EIE-06-256 REEPRO

Promotion of the Efficient Use of Renewable Energies in Developing Countries

Level 2 Course 1

Workshop Training on construction of Low cost small gasifier

11-14.11.2008

Report

Author

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November 2008

List of Content

List of Appendix

List of Figures

List of Acronymes

FE	Faculty of Engineering
NUOL	National Uniersity of Laos

1. Summary Sheet

Event: REEPRO Level 1 Training

Task number

Date, Location, Time: 11-14.11.2008, 9:00-16:30

Sokpaluang campus

Faculty of Engineering, National University of Laos

Theme: Training workshop on construction of low cost gasifier

Target group:

☒ REEPRO trainers

☒ Students

Performance:

- Brief theoretical presentation
- Practical works in construction of simple gasifier

Participants: 27 participants, see attached list of participants

Success:

Dr. Jens Berkan and Dr. Jan K. Dobelmann presented principle of design and construction of a low cost small scale gasifier, using as much as possible cheap local construction materials.

Trainees have learned how to design and construct a simple gasifier by using mostly local available materials such as mud, used 200-littre oil drum, wood, rice husk, so that the construction costs are significantly reduced and there is a possibility for locally made gasifier

At the ending session, the reactor was run for structure test and drying up.

Then discussions were going on themes how to test the reactor and to do further modification

Some students and staff of FE/NUOL were interested in gasifier tesing and improvement.

Download: This report and some more photos of the training can be downloaded under www.reepro.info

Vientiane, Lao PDR

Dr. Khamphone Nanthavong

Faculty of Engineering (NUOL), REEPRO Training coordinator

2. Workshop Preparation

Preparation of Construction materials:

- mud, rice husk were delivered in advance
- other construction materials were procured before and during the training

The preparation of the workshop based on the book 'Draft Specification rural gasifier below 5 kW' that is shown in appendix (page 12). After completing revision the book will be used as REEPRO Level 2 training manual.

3. Workshop Performance

Day 1, 11 November 2008

- Procurement of necessary construction materials: used 200-L oil drum, steel bars and sheets, welding materials, wood materials, charcoal, etc

Day 2, 12 November 2008

- Short theoretical session was conducted at Mechanical Lab building, FE/NUOL
- Then the trainees were grouped into three groups to perform tasks three tasks independently, such as: (1) Reactor preparation; (2) Mud preparation; (3) wood frame preparation
- The practical works were conducted at Mechanical workshop

Day 3, 13 November 2008

- Continuation of preparation works for Reactor and wood frame preparation
- Building of reactor was started before noon with filling the reactor with pure mud (as seal) and mud-rice husk mixture (as insulation).

Day 4, 14 November 2008

- Building of gasifier was almost finished just after noon.
- The reactor then was loaded with charcoal and fired
- The test run has shown satisfactorily working condition of constructed gasifier: reactor, air holes,

3.1. Presentation

- Short theoretical presentation was done by Dr. Jens Berkan and Dr. Jan K. Dobelmann, moderated by Dr. Khamphone Nanthavong (see details of design sketches of the gasifier in book 'Draft Specification rural gasifier below 5kW' - Appendix)
- Further detailed instruction and guidance in construction of gasifier were done along with the practical works

3.2. Discussion

During the training, some discussions were going on regarding such issues as:

- Fabrication of fuel feeder cone: using of oil drum seems more expensive and difficult than use of cheaper galvanized steel sheets, and easier fabrication
- Steel tubes may also be replaced by ready galvanized one or even bamboo
- Outsider walls can be built of cement blocks or bricks, which are more resistant to weather, but of course, slightly some more money added
- Blower must have speed regulator in order to control air speed for using different raw feeding materials, which may have different resistance to air flow

3.3. Conclusion

The training was very good opportunity for our trainers and students to learn how to construct a simple low cost gasifier by make use of local cheap construction materials.

4. Workshop Documentation

4.1. Invitation

To: All REEPRO trainers

Subject: Invitation for Training workshop on construction of low cost gasifier.

Dear all REEPRO trainers,

Coordination of REEPRO project would like to inform you that the training on design and construction of community's gasifier for power production will be held at Faculty of Engineering (NUOL, Sokpaluang campus) between 11-15 November 08, from 9:00 with participation of experts from Australia and Germany, and some trainees from Cambodia (to be confirmed).

This will be good opportunity to learn how to construct simple low cost gasifier for community use (power generation with ordinary engine-set, or any small thermal applications). So, all of you are cordially invited to join the training.

