in Thailand. The workshop was attended by 60 participants from 43 organizations, companies, institutions. Group discussions were performed in two groups: PV solar and biomass group. At the end of discussion each participant submitted written suggestions. Both, the Thai and Lao workshop gave subtential input for the preparation of the final study.

Figure 4: Second stakeholder workshop in Laos (left group discussions) and Thailand (right audience during presentations)

II.3 Task C Homepage and Data Base

A project home page was launched and linked with the home pages of all partners in order to make available all collected data, research results, reports and the whole study for a wide audience. Furthermore, the home page was used to announce the performance and the results of the stakeholder workshops. The homepage was created by the DGS in a Typo3 environment. The homepage was installed as part of the DGS homepage to avoid web hosting costs during and after the Asia Pro Eco project. The DGS assures the operation of the project homepage with all results and interactive features for a period of five years after the final date of the project.

All partners, provided information and reports can be seen at the home page. The layout of all delivered information was according to the regulations of the project manual.

II.3.1 Task C1 Development of a task list

The task list was developed by the DGS project management according the project proposal. It included all tasks with descriptions, responsibilities and deadlines. The first version of the task list is attached in Appendix 10. The task list was subject to further

development within the project implementation phase. Whereby, no substantial changed had to be made.

II.3.2 Task C2 Typo3 home page

The project home page (www.dgs.de/asiaproeco) has already been launched in the beginning of September 2005. All management tools and important documents e.g. the project manual, the task list, templates etc. were uploaded consecutively by the DGS management to provide the partners with relevant project information. The partners prepared and reviewed the presentation of their organisation, their countries and the project. Next to the internal communication platform the homepage is an important source of RE information for local stakeholders. The stakeholders still can sign up in the projects stakeholder pool on the homepage (http://www.dgs.de/1267.0.html).

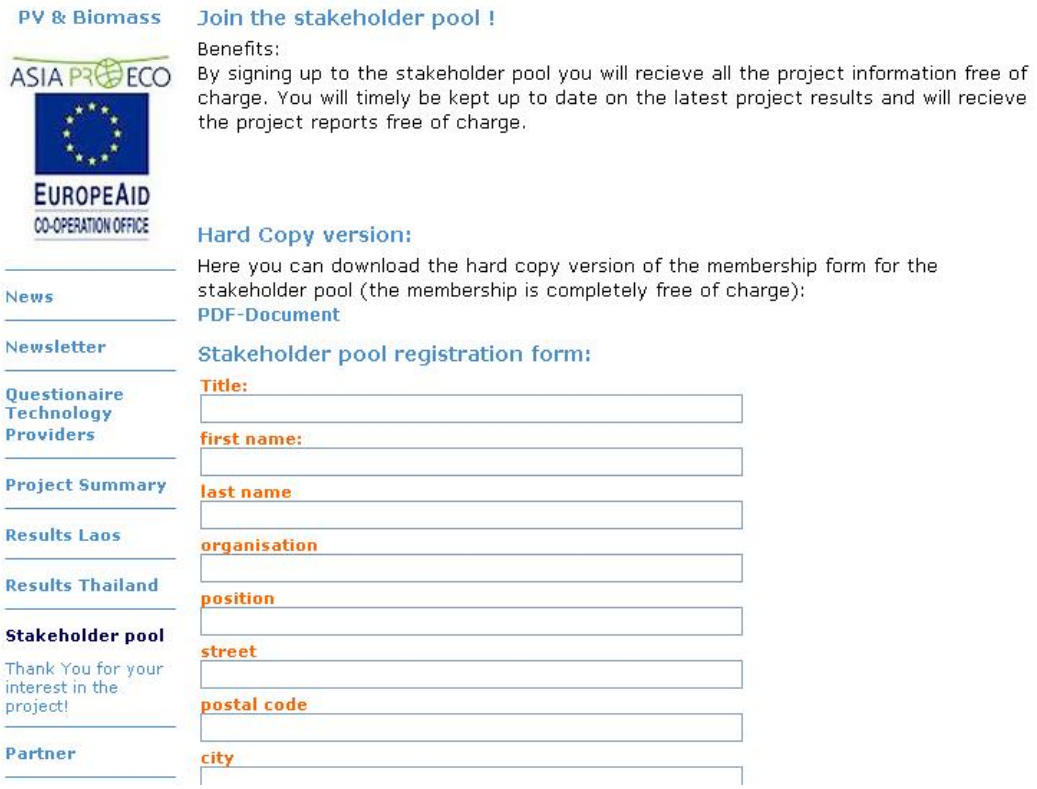


Figure 5: Screen shot of the online stakeholder registration

The public part of the project home page was expanded in the 2nd project quarter. Since then it has been showing not only information but also interim results from all sections of the project. For each country, Laos and Thailand, a project result page was introduced. The prepared reports were published there step-by-step (see *Results Laos*, *Results Thailand*).

II.3.3 Task C3 Address data base

The stakeholder pool today counts about 200 registered stakeholders, which provided detailed information on their profile. Additionally, about 500 Asian and 6000 European stakeholders are member of the pool and received all project information.

The partnership decided to develop a totally new data base as existing data bases of the partners are not compatible with the project requirements to collect information on the type of organisation, profession and RE interests of every stakeholder. Next to the general contact information the stakeholder pool members provided the following information:

Profession

☐ engineer	☐ banker	☐ civil servant	☐ teacher
☐ manager	☐ technician	☐ farmer	☐ entrepreneur
☐ politician	☐ craftsman	☐ researcher	☐ citizen
☐ journalist	☐ others		

Institution

☐ NGO	☐ Governmental	☐ international organisations	☐ R&D
☐ education	☐ private Sector	☐ funding and Financing	
☐ policy development		☐ others	☐ media

Technology Interests

☐ biogas	☐ PV	☐ solar thermal	☐ solar cooling
☐ energy efficiency	☐ wind power	☐ small hydro power	☐ geothermal
☐ energy farming	☐ biomass combustion	☐ co-generation	☐ gasification
☐ organic fertilizer	☐ bio fuel		

II.4 Task D Data Collection

The first part of the study was the evaluation of the present situation of solar and biomass to energy use and potential in Lao PDR and Thailand. The evaluation comprises a data collection of solar and biomass to energy potential, closed and ongoing research and development projects, closed and ongoing pilot projects, available technologies, statistics and cost structure of the energy sector, energy demand in urban areas especially in industrial estates, financing and funding possibilities, legislation, relevant governmental institutions and stakeholders from the private and non-profit sector and organic fertiliser market. Basis for the data collection was the evaluation of the first stakeholder workshop, the review of statistics on energy consumption and production, of literature especially project reports of closed studies, reports on research, development and pilot projects, interviews and questionnaires. The data collection were performed by the Asian partners and backstopped by the European partners. The data collection was divided in 3 main parts:

- D1 general data collection
- D2 Solar Energy Data Collection
- D3 Biomass to Energy Data Collection

The data collection was performed by the local partners advised by the European partners. Next to interactive long-distance discussions via e-mail and telephone conferences additional on-site meetings were necessary to ensure the high quality of the different technical reports. The local partners had to work on 12 reports and 2 questionnaires in parallel in the second quarter. The onsite meetings gave all partners the possibility to discuss about the progress of the single tasks, the targeted content of the single reports, the obstacles of the data collection and suitable approaches to perform the project work. Hence, the frequent presence of the European partners was utilized to guarantee a targeted approach of the work and curb on overlapping activities.

II.4.1 Task D1 General Data Collection

The collection of the basic data for the study development already started with the stakeholder workshops and was continued afterwards. All parts of the general data collection started within the first project quarter. The final reports of the single sub-task described below are available on the project home page and formed the basis for the respective chapters of the final studies.

II.4.1.1 Task D1.01 Relevant contacts

See II.3.3.

II.4.1.2 Task D1.02 Relevant Laws and guidelines

The WU team was responsible for supporting the Lao partner RESDALAO and the Thai partners REEC in completing the legal and institutional analysis. As neither of the partners had experience in such research, detailed instructions and comments were given. Further support was given to both teams in finalising the report, with the WU team editing and reorganising substantial amounts of text within the report.

II.4.1.3 Task D1.03 Statistics and cost structure of the energy sector

A clear overview of the energy production, consumption, import, and export as well as price structure was compiled, based on the existing governmental statistics, energy prices and the conditions for small or independent power producers.

REEC and RESDALAO prepared a final report including information on: national energy production, consumption, import, export and price structures, energy prices and the conditions for small or independent power producers and energy situation and RE application potential.

II.4.1.4 Task D1.04 Of-grid and feed-in conditions

The DGS developed data sheets and steered the local partners related to the collection of information about statistics and cost structure in the energy sector, in grid technology and in feed-in conditions, as well as in information on financing and funding possibilities (task

D1.5), available biogas and PV technologies (Task D1.6). In Laos RESDALAO took over this work and in Thailand REEC.

II.4.1.5 Task D1.05 Financing and Funding

An internet research identifying suitable donors and banks with their programmes and conditions was carried out by REEC and RESDALAO to obtain general information on financing and funding possibilities. The objective of this task was to gather information on financing tools for interested investors, farmers, households and other RE users. Some funds, loans and grants were identified by the local partners but the access to the information was difficult and the programmes were limited.

II.4.1.6 Task D1.07 R&D

RESDALAO and REEC prepared detailed overviews about research and development project, pilot projects and studies in their countries. The information was collected in each one overview table. For every project the following information was collected:

- Project title
- Duration
- Short info, objectives and or results
- Donor
- Budget
- Contact

II.4.1.7 Task D1.08 Social situation and mentality

Taking the results of various reports from the Lao and Thai partners the WU team wrote a detailed review paper on the societal acceptance of renewable energy. This study was a key contribution by the WU team in the completion of the studies for Laos and Thailand.

II.4.2 Task D2 Solar Energy Data Collection

II.4.2.1 Task D2.01 Meteorological Analysis of Solar Irradiation Data

Based on an extensive literature review and frequent internal discussions between DGS, NUOL and REEC, DGS performed the meteorological analysis of solar irradiation data. DGS compared the suitability of different simulation programmes. A draft report on this task D2.1 where prepared within the 3rd quarter. This draft reports were used as based for the related chapters in the final studies.