Your prompt feedback would be appreciated very much

Best regards

Khamphone Nanthavong
Faculty of Engineering,

REEPRO Training coordinator
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4.2. Programme

EIE-06-256 REEPRO

Intelligent Energy Europe

Promotion of the Efficient Use of Renewable Energies in Developing Countries

Training workshop on low cost small gasifier construction

Tentative Training program

Date: 11-14 November 2008

Venue: Sokpaluang campus, Faculty of Engineering

National University of Laos

Prepared by
Khamphone Nanthavong

October 2008

REEPRO training on small low cost gasifier construction

Day 1: 11 November 2008		
9:40	Arrival of experts	
12:00-16:00	Procurement of necessary for the training equipments and materials	
Day 2: 12 November 2008		
8:30-9:00	Registration	Thongvanh
9:00-9:10	Some remarks	Khamphone
9:10-9:30	Introduction: Workshop's objectives and activities	Dr Kai Dobelmann
9:30-10:30	Principle and design of low cost gasifier:	Dr. Jens Berkan (moderated by Dr. Kham-phone Nanthavong)
11:00-12:30	Groups' work: Gasifier Components	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Kham-phone Nanthavong)
13:30-16:30	Groups' work:	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Kham-phone Nanthavong)
Day 3: 13 November 2008		
9:00-12:30	Groups' work	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Kham-phone Nanthavong)
13:30-16:30	Groups' work	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Kham-phone Nanthavong)
Day 4: 14 November 2008		
9:00-12:30	Groups' work	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Kham-phone Nanthavong)
13:30-16:30	Finalizing works ▪ Reactor test run	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Kham-phone Nanthavong)
Day 5: 15 November 2008 8:00 Departure of experts		

4.3. Registration Form

Training on Design and Construction of gasifier for REEPRO project

Vientiane, Lao PDR, 12-14 November 2008

Registration

Full name	Organi-zation	E-mail address	Tele-phone	Signa-ture
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4.4. Signed list

Training on Design and Construction of gasifier for REEPRO project
Vientiane, Lao PDR 12-14 November 2008
Registration

Full Name	Organization	e-mail	telephone	Signature
1. Mr. Bounangern	CDEA	bsayalath@yahoo.com	2423820	
2. Mr. Khambang	sunlabob	-	2458579	
3. Mr. Volachit	STRI	Triresearch@hotmail.com	218711	
4. Mr. Phouang	FE	pphouthavong@yahoo.com	2400879	
5. Mr. Sengratry	FE (NUoL)	sengratrys@yahoo.com	77704904	
6. Mr Soulivanh	FE (NUOL)		2432563	
7. Mr Sengsouly	FE (NUOL)		7488519	
8. Mr Somnit	FE (NUOL)		6406579	
9. Mr SOUKSANH.	FE (NUOL)	Kittesd@Hotmail.com	7536518	
10. Mr. Vongsavanh	FE		6019707	
11. Mr Sivang	MEM	x.sivang@yahoo.com	7518777	
12. Mr. In pone	ME		7877747	
13. Mr. Xayalak	FE (NUOL)	xayalak VILAIDA@yahoo.com	7814613	
14. Mr. Sivanhsay	ME		2454622	
15. Mr Phai Pa phet	ME		6257096	
16. Mr Mak no	ME		7627240	
17. Mr. Vitaya Sayavong	ME		2511221	
18. Mr. Phou khamVOLACHITH	ME		6004925	
19. Mr Soukanh	STRI		218711	
20. Mr MANG KONE	STRI		7916198	
21. Mr Pom	ME		7870058	

Training on Design and Construction of gasifier for REEPRO project
Vientiane, Lao PDR 12-14 November 2008
Registration

Full Name	Organization	e-mail	telephone	Signature
22 1. Mr Hong Khon Vom	ME		6650355	
23 2. Mr. Phout tha vong	ME		6819582	
24 3. Mr: Somsavart	ME		7453764	
25 4. Mr: Keomanevone	ME		2666800	
26 5. Mr. Phetpaphai	Live		5679260	
27 6. Khamphone Nathavi	NUOL	khamphonek.nathavi@yahoo.com	4554654	
7. Mr. Phonesavanh	STRI	triresearch@hotmail.com	7706357	
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4.5. Photos