II.4.2.2 Task D2.02 Potential and Demand PV in urban areas

Two different-sized pilot areas in Thailand were selected for the collection of specific information on the demand and potential of biomass to energy and PV solar in urban areas: the city of Angthong and the city of Banglen. The city of Vientiane and the city of Santhong were chosen for Laos. One data sheet on potential and demand on RE was developed by

the partnership. The partnership decided to collect not only PV related but also EnergyFarming related information with this survey.

REEC started the data collection in the above mentioned pilot cities in the second project quarter but faced serious difficulties to get the required information. The Thai partner REEC changed the pilot cities to Phanusnicom District (also called Phanat Nikhom district), in the Chonburi province and Siekew District (also called Sikhio district) in the Nakhon Ratchasima province to allow more practical data collection and to ensure that the needed data are available on the desired local level and not only in a statistical manner. The change of the pilot cities resulted in a slight delay in the performance of all related work. However, the REEC work on survey and analysis could be completed in March 2006 well within the overall project timeframe.

The project team prepared a template with all needed information in the following fields:

1 Geography
2 Social-economical structure
  2.1 Population on a communal level
  2.2 Employment
  2.3 Household (national data or data from target areas)
  2.4 Poverty, livelihoods and well-being
  2.5 Area utilisation
  2.6 Building density and residential area
3 Waste management structure
  3.1 Current waste accumulation, quantity development and composition
  3.2 Organic waste
  3.3 Collection and transportation of organic waste
  3.4 Existing organic waste treatment
  3.5 Cost structure of the waste disposal
4 Industry
  4.1 Industrial situation:
  4.2 General data
5 Agriculture
  5.1 Crops
  5.2 Fertilizer
  5.3 Fuels from waste, respectively dried waste
6 Energy
  6.1 Technical energy data for PV:
  6.2 Technical energy data:
  6.3 Solar energy potential
    6.3.1 Industrial data:
    6.3.2 Private data:
7 Other documents
  7.1 Waste management documents, if exciting
  7.2 Maps

This template served REEC and NUOL as guideline for the data survey, whenever not all targeted data could be collected. The results of the data collection are presented in the chapters “Potential and Demand of Biomass and Solar Energy in Urban Areas” of the Lao and the Thai study.

The evaluation of the collected information was combined with the evaluation of the questionnaire on “Potential and Demand of RES in urban areas”. For more details see chapter II.4.3.6.

II.4.2.3 Task D2.03 Educational Demand

The NUOL and the REEC completed the evaluation of the educational demand based on the data collection list provided by DGS within the 3rd project quarter. Based on the results of the reports DGS selected relevant training courses for the local partners. DGS provided the selected courses to the local partners for their individual use within the fourth quarter. In the frame of the April travel DGS experts already gave lectures on biomass and PV solar for students and lecturers of the NUOL.

II.4.3 Task D3 Biomass to Energy Data Collection

II.4.3.1 Task D3.01 Report on agricultural land use and potential biomass production

Based on literature review, especially the evaluation of national statistics, CDEA and REEC prepared a comprehensive report on the agricultural land use and potential biomass production in Laos and Thailand. Results of this work can be seen on the project home page and in the final studies.

II.4.3.2 Task D3.02 Organic residues potential

Based on literature review, especially the evaluation of national statistics, CDEA and REEC compiled detailed information on the organic residues potential in Laos and Thailand. Results of this work can be seen on the project home page and in the final studies.

II.4.3.3 Task D3.03 Suitable Crops

The selection of the 5 most promisingly energy crops for Laos and Thailand was performed in the 4 steps explained below.

Step 1: List of potential energy plants for digestion

In a first step a list of agricultural crops worth to be planted were created for Thailand and Laos based on literature review and individual interviews. The crops were classified according to the vegetation period for the plant growth, the dry matter yield per hectare and the percentage of crude fibre, in order to estimate theoretically their degradation ability.

Step 2: Selection of the 10 Most Promisingly Energy Plants

After the overview about the potential energy crops was prepared, the next step was to select 10 energy crops for the cultivation tests. The selection criteria were not only the biogas potential and the yield per hectare but also local circumstances and habits. The main criteria for the selection of the energy plants for cultivation were:

- The degree of familiarity with the farmers

- Widely known among farmers – no new or exotic plants or varieties were selected.
- The appropriateness for crop rotation
- The capability for soil enrichment, as it is known of legumes
- The reduction potential of chemical fertilizer application

The following tables show the selected energy crops and the justification of their selection for Thailand and Laos.

Table 1: List and selection justification for the 10 most promisingly crops in Thailand

	Selected Crop	Justification
1	Rice	Rice is the main crop in Southeast Asia (SEA). Therefore it is necessary to have the overview about the possibilities of energy farming with rice as energy crop.
2	Napier grass	Napier grass is a common variety of grass in Thailand and SEA. It has a high potential for DM production. I can be cut every 6 weeks. So no silo for the storage of the biomass feedstock is necessary.
3	Water hyacinth	Water hyacinth is a weed in the rivers and lakes. With the harvest and the digestion and the utilization of the biogas a big problem can be solved in an economical feasible way.
4	Banana – leafs & stem	For future utilization of biomass from orchard or agroforesting the banana is a good example for the combination of biomass as feedstock for biogas plants and the fruit production for the market.
5	Papaya	There is an overproduction of papaya in Thailand. To reduce the overproduction the biogas production can be a solution. Is has to be evaluated, whether this is feasible or not.
6	Sugar cane	Sugar cane is a crop with a very high DM yield per hectare. In the state of full growth it is not suitable for biogas plants because of its high fiber content. Therefore it will be tested, whether the sugar cane in an earlier growing state is digestible.
7	Pumpkin	Pumpkin is an easily to grow vegetable with a high biomass yield. They can be grown only in the rainy season. So a combination with sorghum for the dry season can fit.
8	Sorghum	Sorghum is suitable for dry areas or dry seasons. This is a combination with pumpkin for the rainy season.
9	Bean	Bean is a fast growing vegetable and a leguminose. This plant has the potential to improve the soil. It can be in a energy crop rotation very valuable.
10	Cassava or corn	Corn or maize is the main energy crop for biogas in Europe. A comparison between Europe and Asia is possible. Cassava is the main crop for the feedstock for ethanol production in Thailand. A comparison of the feasibility for ethanol and for biogas benefits to future political decisions for energy farming.

Table 2: List and selection justification for the 10 most promisingly crops in Laos

	Selected Crop	Justification
1	Rice – beginning of flowering stage	Rice is the main crop in Laos. To get more basic data, rice will be harvested and the biogas yield tested in 3 growing stages: 1. beginning of flowering, 2. full flowering, 3. milky stage. It is expected, that in the milky stage the biogas yield is the highest. But to get information about the dry matter content during growing it is necessary to test different growing stages. We could not get information about the dry matter of rice in Laos. Even the agricultural experts had no knowledge about this.
2	Rice – full flowering stage	
3	Rice – milky stage	
4	Maize	Maize is the main crop in Germany and Europe as feedstock for biogas plants. Maize is also produced in Laos. Maize is selected as energy crop to have a comparison between European and Laos conditions. Maize has the biggest potential for the dry matter (DM) production as energy crop. On the other hand maize production can be a problem to the environment as groundwater pollution and soil erosion, if the cultivation is not proper done.
5	Grass; Panicum maximum, Variety:Si Muang	Grass as energy crop is easy to produce; no special technology is required. It has a high potential for DM production. I can be cut every 6 weeks. So no silo for the storage of the biomass feedstock is necessary. The national agricultural experts recommended cultivating for energy purpose the variety Si Muang.
6	Legume. Arachis pintoi Variety: Amarillo	Legume enriches the soil fertility and this fits to the objective to develop sustainable crop rotations.
7	Legume. Gliricidia sepium Variety: Retalhuleu	Legume enriches the soil fertility and this fits to the objective to develop sustainable crop rotations.
8	Legume. Stylosanthes guianensis Variety: Stylo 184	Legume enriches the soil fertility and this fits to the objective to develop sustainable crop rotations.
9	Soy bean	Soy bean is a common plant and easy to grow. The introduction as energy crop is easy. It can be used as oil crop, too. This gives the opportunity for a optimum feedstock ratio of fat, carbohydrates and proteins.
.10	Mung bean	Mung bean is easy to grow and the farmers are familiar with.

For each of the selected crops a profile was compiled with respect to its utilization as an energy crop.

Sept 3: Cultivation of the 10 Energy Crops

See chapter II.4.3.4 below.

Step 4: Selection of the 5 Most Promisingly Energy Crops

See chapter II.5.4 below.

II.4.3.4 Task D3.04 Cultivation of Energy Crops

The cultivation of the energy crops were step 3 of the energy crops selection.

The 10 selected crops were grown in Thailand according the following schedule.

Table 3: Plantation schedule for the selected crops in Thailand

N	Common name	Land preparation date	Date planted
1	Rice	15-Nov-05	22-Nov-05
2	Napier grass	15-Nov-05	22-Nov-05
3	Water Hyacint	15-Nov-05	22-Nov-05
4	Banana (leaf and	15-Nov-05	22-Nov-05
5	Papaya	15-Nov-05	22-Nov-05
6	Sugar cane	22-Nov-05	29-Nov-05
7	Pumpkin	22-Nov-05	29-Nov-05
8	Sorghum	22-Nov-05	29-Nov-05
9	Bean	22-Nov-05	29-Nov-05
1	Corn	22-Nov-05	29-Nov-05

The cultivation was under responsibility of REEC, which took care on the plantation by itself. The objective of the plantation was to determine the most suitable energy crops for further analysis. Thereby, it was of special interest to analyses the optimum harvest time for the single crops. Figure 6 documents the crop cultivation on the REEC research centre.

Figure 6: Monitoring of the energy crop cultivation in Thailand

The 10 selected crops were grown in Laos according the following schedule.

Table 4: Plantation schedule for the selected crops in Laos

N	Description	Month 2005			Month 2006					Remarks
		10	11	12	01	02	03	04	05	
Rice production										
1	Land preparation									
2	Seed sowing									Fertilizer rate
3	Transplanting									N P K = 60- 90-60
4	Tinning									
5	First top dressing									Fertilizer use:
6	Second top dressing									Urea 46%
7	Flowering initiation stage									P2O5 46% =
8	Flowering full stage									KCL 60%. =
9	Harvest									
Maize production										
1	Land preparation									
2	Fertilizer apply before planting									Fertilizer rate
3	planting									N P K = 60- 60-90
4	Tinning									
5	First top dressing									Fertilizer use:
6	Second top dressing									Urea 46% =
7	Flowering Initiation stage									P2O5 46% =
8	Full flowering stage									KCL 60%. = 60kg/ha
9	Harvest									
Mung Bean production										
1	Land preparation									
2	Fertilizer apply before planting									Fertilizer rate
3	Planting									N P K = 60- 90-60
4	Tinning									Fertilizer use:
5	First top dressing									15-15-15 =
6	Second top dressing									P2O5 46% = 46%
7	Flowering Initiation stage									
8	Full flowering stage 100%									
9	Harvest									
Soy Bean production										
1	Land preparation									Fertilizer rate
2	Fertilizer apply before planting									N P K = 60- 90-60
3	Planting									Fertilizer use:
4	Tinning									Urea 46% =
5	First top dressing									P2O5 46% =
6	Second top dressing									KCL 60%. =
7	Flowering Initiation stage									
8	Full flowering stage									
9	Harvest									

The cultivation was under responsibility of CDEA, which co-operated with agricultural researchers from various Lao institutes and local farmers. The objective of the plantation was to determine the most suitable energy crops for further analysis. Thereby, it was of special interest to analyses the optimum harvest time for the single crops.

II.4.3.5 Task D3.05 Cultivation and harvest technology

CDEA and REEC prepared each one report on available cultivation and harvest technologies and their costs for the five selected energy crops. For each crop the following information was gathered:

- Production pattern
- Cultivation technology
- Land preparation costs per hectare
- Harvest technologies
- Harvesting costs per hectare
- Production costs per hectare

II.4.3.6 Task D3.06 Potential and Demand of RE in urban areas

One data sheet and one draft questionnaire on potential and demand on RE and one draft questionnaire on the potential of EnergyFarming were developed by the partnership as basis for the data collection in the agricultural belts of these cities.

Laos

In order to get a general picture on the potential and demand of biomass and solar energy in urban areas Vientiane Capital as the major urban area of the country was surveyed in detail. By means of individual interviews, surveys, questionnaires and literature reviews information on the energy demand and consumption in Vientiane Capital were collected.

Figure 7: Map of Vientiane Capital City

The three main tools for data collection in Vientiane capital were:

- A data survey on the geography, social-economical structure, waste management structure, industry and agricultural sector performed by the NUOL.
- A questionnaire on the potential and demand of PV and biomass based renewable energies in the industry sector involving 75 companies and

- A questionnaire on the energy consumption patterns of private households involving 100 households.

By the means of two questionnaires the following information were collected:

- A - General Information
- B - Energy Situation
- C - Potential of RE application
- D - Acceptance of RE

Thailand

In order to get a general picture on the potential and demand of biomass and solar energy in urban areas two typical pilot cities, one with a more urban and one with a more peri-urban character were surveyed in detail. The two pilot cities were Phanusnicom District (also called Phanat Nikhom district), in the Chonburi province and Siekew District (also called Sikhio district) in the Nakhon Ratchasima province, as for the survey of the organic fertilizer market (See Figure 10 and Figure 8).

Province Chon Buri

1. Mueang Chon Buri
2. Ban Bueng
3. Nong Yai
4. Bang Lamung
5. Phan Thong

6. Phanat Nikhom

7. Si Racha
8. Ko Sichang
9. Sattahip
10. Bo Thong
11. Ko Chan

Province Nakhon Ratchasima

1. Mueang Nakhon Ratchasima
2. Khon Buri
3. Soeng Sang
4. Khong
5. Ban Lueam
6. Chakkarat
7. Chok Chai
8. Dan Khun Thot
9. Non Thai
10. Non Sung
11. Kham Sakaesaeng
12. Bua Yai
13. Prathai
14. Pak Thong Chai
15. Phimai
16. Huai Thalaeng
17. Chum Phuang
18. Sung Noen
19. Kham Thale So

20. Sikhio

21. Pak Chong
22. Nong Bun Mak
23. Kaeng Sanam Nang
24. Non Daeng
25. Wang Nam Khiao
32. Chaloem Phra Kiat[1]
26. Thepharak
27. Mueang Yang
28. Phra Thong Kham
29. Lam Thamenchai
30. Bua Lai
31. Sida

Figure 8: Maps of the Chon Buri and Nakhon Ratchasima province

By means of individual interviews, surveys, questionnaires and literature reviews information on the energy demand and consumption in the pilot areas were collected. The two main tools for data collection were:

- A data survey on the geography, social-economical structure, waste management structure, industry and agricultural sector performed by the REEC.

- A questionnaire on the potential and demand of PV and biomass based renewable energies in the industry sector involving 76 companies and

By the means of the Questionnaire the following information were collected:

- A - General Information
- B - Energy Situation
- C - Potential of RE application
- D - Acceptance of RE

The results of both questionnaire actions and the Task D2.2 survey are presented in the respective parts of the final studies.

II.4.3.7 Task D3.07 Organic Fertiliser Market

One questionnaire on the potential of EnergyFarming was developed by the partnership as basis for the data collection in the agricultural belts of these cities. Interviews with the EnergyFarming questionnaire were performed by CDEA. The interviews and data collection was finished in January 2006.

Laos

Laotian partners CDEA performed and evaluated one questionnaire action in the two Lao pilot cities, Vientiane and Santhong. DGS and the Lao partners jointly developed the questionnaires on “Organic Fertiliser” during the project visit in January. Two questionnaire surveys and a literature review were performed to collect information on the organic fertilizer market in Laos. All focused on Vientiane Capital considering especially the potential of fertilizer application in urban areas.

Farmer Survey

A total of 72 farmers were interviewed in the peri-urban districts of Saysetha and Hadsayfong and a further 25 in the urban districts of Sikhot and Chanthabouly (Figure 9). The questionnaire comprised five sections: 1. general information on the size and seasonality of farming; 2. potential of energy farming; 3. fertilizer use; 4. perceptions of energy farming; and 5. community organization and farmers involvement in village level development activities. Care was taken to ensure that all questions, including technical terminology, were clearly explained to respondents with technical and new concepts translated by the survey team.

Organic Fertilizer Survey Consumers and Dealers

The second questionnaire based on a Canadian project survey in 2004 and targeted consumers and retail shops. In total sixteen shops selling organic fertilizer were surveyed: 4 are located half-way to the airport, 8 are along Phousinaun road, 2 on the road to the Friendship Bridge and the final 2 on the Phoukang road, 13 km to the South.[1]

Selected districts to survey

Figure 9: Map of Vientiane Municipality showing survey locations

Thailand

One questionnaire surveys and a literature review were performed to collect information on the organic fertilizer market in Thailand. Two pilot cities were selected as pilot areas for analysis. The two pilot cities were Phanusnicom District (also called Phanat Nikhom district), in the Chonburi province and Siekew District (also called Sikhio district) in the Nakhon Ratchasima province. The first city, Phanusnicom, covered an area of 448 sq. km with a population of 116.939. Population density is 261 persons/sq. km. The second city, Siekew, covers an area of 1.247 sq. km with a population of 97.019. Population density is 78 persons / sq. km. Phanusnicom District is considered to be an urban area with some farming area surrounding the city. This is a typical type of district in Thailand. Small city population lives near to the farming area. The farming size is rather small in Thailand; therefore, farmers live near to the main city. Siekew district is considered to be rural district, a city with a peri-urban structure.

A total of 70 farmers were interviewed in the peri-urban district of Sekiew and a further 25 in the urban districts of Phanusnicom. The questionnaire comprised five sections: 1. general information on the size and seasonality of farming; 2. potential of energy farming; 3. fertilizer use; 4. perceptions of energy farming; and 5. community organization and farmers involvement in village level development activities. Care was taken to ensure that all

[1] Previously 23 nurseries operated but now there are only 16. This decline is predominantly caused by

questions, including technical terminology, were clearly explained to respondents with technical and new concepts translated by the survey team.

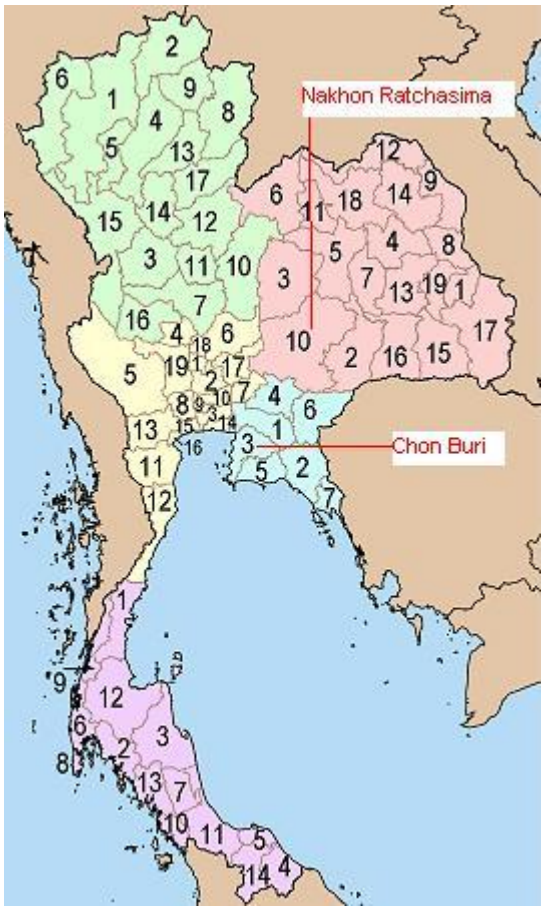


Figure 10: Map of Thailand highlighting Chon Buri and Nakhon Ratchasima

The results of both questionnaire actions are presented in the respective parts of the final studies.

II.5 Task E Laboratory Analysis

II.5.1 Task E1 Lab digester design

The digesters for the laboratory analysis were designed by DGS, REEC and NUOL in the first project quarter. Parallel, they developed a detailed research schedule and started the construction of the lab digester. The digestion tests of five selected energy crops are scheduled on January 2006.

II.5.2 Task E2 Lab equipment manufacturing

The digesters for the laboratory analysis were constructed by REEC in Thailand and NUOL in Laos. REEC developed and constructed six gas flow meters for the NUOL and seven

road construction with the shops forced to move their location

units of gas flow meter and seven lab digestion tanks for its own experiments. The seventh unit of those are for sludge inoculums and would be used for the correction of the gas flow calculation. NUOL constructed six lab digestion tanks. The NUOL and the REEC laboratory analysing units comprise of one heating tank, one water pumping system, one heating system and six respectively seven digesters. The function of the laboratory analysing units of REEC and NUOL were tested by DGS staff in February 2006. In February, Water Danner (DGS biogas expert) visited the REEC and NUOL laboratory and trained the staff responsible for the digestion tests in all necessary matters. One full day lecture was delivered to the REEC and one to the NUOL project staff. This method would ensure that experiment would be performed according to the DGS work programme and international standards and hence be reliable and repeatable.

II.5.3 Task E3 Research plan according

The DGS guided the National University of Laos (NUOL) to design and perform the fermentation trials according the German VDI Guidelines 4630 “Vergärung organischer Stoffe” (Fermentation of organic substances) (VDI, 2004). All data on the trials were collected according the VDI guideline.

II.5.4 Task E4 Selection of the 5 most promisingly energy crops

As a fourth step of the energy crop selection describes in chapter II.4.3.3 the five most promisingly energy crops were chosen for the biogas trials. In order to select those plants their in a first stage the relevance of the single crops in the daily usage was considered as it is very important to use crops that the farmers are already familiar with, know how to grow and harvest them, and were they already have experience with. As the farmers already use these crops, they are the easiest ones to implement. The second criterion was the expected biogas yield of the single crops. Based on these requirements the following crops were selected:

Table 5: 5 Most Promisingly Energy Crops in Laos and Thailand

Thailand	Laos
• Maize	• Rice – milky stage
• Water hyacinth	• Soy bean
• Banana – leafs & stem	• Sweet corn (as food)
• Papaya	• Corn – ripe stage (as forage)
• Sugar cane	• Mustard

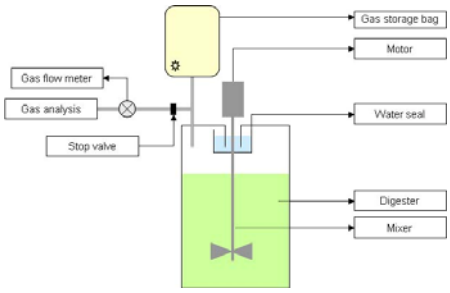
II.5.5 Task E5 Digestion tests in Thailand and Laos

The laboratory analysis started in Thailand on April 12th and in Laos on March 14th. In Thailand first 3 parallel trials with maize and water hyacinths and one zero experiment with inoculum were conducted. In Laos, the NUOL started to analyse the digestibility of sweet corn, soybean, rice- late flowering stage (50%), rice-early milky stage, corn-old, corn - young stage, rice - young stage and mustard. The data of the trials were delivered to the DGS. The

laboratory equipment including the gas meter were developed and constructed in the frame of the reported project. Due to several reasons as material availability, design adjustments of the gas flow meter, training of the Asian partners the laboratory analysis could only be started 3 month behind their scheduled start in January 2006, but despite this scientifically the research was completely done.

Digestion trial set up

The digestion trials in Laos were performed in 6 batch digesters with a volume of 20 l under mesophilic conditions. The set-up of the single digesters and the principle set-up scheme of the trials are shown in Figure 11 to Figure 13.



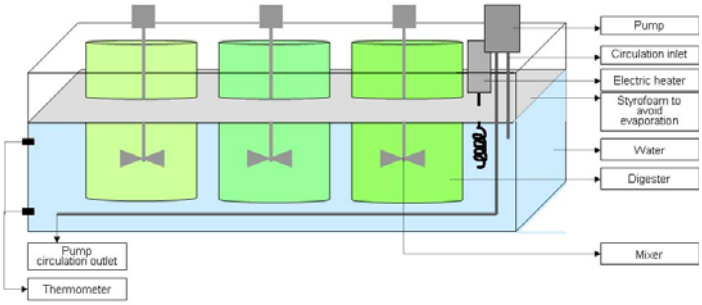


Figure 11: 20 l Digester set-up **Figure 12: Principle set-up scheme**

Figure 13: Lao laboratory set-up

The Lao laboratory equipment comprises of the following components:

- Heating tank sized: height x length x width (m) = 0.7 x 1.4 x 0.7, insulated with 2-cm foams and coating by galvanized steel sheets.
- Water Pumping system for water circulating inside the tank.
- Heating system consists of 4 heating elements, which are automatically switching on and off by a thermo-regulator for getting necessary temperature in the tank
- Digesters are made off 6 drinking water gallons, each has volume of 20 litters
- 6 gas meter designed and manufactured by the Thai partner REEC

- 6 gas bags provided by the TU Muenchen-Weihenstephan.
- Suspension plates fort the 6 digesters

The Thai laboratory equipment comprises of:

- Water Pumping system for water circulating inside the tank.
- Heating system consists of 4 heating elements, which are automatically switching on and off by a thermo-regulator for getting necessary temperature in the tank
- 6 stainless steel 20 l digesters
- 6 ISUZU MT3-12 motors for agitation
- 6 gasmeters and 6 gas bags

Figure 14: Thai laboratory set-up

The biggest challenge was the design of a gas flow meter. The REEC team developed two gas flow meters. The first version only had a limited capacity which made the development of a second version necessary. The 1st design gas flow meter functions as follows: The gas flows into a water filled column, where the gas forms a gas bubble which is automatically counted. Calibrations before testing showed that each gas bubble is equal to 12 ml of gas. In case the bubbles flow to quick in the water column the counting is not anymore correct as the counter is not able to count every bubble.

The second gas flow meter functions as follows: The generated gas is accumulated in a small cup which is divided into two compartments. When one of the compartments is filled up with a certain volume of gas, the cup is lifted up and rotates to release the gas to exhaust pipe. Upcoming gas is filling up another compartment until next rotation. Each rotation of the cup axis represents a fixed volume of gas. Axis rotation is detected using digital counter. Each gas flow meter was accurately calibrated before tests in the REEC laboratory.

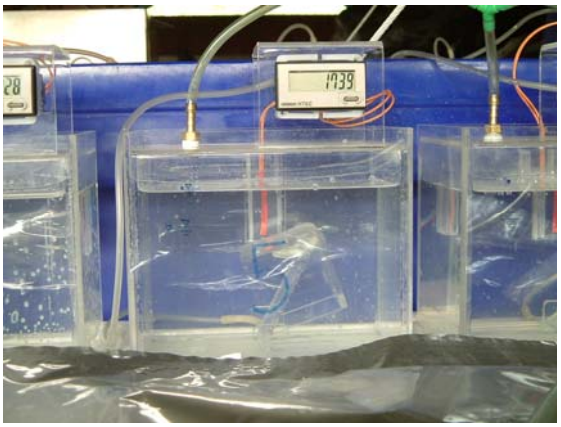


Figure 15: Gas flow meter (left: 1st design, right: 2nd design)

The digestion trial performance is described in detail in the chapters “Biogas potential of the five most promisingly energy crops” of the final studies.

II.5.6 Task E6 Comparison of the Results with Literature Values

The comparison of the results, its discussion (task E7) and the preparation of the final report (task E8) was performed jointly by REEC, NUOL and DGS. All results are documented in the chapters “Biogas potential of the 5 most promisingly energy crops” of the final studies. Anyway, the main results are presented below.

Laos

Due to short project period of one year only one sample per crop could be tested. Biogas yield tests are time consuming, because each test takes minimum 30 days retention time in the laboratory digester and one week for preparation. Therefore the results give the first direction of biogas yields of Laotian energy crops.

FE/NUOL staffs were inexperienced in biogas technology, therefore, there were many inaccuracies incurred within the tests,

- Each material was tested for digestion for one time in single digester only, therefore, no parallel data to compare with;
- Biogas outputs of inoculum were not tested in parallel and therefore, unable to be excluded from the recorded results;
- Gas analysis was not done during the testing times (the gas components were analyzed several weeks later).

Anyway, the received data give a first insight in the biogas potential of the selected energy crops and are a sufficient basis for the further calculation within this study. In the results of the biogas yield test are shown in the table below.

Table 6: Test results of the different samples

		Formed gas Volume V in l	Feeding rate in kg	Dry Matter in %	Volatile Solid in %	Biogas yield per ton of VS in m^3	Methane (CH_4) content
1	**Sweet Corn**	544	0,3	24	91	396	55%
2	**Soy bean**	239	0,3	12	86	823	52%
3	**Flowering Corn**	837	0,3	24	91	609	50%
4	**Milky Rice**	280	0,3	25	93	217	53%
5	**Old Corn**	1.286	0,3	33	91	1287	51%
6	**Milky Corn**	323	0,3	25	91	245	52%
7	**Mustard**	141	0,3	25	91	107	52%
8	**Young Corn + Mustard**	131	0,3	32	90	125	50%
9	**Milky Corn + Mustard**	974	0,3	33	90	964	51%
10	**Flowering Corn + Mustard**	145	0,3	32	90	139	52%
11	**Canteen Waste**	147	0,3	32	90	141	53%

These are the first locally produced laboratory results and need further evaluation by more biogas yield tests.

Result Discussion

The results of the laboratory test were compared with available literature values mainly from the KTBL to verify the obtained data. The KTBL, Kuratorium für Technik und Bauwesen in der Landwirtschaft, German paper „Gasausbeute in landwirtschaftlichen Biogasanlagen“ (Biogas yield in agricultural biogas plants) is the most comprehensive overview worldwide on energy plant properties.

Table 7: Comparison of test results with literature values

	Crop		Dry Matter in %		Biogas yield per ton of VS in m^3		Methane (CH_4) content	
	Study	KTBL	Study	KTBL	Study	KTBL	Study	KTBL
1	Sweet Corn	corn silage	24	32	396	642	55%	
2	Soy bean		12		823		52%	
3	Flowering Corn	corn silage	24	32	609	642	50%	
4	Milky Rice	Rice silage	25	29	217	664	53%	
5	Old Corn	corn silage	33	32	1287	642	51%	
6	Milky Corn	corn silage	25	32	245	642	52%	
7	Mustard	Fresh mustard*	25		107	300	52%	
11	Canteen Waste	Kitchen waste	32	16	141	680		

*Source for fresh mustard: not KTBL but Gunaseelan (1997)

- The results of sweet corn (1) with 396 m^3/to VS and flowering corn (3) with 609 m^3/to VS are quite reasonable in comparison to the standard in Europe. The figure of milky corn (6) is too low.
- Due to the different DM and different varieties of corn the biogas yield are not comparable. The main difference is that the KTBL value is the mean of 17 lab results, while the NUOL figures are a result of one test and each figure stands alone.

- Soy bean shows a very high biogas yield. No European laboratory biogas yield test is available. No data could be obtained from other papers. From the practical experience and due to the high protein content of soy beans the findings sounds reasonable.
- Milky rice is the most interesting crop, because rice is the main crop in Laos. The produced figure is unreliable, if it is compared to the biogas yield of rye silage in Germany according KTBL. The expected biogas yield was three times higher as the measured output. Additional tests are required to verify this figure.
- Old corn (5): This figure is too high in comparison to KTBL.
- Mustard (7): The biogas yield is very low. Figures from 1986 show the double biogas yield.
- Canteen waste (11): This figure is much too low in comparison to KTBL food waste digestion results
- Mixed biomass (8,9,10): No assessment is possible, because no data for a comparison exist

According to the information of the NUOL team this was the first time that biogas yield tests with energy crops and waste were conducted. Many difficulties arose due to the inexperienced local team. The guidance from Europe couldn't fill this gap. After the first set of tests in the project other tests should follow. The equipment has to be improved to avoid leakages. The low biogas rates leads to the idea, that the laboratory digesters were not completely sealed.

The measured data are not suitable to use them for feasibility calculations. It is recommended to use the KTBL data for feasibility calculations until reliable data from Laos are available.

Thailand

These net gas productions were used to calculate biogas yields in Table 8.

Table 8: Test results of the different samples

		Gas Volume (litre/30 days)	Feeding rate (kg fresh)	oDM/m^3 (kg)	Dry Matter (%)	Volatile Solid in (Estimated) (%)	Biogas yield per ton of VS (m^3)	Methane (CH_4) content (%)
1	**Maize**	26.18	0.303	3	22	90	436	48.9
2	**Water hyacinth**	1.78	0.317	1	7	90	89	49.6
3	**Babana**	26.32	0.512	3	13	90	438	52.6
4	**Papaya**	35.77	0.444	3	15	90	596	53.5
5	**Sugar cane**	23.11	0.312	3	17	90	385	52.5
6	**Maize + Water hyacinth**	26.13	0.554	3	12	90	435	48.5

Discussions

Results of the experiments performed in three batches were satisfactory. Each crop was tested with three replications. It was found that all three replications gave similar results. Results shown in Table 2-19 showed the biogas yield per ton of volatile solid or ton of organic dry matter (oDM). The following conclusions can be drawn:

Papaya gave the highest biogas yield compared to other crops used in the experiment. It gave 596 m^3 biogas /ton of VS with 53,5 % methane content.

Maize and banana gave similar gas production of 436 and 438 m^3 biogas /ton of VS. The methane contents of maize and banana were 48,9 % and 52.6 % respectively.

Biogas production of water hyacinth was the lowest compared to others. It gave biogas yield of 89 m^3 biogas /ton of VS with 49,6 % methane content. When water hyacinth was mixed with maize, the combined substrate gave 435 m^3 biogas /ton of VS with 48,5 % methane content. The combination was mixed using 12 % DM. This showed advantage of using water hyacinth as additional water to corn which contained 22 % DM. Mixing the water hyacinth with other crops that contained high dry matter would reduce water consumption for mixing.

The results of the laboratory test were compared with available literature values. Table 9 shows the methane production calculated from data in Table 8 and average literature values.

Table 9: Comparison of study and literature methane yield values of the selected crops

Crop	Study Results	Average Literature Values	Source
Maize	213,20 m^3 CH4/ton of VS	316 m^3 CH4/ton of VS	FNR
Water hyacinth	44,14 m^3 CH4/ton of VS	45 m^3 CH4/ton of VS	Kunst et al*
Banana	230,39 m^3 CH4/ton of VS	400 m^3 CH4/ton of VS	KTBL**
Papaya	318,86 m^3 CH4/ton of VS	400 m^3 CH4/ton of VS	KTBL**
Sugar cane	202,13 m^3 CH4/ton of VS	260 m^3 CH4/ton of VS	Lehtomaki

*calculate based on the given biogas yield value: 100l/kg dry matter (calculation basis: VS=90 %, methane: 50%)

**KTBL values for fruits, no information on papaya and Banana available

The tested results above showed that maize, banana, papaya and combination of maize and water hyacinth gave biogas yields similar to the reference figure of vegetable waste. However, the gas yield of Maize obtained in the experiment was lower than the reference figure. Also gas yield of sugar cane was lower than the reference figure. However, the values of oDM loading of those reference figures were not available.

During the first experiment, the effect of inoculum was significant. Therefore, more tests with maize and water hyacinth should be further conducted to obtain more information.

Overall results showed that the use of crop residues as energy crop is feasible in terms of biogas potential.

There are many other crop residues in the Thai agricultural system. Those residues include pumpkin fruit, water melon fruit. These residues are left in the fields after harvesting as they

have unsuitable sizes for market. Therefore, utilization of crop residues has high potential for renewable energy production.

The experiments performed during this project used a load of 3 kg oDm. Further tests should be done for different organic loads. These tests could not be done during the project due to time constraints.

Database of biogas yield for energy crops and suitable crop residues for Thailand should be done. This requires a few years of tests and survey.

II.5.7 Task E7 Discussion of the lab results within the TF Biomass

See Task E6.

II.5.8 Task E8 Report

See Task E6.

II.6 Task F Technology Survey

II.6.1 Task F1 Data Sheet Development and Data Collection

For the collection of information on appropriate technologies (PV Solar, biogas, co-generator) data sheets were developed.

II.6.2 Task F2 Demand Analysis

In the frame of the mid-term project meeting the Asian partners presented the results of their different surveys of the present situation in their countries. Based on this presentation the demand analysis was performed jointly during and after the meeting.

II.6.3 Task F3 Identification of Appropriate European Technologies

A questionnaire for technology providers was implemented in the home page to collect basic information on available biogas and solar energy technology for the Technology survey. In February 2006 a special newsletter was sent to the DGS news-network to announce the publishing of the questionnaire for technology providers. The questionnaire was also announced to a broader audience with the 2nd project newsletter in March 2006.

Unfortunately, the resonance of this campaign was very limited. Therefore, additionally European suppliers were contacted by a mailing and asked to provide technical data on their technologies by a mailing. The provided information was catalogued by the DGS and is available upon request for all project partners.

The evaluation of the results of the demand analysis and the provided data of the European companies showed that most of the European technologies, especially the available biogas and co-generation technologies are not suitable for Laos. The suitable PV and Biogas technologies for Laos and Thailand are described in the final studies.

II.6.4 Task F4 Identification of Appropriate Local Technologies

Based on the general data collection (see D1.6 and D1.7) appropriate technologies or applications for replication were identified and compiled. Based on this evaluation the information on the identified suitable technologies or combinations of technologies was used for the development of the strategies of the final studies.

II.7 Task G PV&Biomass Study Development

The last part of the project work was the development of each one study on study on solar and biomass energy potential and feasibility in Laos and Thailand.

The study consist of the following three main parts: a description of the present situation, a strength, weakness, opportunity and threat (SWOT) analyses and strategies for the implementation of solar and biomass energy in Thailand and Lao PDR. Based on the reports of the Asian partners a first interim paper was developed and discussed during the mid-term meeting. This first draft mainly included external information. It was further developed based on the results of the mid-term meeting discussions and the results of the performed surveys, questionnaire, crop cultivation and biogas trials. This study version was the basis for the organisation of the 2nd stakeholder workshops. During these workshops and the final project meetings very important information was collected to finalise the study.

II.7.1 Task G1 Present Situation Chapter

All collected data were compiled in the present situation chapters of the Thai and Laos study. The finalising of the study was performed in the last project quarter involving all project partners. The first chapter of the study contains information on the following subjects:

- Relevant institutes
- Legislation
- Statistics and cost structure of the energy sector
- Potential and demand of biomass energy in urban areas
- Financing and funding possibilities
- Grid technology and feed in conditions
- Solar Energy specific Data Collection
    - Meteorological solar irradiation data
    - Research and development, pilot projects and studies
    - Available technologies
    - Educational demand for operators and applicants of the technology
- Biomass to Energy specific Data Collection
    - Biomass with energy potential
    - Research and development, pilot projects and studies
    - Available technologies
    - Demand and cost structure of the organic fertiliser market

II.7.2 Task G2 SWOT Analysis

The SWOT (strength, weakness, opportunity and threat) analysis is the most important part of the study. The main headlines of the SWOT analyses were:

- PV Solar
- Biomass
- Legislation

The SWOT analysis was performed as an ongoing process, which started in the frame of the mid-term meeting and was finalised within the final meeting and the 2nd stakeholder workshop. Especially, the involvement of the stakeholders with the knowledge on the local conditions brought very interesting aspects in the SWOT analysis.

In order to enable the stakeholders to participate in the SWOT analysis the 2nd stakeholder workshops started with a presentation of the collected data and findings. In small discussion groups the stakeholders worked on the themes: legislation, rural electrification and use of PV solar and EnergyFarming as renewable energy sources for urban areas. Every group was provided with information on the main findings and some provocative questions. For details see the attached stakeholder workshop documentations.

Table 10: SWOT Matrix

	Strengths	Weaknesses
Opportunities	S-O strategies pursue opportunities that complement the companies strengths.	W-O strategies overcome weaknesses to pursue opportunities.
Threats	S-T strategies identify ways in which the firm can use its strengths to reduce its vulnerability to external threats.	W-T strategies establish a defensive plan to prevent the firm's weaknesses from making it highly susceptible to external threats.

II.7.3 Task G3 Strategy development

The last part of the study shows economical, technical and legislative strategies for renewable (solar and biomass) energy application for Lao PDR and Thailand. It was developed by the European project partners based on the results of the discussions with the Asian project partners in the frame of the final meeting and on the results of the 2nd stakeholder workshop. The draft study was send to the Asian project partners and finally discussed with them during the individual meetings between DGS and the Asian partners in November 2006. Subsequently DGS finalised the study co-ordinated its distribution via the project home page and locally as CD on demand by the Asia partners.

The final strategies are presented in chapter 4 “Strategies for the implementation of Solar and Biomass Energy” or each study.

III Partnership

The REEC was responsible for all the Thailand related work. The distribution of the responsibilities between the three Lao partners was changed to the proposal after the kick-off meeting. RESDALAO consist of high experienced staff from different sectors. Some of them were former high ranking public servants. Their relationships with the government officials are an excellent facility for an access to information and for the simplification of organizational belongings. Thus RESDALAO was appointed to be responsible for the general data collection. CDEA is often working in rural development together with farmers and farmer groups and was responsible for the biomass data collection. NUOL has long term experience in PV solar and was the only partner with own research facilities and took over the PV solar data collection and the laboratory analysis of the energy crops selected by CDEA. Additional to the Environmental Technology group headed by Prof. Wim Rulkens, the Environmental Policy group headed by Prof. Arthur Mol are involved for WU in the project as requested by the European Commission in the frame of the contract award procedure. The environmental policy group was involved in the preparation and performance of the stakeholder workshops and the development of the report on relevant laws and guidelines in Thailand and Laos. The main role of the environmental technology group was backstopping and supervision of project reports in the field of biomass. DGS was the leading project partner and managed the overall project performance. The different DGS experts were involved in the development of all activities of the reporting period. They developed questionnaires, data sheets and research planes and backstopped the project work of the local partners. The responsibilities of the different partners are detailed below.

REEC

The main role of Renewable Energy and Environment Centre (REEC) was to perform project activities in Thailand. Those activities included data collections and reporting, coordination with stakeholders in implementing project activities, and conduction of tests as specified in the project task lists. Another role was to cooperate with other partners, e.g. Lao partners. REEC designed and built gas flow meter for digestion tests in Laos. Exchange of information and experiences with Lao partners were also accomplished. Least but not last, exchange view and ideas with EU partners was also done.

The main strength of REEC was the capability to design and build laboratory test units by its technical staff. Therefore, experiments were proceeded without serious problems. Repair, correction and replacement of damaged lab facilities were managed by REEC without delay or having time loss to wait for spare parts. All equipment built for tests in the project were locally made. Methodologies used in the experiments were adopted from standard procedures recommended by DGS experts. This resulted in an excellent capacity building process for REEC staff to continue working in this area after the project end.

NUOL

The role of the NUOL in the project implementation can be described as followed:

- Facilitated the kick-off and final meetings, hosted some activities where were possible.
- Facilitator of the specially organized for EU partners study tour.
- Participation in stakeholder workshops' activities. At these workshops NUOL team was responsible for (1) presenting current situation of energy resources, energy supply and consumption in Lao PDR; (2) moderating presentation of the project study results and (3) presenting groups discussion results.
- Literature review and interview to gather information on current status of solar PV and biogas technology application in Lao PDR; data sheet and reports were prepared.
- Pilot areas selection, questionnaires action and pre-evaluation for study of renewable energy in selected areas. Some mechanical students were involved into this questionnaires action.
- Reports on potential and demand analyses of solar energy and biomass in selected areas
- Reports on agriculture organic residues and husbandry wastes in Lao PDR;
- Suggestion on education demand for renewable energy technology; new strategy for solar energy for Lao PDR.
- Fabrication of lab digester, anaerobic testing; results evaluation and report

CDEA

The main role of CDEA was the organisation of the Lao stakeholder workshops, the performance of the EnergyFarming related data collection and the cultivation of the selected energy crops. CDEA's main activities were:

- Organisation, performance and reporting of 2 stakeholder workshops in Laos.
- Co-operation in the development of questionnaires to evaluate the potential and demand of renewable energies of farmers.
- Performance of the farmer questionnaire action and evaluation of the results in co-operation with the WU and the DGS.
- Development, performance and evaluation of one survey on the organic fertilizer market in Vientiane Capital.
- Organisation, performance and documentation of the energy crop cultivation and harvest for the biogas trials.
- Development of reports on:
    - D3.1 Agricultural land use
    - D3.3 Suitable Crops
    - D3.4 Crop Cultivation
    - D3.5 Cultivation and Harvest Technology
    - D 3.7 Organic fertilizer market

RESDALAO

The main role of RESDALAO was the performance of the general data collection in Laos. Additionally, the RESDALAO team participated in the stakeholder workshops, linked the project team with the relevant Lao governmental organisations and contributed to the SWOT analysis and the study development. RESDALAO prepared reports on the following subjects:

- Task D1.2 Laws and Guidelines
- Task D1.3 Statistics and cost structure of the energy sector
- Task D1.4 Of-grid and feed-in conditions
- Task D1.5 Financing and Funding
- Task D1.7 R&D projects

WU

The Wageningen University (WU) team has contributed to the gathering of information and the development of new knowledge over renewable energy in Southeast Asia:

- Clearer assessment and review of policy and law for renewable energy in Lao PDR and Thailand
- Some of the first empirical social information gathering about renewable energy in Lao PDR
- A clear understanding of who the key stakeholders are in the development of existing forms of RE (such as PV Solar) and new forms of RE (such as energy farming).
- Greater awareness and understanding by project participants of integrating technical aspects of renewable energy production with social and political aspects.
- Clear policy recommendations have been developed for Lao PDR that directly addresses the technical and socio-political needs for continued success of the renewable energy sector.
- Ongoing partnerships have been built up with Asian partners through new MSc student projects addressing some of the research recommendations put forward within the project.
- Expansion of research through MSc research has been developed in other countries of Southeast Asia – applying a similar methodology to the social analysis carried out in the project in the Philippines.
- Input with regard to research methods in the field of testing digestibility of plant materials.

As with many short research projects it is difficult to assess the specific impact of WUR inputs on the target groups. Nevertheless, given the knowledge developed by the Lao project partners it is likely that renewable energy policy and extension practice will be more effective in the future. Both state and private sector service providers have been able to critically reflect on the activities of both their own extension work and the work of other organisations. As users of RE in rural and urban areas are the direct recipients of these activities they are likely to benefit.

DGS

DGS as applicant was responsible for the overall project management, the external communication and the communication and reporting with the European Commission. The involved PV and Biomass experts steered the data collection and backstopped the work of the Lao partners in all three main project fields: general, PV and Biomass data collection.

The main activities of the DGS were:

- Implantation and maintenance of the project home page.
- Co-organisation of the stakeholder workshops in Laos and Thailand.
- Backstopping of the data collection of the Asian partners including report review.
- Co-operation in the questionnaire development for Laos and Thailand for farmers and companies.
- Planning and organisation of all energy crop related research as crop cultivation and biogas trail performance.
- Evaluation of all reports and research results form the Asian partners.
- Co-ordination of the SWOT analysis.
- Preparation of the final studies for Laos and Thailand based on the reports of the Asian partners.
- Evaluation of the present situation, finalising of the SWOT analysis and development of strategies for the implementation of PV and biomass based RE in Laos and Thailand.
- Co-ordination of the project work with third parties and promotion of the interim and final project results.

IV Methodology and Effectiveness

The implementation of the project was be conducted through a variety of methods and instruments, partnership meetings, stakeholder dialogue, task force work and internal long-distance communication using the homepage, email, fax and telephone. The DGS project manager linked up carefully those methods with each other and organise them in the right sequence during the different project phases.

In order to facilitate the co-ordination of the work a detailed task list was developed by DGS and uploaded to the project home page (see Appendix 10). The task list described the content, outputs, responsibilities and deadlines of every sub-task of the 7 Main tasks (A-Project Management, B-Stakeholder Workshops (WS), C-Homepage and Data Base, D-Data Collection, E-Laboratory Analysis, F-Technology Survey and G-PV&Biomass Study development). The task list was part of the project manual. The task list could be accessed by the project partners on the internal page of the project home page: http://www.dgs.de/1197.0.html (username: ape, password: ape). The home page gave not only an overview about the open tasks but also describes them in detail and showed which tasks are completed. Additionally to the home page, the DGS informed the partner frequently by email about open tasks and deadlines. The home page with its interactive up- and download area was the main project management tool.

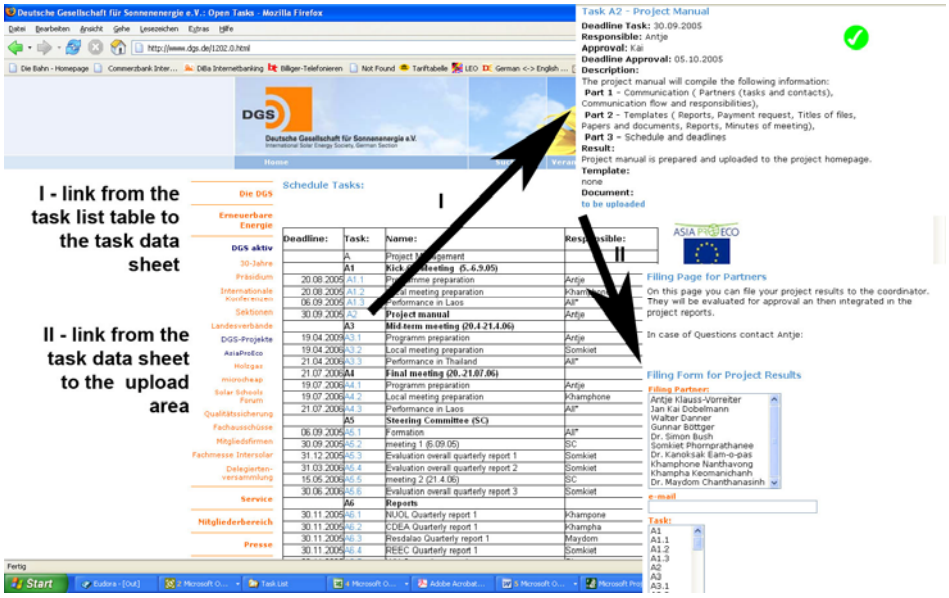


Figure 16: Interactive task list

Next to the task list the project manual (see Appendix 11) was developed by the DGS management. The project manual was not only the basis for the implementation of the single project activities, but also for the evaluation of the project progress. In order to avoid mistakes and problems with the classification of the different data, a clear ID-identification was developed and used.

Additionally to the long-distance communication 3 project meetings were performed: The kick-off meeting in Laos in September 2005, the mid-term meeting in Thailand in April 2006 and the final meeting in Laos in July 2006.

The steering committee was established during the first project meeting. Kai Dobelmann (DGS), Arthur Mol (WU) and Maydom Chanthanasinh (REDALAO) are members of the committee. The partnership decided that a steering committee with 3 members will be more flexible in its collaboration and decision making than one involving the project heads of each partner. The steering committee performed 3 project evaluations without identifying any problems or irregularities.

In stead of the 4 task forces the following 4 mailing list were established: Communication, Study, Biomass and PV solar. The involved experts of every partner are members of the respectively mailing list. The responsibilities for performance and approval of the single tasks are defined in the task list in detail, which made the formation of task forces unnecessary.

Additionally to the described methodology each project partner provided quarterly updated and financial reports to the DGS project management. By this a continuing documentation and overview of the work of the single partners was ensured. The description and deadlines for this work can be seen in the attached task list.

The work within the 2nd project quarter, the data collection and the preparation of the laboratory analysis, required on-site meetings, additionally to the long-distance communication. Group discussions, brainstorming and the clarification of misunderstandings required vis-à-vis discussions. Which not only were useful for the work on the discussed tasks but also to improve the overall collaboration and the harmonisation of the different work approaches of the different partners. Thus, one change in the methodology was the performance of additional on-site meetings.

V Impact to date

V.1 Overall Achievements

V.1.1 List of Project Achievements

The main project achievements are:

- Establishment of a project home page as information and communication platform
- Online publication of interim reports on:
  - Laws and Guidelines
  - Energy Sector Data
  - Grid and Feed-In Condition
  - Realized Projects
  - Financing and Funding
  - Research Structure
  - Education Structure
  - Solar Potential
  - Biomass Potential
- Performance of each 3 Stakeholder workshops with 40-60 participants each
- Dissemination of project information by means of flyers, brochures, the project home page and email newsletters.
- Forming of a stakeholder network outlasting the project period.
- Forming of a European – Asian partnership between the project partners with the aim of further co-operation. (One new joint project started already in January 2007: Promotion of the Efficient Use of Renewable Energies in Developing Countries" (REEPRO), proposal n° EIE-06-256)
- Development of 2 studies "Study on Solar and Biomass Energy Potential and Feasibility in Lao PDR" and "Study on Solar and Biomass Energy Potential and Feasibility in Thailand" as basis for the further development of renewable energy projects in Laos and Thailand.
- Involvement of the local stakeholders in each project activity and thus creation of a strong local ownership of the project results.

V.1.2 Impact on Target Groups

The active involvement of all Lao and Thai RES stakeholders in the study development process by stakeholder dialogues and individual co-operations was a first step to build institutional and technical capacity in Lao PDR and Thailand in the biomass and solar energy sector. The target group was involved in the project from the first stakeholder meeting until the presentation of the final study. They learned how to conduct stakeholder dialogues, efficient working meetings, and individual meetings and how to develop new strategies. They were encouraged to follow up the stakeholder network established during the project. Due to their involvement in the study development, they not only improved their managerial capabilities but also their know-how on solar and biomass energy. They learned more about their potential and appropriate technologies for their implementation in Lao PDR and Thailand. In the process of the project implementation the stakeholders were informed about the existence and potential of EnergyFarming. Once familiar with the general approach of EnergyFarming, they developed strategies how to implant it in their countries. In the field of rural electrification the stakeholders were widely informed about the different options that photovoltaic electricity hold on stock for the development of the countryside. The target groups that were informed on photovoltaic electricity were compiled of technicians, politicians, government staff and financiers and investors. The materials presented to these stakeholders are still continuously requested and downloaded by the target groups as it can be seen by the frequent web traffic the website is enjoying.

V.1.3 Impact on the Applicant and Partners

The APE Project – PV solar and Biomass was mutually implemented by the European and Asian partners. Thus, all partners learned more about the different European and Asian work approaches. The main strength of the partnership is the interdisciplinary collaboration. Experts with different backgrounds, social scientists, engineers, civil servants and agronomist jointly developed questionnaires and reports. The distinct views of the different experts influence the project work positively. All partners can use this experience for future projects as well. Furthermore, frequent visits enabled the European partners to gather a better understanding of local conditions and hence formed a strong collaboration of all partners. Additionally, those on-site visits formed an important basis for a common understanding. A weak point of the partnership was the fact that most of the partners were collaborating for the first time in a big-scale project, not being aware about the work approach of the others. It was tried to compensate this by frequent meetings. Nascent misunderstandings could be solved due to the DGS management system and frequent on-site meetings as well as a general positive approach by all partners frequently communicating and asking questions to management and task leaders. Within the project period the partnership grew up to a well working team, which intends to collaborate in further projects in the long term. As an overall impact for the coordinator DGS can be summarized that a general strategy for the implementation of renewable energy in developing countries was formed upon a solid basis. The DGS is in the comfortable situation after the project that

a long term strategy was formed which will be continuously integrated into the public communication and policy recommendation by the organization towards the German lawmakers and development agencies.

V.1.4 Contribution to the Achievement of the Objectives of the Asia-wide Programmes

The reported project with its different activities is compatible with several objectives of the Asia Pro Eco programme as described below. The main outcomes of the country specific "PV&Biomass Study" for Lao PDR and Thailand are a comprehensive description of the potential and the demand of renewable energies in Laos and Thailand and strategies for the further development of biomass and PV solar based renewable energy. Those strategies were developed based upon the evaluation of the present biomass and solar energy situation and the potential in Lao PDR and Thailand, compatible European best practice approaches and experience of the partnership and the involved stakeholders. Hence, the implementation of those strategies will foster the demand for modern environmentally-sustainable technical solutions and fertilise the ground for sustainable and responsible investment in the renewable energy sector.

The project promotes measures to tackle environmental pollution and to develop more resource-efficient products, processes & services, particularly in the fields of agricultural waste management and clean energy, thereby it also influence positively the global climate change. The "PV&Biomass Study" will be a basis for the implementation of economically feasible renewable, clean energy projects and the creation of adapted local products and service structures after the project completion. These measures will reduce the environmental pollution, emissions and abuse of natural resources caused by use of fossil fuels, the use of old inefficient diesel generators, the use of wood fuel as thermal energy resource in highly inefficient private and industrial stoves, etc..

The "PV&Biomass Study" was mutually developed by European and Asian partners. All partners acquired extended knowledge about the different European and Asian work approaches, which facilitating the EU-Asia practical co-operation in a long-term. The active involvement of all Lao and Thai RE stakeholders in the study development process by stakeholder dialogues and individual co-operations was the first step to build institutional and technical capacity in Lao PDR and Thailand in the biomass and solar energy sector. Furthermore, the "PV&Biomass Study" shows opportunities to alleviate poverty in rural and suburban areas. The construction and operation of biomass and solar energy plants within the urban areas will create new jobs within the cities.

The approach of using the city's agricultural belts for the production of biomass will give new income possibilities for the farmers, who often struggle with low product prices and thus with low incomes, often too low to cover all their expenses - a process that leads to rural migration. The production of biomass to energy for local use will make them independent from the low world market prices of agricultural products and provide them with a stable income and as a result reduce rural migration.

V.2 Impact to date in Laos

The main achievements from the project activities in Laos are listed below:

- Awareness of target groups on biomass and solar PV potential and technologies have significantly raised
- Wishes and Constrains for renewable energy technologies promotion have been expressed out
- Lao partners have learned the best practices from Europe in application of biomass and solar energy
- Lao partners are now aware on potential of solar energy and biomass in their country; feasibility of these resources for socio-economic development;
- Lao partners, learned how to perform anaerobic digestion trails and which obstacle such research faces.
- The Lao partners gained experiences in international cooperation. The Lao partners consider such multilateral cooperation projects as a way to improve their staff's capacity in both technical and management skills
- Local counterparts have gained valuable experiences in conducting research, project implementation and management;
- APE Project team and office would become a nuclear of a future Centre for Renewable energy study at NUOL
- Students of NUOL have got opportunities to start their scientific work by participating into some project tasks implementation, such as laboratory anaerobic test; European best practices for solar PV and biomass technologies; data survey and evaluation;
- Successful Practices and Experiences of biomass and Solar PV application in Europe would be transferred to Lao partners
- Skills and capacity of Lao partners are to be further improved, and there assistance and support from EU partners are most desirable
- The project would serve as the starting point for further multilateral regional and international cooperation programmes

V.3 Impact to date in Thailand

The main achievements from the project activities in Thailand are listed below:

- Based on the opinion of stakeholders during the two workshops organized by REEC, those stakeholders indicated satisfactory acceptance to the project results.
    - One is the new information they obtained on PV solar technology. Quality assurance and customer guarantee were introduced to Thai industries.
    - Second is the information on digestion tests results. The stakeholders indicated interest in using the information. The most important and significant impact was that one farmer organization in the north-east of Thailand travelled to Germany to study the digestion technology. The design and construction work of one biogas plant using energy crops is being done.

- Impact to target groups which divided into three sections were, that for farmer group, they used information and technology to build biogas plant in the municipality. Impact to private sector was not so significant due to the fact that less private companies were interested to digestion technology and PV solar due low feed in tariff. They indicated during the workshop that if feed-in tariff increases, this would help them to expand activities in PV solar and biogas plant. Finally, impact to government offices is in the form of information dissemination.
- Impact to REEC as a local Thailand partner is that REEC staff gained expertise in performing research work in the area of PV solar and energy crops.
- The Asia Pro Eco project initiated another angle of work area for REEC as a local partner. The project work emphasized on correct methodologies and information links to stakeholders. This was accomplished from budget availability to organize two workshops. Therefore technical aspect of REEC is improved and management of REEC is adjusted to work with international environment
- The cooperation of research work with partner in Laos and EU provide good relationship and know how transfer. This served well to the objectives of the Asia-wide Programme. Capacities buildings for Thailand and Lao partners were obtained during the project period.
- In conclusion, relationships between the EU partners and the Asian partners, Thailand and Laos in particular were established. Clear know-how transfer of PV solar technology and digestion technology was done. Collaboration between DGS and local Asian organisations, EEEC, and Laos organisations were established.

VI Links with other projects/programmes

Due to the CDEA project (Urban Waste and Organic Composting Project), funded by the Canada Fund, project number Lao 04/013, the CDEA has a close contacts to local farming communities who understand the importance of Biomass, due to training received as part of the Urban Waste and Organic Composting Project. CDEA could provide those farmers with present information from the Asia Pro Eco project and could use the communities as source of information for their work within the Asia Pro Eco project.

The interim and final results of the Thai DEDE “Promotion of Renewable Energy Technologies: Action Plan for the Development of the Market in Thailand” programme brought interesting input on the present situation and future policy on renewable energies in Thailand.

A strong co-operation could be build up with the SNV Netherlands Development Organisation. The Netherlands Development Organisation and the Lao Ministry of Industry and Handicrafts singed a Memorandum of Agreement on the implementation of a Biogas Pilot Programme in Lao PDR. The with 1,1 Million EUR supported programme will be in operation from 2006 to 2010 and aims to support the installation of 6.000 household biogas plants. Within this programme SNV co-finances the installation of household biogas plants for the treatment of human excrements and livestock manure with 100 $. The total costs are 400 $. Additional SNV gives technical support on the implementation of the plants. The SNV and the project team collaborated in the data collection and evaluation on biomass to energy potential of Laos both performed. The established co-operation can be a good basis for future joint activities.

VII Sustainability

The projects partners have seen successful creation of lasting bi- and multilateral partnerships. By clearly advocating a more socially and politically aware research agenda the project has been successful in identifying areas for further research and raising areas for future education and awareness raising for different renewable energy technologies. Sustainability of the sector will only be assured if measures are taken to ensure ongoing assistance to government and non-government organizations involved in the extension of renewable energy technologies. One of the most important issues relating to sustainability emerging from the results of the project has been the trade-offs between private and state-based service provision. More research is needed into understanding the social and political drivers, as well as implications, from greater competition between the private and public sectors. However this understanding was generated deeply in the target groups during the stakeholder dialogues. Therefore a deep and longer term impact of the project goals could be secured.

Renewable energy is emerging as a key challenge for development and environment in Southeast Asia. As many of the issues relating to EnergyFarming and biofuels are similar between countries the results of the project provide an important starting point for further critical diagnosis of the potential for different renewable energy technologies under a range of socio-political circumstances.

Further proposal for research funding are currently being developed by the WU team to further investigate some of the key technologies, social and political issues noted above. These research initiatives will build on existing partnerships in Lao PDR and Thailand as well as extend to other countries of Southeast and East Asia.

The DGS will safeguard the situation of a continuous dissemination of the project results through the project website which is interlinked in the DGS operations. By this way roughly 2.000 visitors per day will be actively informed about the content and results of the project. The DGS's dissemination strategy will also rely on active measures for the distribution of the project flyers to decision makers in the stakeholder pool which also will remain active over the project period.

The DGS possesses over 3.000 members from which roughly 5% are active in the development of rural electrification programmes in many levels. Especially the industry partners are active in the provision of equipment for renewable energy installations for export into developing countries. The generation of such a strategy by the organisation will provide a lot of discussion material and political lobbying basis for these actors in the renewable energy field.

The synergies will be created implicitly in many ways. A direct input can be detected into the RREPRO project of the EU Intelligent Energy Europe Programme which is funded under the Coopener funding. Generally the results will be utilized in many ways as previous projects by the DGS have proven. The Network on renewable energy in Ecological Agriculture for

instance is having its final report downloaded for over 100 times a month continuously since 2003.

The projects that will be influenced by the Asia Pro Eco diagnostic study will be funded on all levels nationally in the affected nations and on the international level. Especially the impact on donor agencies will be high and hence the direct influence in the developing nations will be secured.

Laos

The Lao partners described the plan for sustainability and the foreseen exit strategy as followed:

- Potential areas for project success in Lao PDR:
  - off-grid rural electrification in remote areas: solar home systems, rural entertainment, telecommunication, water pumping, vaccine storage and other appliances in rural clinic, school, community office, etc
  - biomass technology application in suburban areas with intensive husbandry and agriculture production: small size biogas digester, gasification and improved wood stoves, agriculture products processing,
- Lessons learned
  - Always tracking the schedule would effectively help implementing the project tasks and on time making correction, if necessary
  - It was not easy to keep following scheduled tasks and deadlines due to inexperience in many things, such as project organization and implementation, workforce management, etc
  - Learning by doing is the best ways to gain knowledge and improving own skill
- Multiplier effects
  - The project outputs will be useful for policy makers in sustainable energy planning, socio-economic development and poverty reduction planning, especially for rural areas
- Replication potential
  - The project would serve as good example for newly created Ministry of Energy and Mine in such kind of thing as resources assessment, stakeholders involvement, partnership between various relevant internal organizations, and international cooperation
  - A similar project could be carried out in other topics of energy field (for instance, study small scale hydropower, rural energy service, perspective of biofuel production in Lao PDR) , or in other sector, for example, rural development projects, income generation in rural areas, marketing agro-forestry products, etc
- Post project financing plans after EC funding ceases
  - A Centre for Renewable Energy Studies (CRES) is to be established at The Faculty of Engineering, National University of Laos. CRES will act as an interdepartmental centre for teaching/ learning and research in the field of

renewable energy technologies. CRES will become an important actor in research and training in energy related fields. CRES will have to seek funding support for it's own human resource development, necessary facility and tools, research activities

  - The CRES has thought of plans to establish a demonstration site for Pico hydropower and other type of rural power installations (bio-fuel gen.-set, hybrid rural power system); appropriate biomass conversion technology (gasification, biogas, etc).
  - CDEA and NUOL participate in the European Commission funded project "Promotion of the Efficient Use of Renewable Energies in Developing Countries" (REEPRO), proposal n° EIE-06-256 which targets the promotion of RE in Laos and Cambodia by developing and implementing an extensive education programme.
- Post project institutional arrangements, giving due consideration to local ownership.
  - The APE office facilities and equipment will be transferred to future CRES and the CDEA office.
  - Faculty of Engineering will provide necessary space and support in the renewable energy studies
- Does the project have governmental support?
  - Government of Lao PDR now encourages promoting renewable energy resources development and utilization, in particular biofuel, solar PV, small scale hydropower, energy efficiency and conservation
  - The University fully supports the idea of creation of the Centre for Renewable Energy Studies at the Faculty of Engineering, but should start with some research or training projects for gaining initial experiences and skills
- Explain dialogue and support mechanisms set with local government.
  - The project would serve as good example for newly created Ministry of Energy and Mine in such kind of thing as resources assessment, stakeholders involvement, partnership between various relevant internal organizations, and international cooperation

Thailand

Project results provided positive impacts to renewable energy sector in Thailand. The results could be used for development of PV solar and digestion work in the future. It could be an important tool for sustainable development of renewable energy in Thailand. The following conclusions can be drawn:

- Digestion technology can be promoted for used at practical level and also at academic level. Improvement of digestion test for higher performance could be done using various crops. This would enable more sustainable development of farming energy in Thailand.
- Potential area of project extension is for local municipality interested in utilizing crop residues as well as those intend to grow energy crop for renewable energy.

- From the comments and brain storm session in the second workshop, it was found that there are many kinds of crops that were available locally. Lesson learnt from farmers was that fresh agricultural residues are abundant. Therefore, extension of digestion test to cover those local fresh materials could be done for better and more sustainable development in this area.
- Based on the results of one successful digestion project to be set by a farmer group in the north-east of Thailand, replication could be possible. One nature of a development structure of Thailand is a good example of a system that work, then, others would invest for the system. Based on this, DGS expert, Mr. Walter Danner provided extra training to a farmer group in Germany to ensure that they would build and operate the system successfully and others who come to visit the plant can learn and replicate or somehow modify the system for their areas.
- After the end of project funded by EC, REEC would use its existing human resources and look for funding from research institutes in Thailand and international organizations. Basically, funding on renewable energy researches both on PV solar and energy crops are increasingly supported. However, the research must be highly academic and proved to be significant result as pilot scale.
- Example of support to be obtained from local research institute in Thailand is that the energy crop proposal was submitted to Kasetsart University research institute. The project could be started in October 2007. Mechanism to support the research project in Thailand base on individual proposal to different supporting offices e.g. Ministry of Sciences and Technology, Ministry

VIII Other Issues

The local data collection by the Asian partners was often interfered by missing collaboration of third parties, bureaucracy and difficulties accessing the necessary data, as stated in chapter I.3. Though, as in the first quarter and even in the second quarter those problems led to minor delays but did not disturbed the overall project implementation, which was generally on time.

The laboratory analyses required the work with fresh biomass which had to be treated directly after the harvest or deep frozen until their utilisation. The NUOL does not have a laboratory freezer, thus no storage of the material was possible which requires a precise performance of the biomass harvest and treatment, this problem was dealt with by the Laotian partner in a professional manner.

The meetings with representatives of third parties mainly from international organisations (see chapter I) gave the DGS the opportunity to collect important information on the state and development of renewable energies in Laos and Thailand.

The project partners build up several new contacts to organisations working in the biomass and PV solar energy sector. Those contacts will were enforced by the 2nd stakeholder meeting in July 2006. The project built up a strong stakeholder network which will results in several new bi-lateral or network projects and activities.

ANNEXES

Project Budget	EUR *416.595,90*
Funds Disbursed by Commission to date	EUR *49.957,54*
Expenditure Incurred by Project to date	EUR *416.595,90*

Contact person:	Dipl.-Ing. Antje Klauß-Vorreiter
Signature:	

Appendix 1: Transfer of Ownership documentation

Appendix 2: Minutes of the kick-off meeting

Appendix 3: Minutes of the mid-term meeting

Appendix 4: Minutes of the final meeting

Appendix 5: Hard copies

- Project presentation brochure
- Project presentation leaflet
- Project result presentation leaflet

Appendix 6: CD with the final Lao and Thai study

Appendix 7: Orbit Paper "New Strategies for the Implementation of Biomass Energy in Southeast Asia"

Appendix 8: Stakeholder workshop documentation Laos

Appendix 9: Stakeholder workshop documentation Thailand

Appendix 10: Project task list – first version

Appendix 11: Project manual