Figure 1 Theoretical session

Figure 2 Fuel feeder cone is made of used oil drum

Figure 3 Groups' work: mud preparation

Figure 4 Tubes fabrication

Figure 5 Wood frame construction

Figure 6 Reactor building

Figure 7 Fuel feeder assembling

Figure 8 Ash trap and Gas Cooler assembling

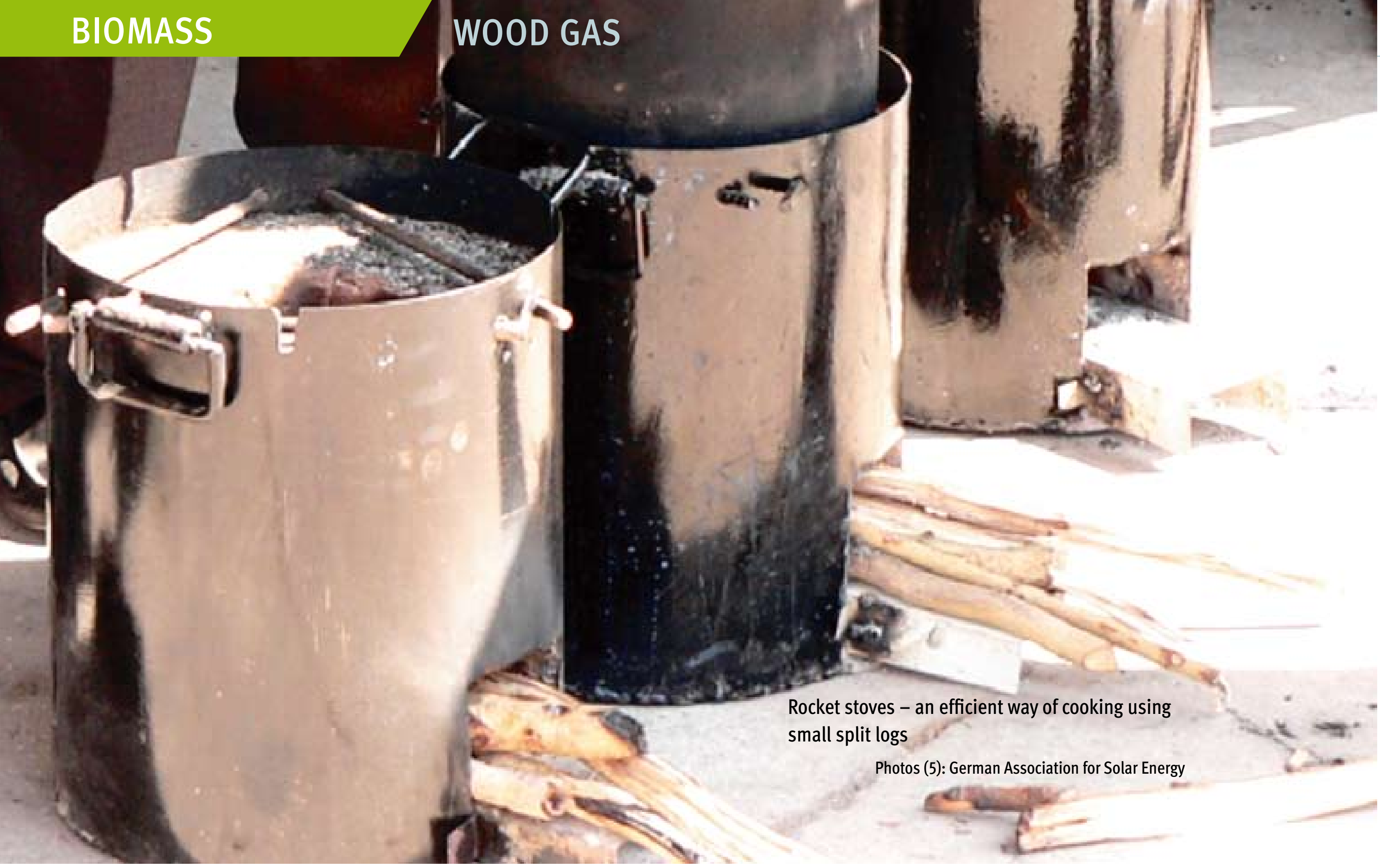
Figure 9 Gasifier is ready for test run

Figure 10 Test run

Figure 11 Constructed gasifier is running to heat up and be dried

Figure 12 Dr Kai Dobelmann is checking frame in the reactor if it was bright or not.

Appendix: From the rocket stove to a mini gasworks, Jens Berkan, Jan Kai Dobelmann, Sun & Wind Energy 1/2009



Rocket stoves – an efficient way of cooking using small split logs

Photos (5): German Association for Solar Energy

From the rocket stove to a mini gasworks

Wood gas is an important source of energy in rural areas in Laos. The use of local bioenergy can reduce dependency on fossil fuels and foreign currency.

The REEPRO EU project gives people in developing countries the knowledge necessary to use the renewable energy sources available in their own country (see also *S&WE* 5/2008). The goal here is to find substitutes for as many fossil fuels as possible and to use a wide range of different renewable energy sources in order to avoid being too dependent on one single energy source (e.g. photovoltaics) on the one hand, and to ensure the greatest possible level of energy availability and stability on the other hand. Keeping equipment and operating costs to a minimum is important in developing countries. The REEPRO project also gives partners and training personnel a basis which they can use to become economically independent themselves in the energy sector. Entrepreneurship training and courses in business provide a foundation that will lead to the start-up of successful small and family businesses in the medium term which will be able to prosper as independent energy suppliers on a local or regional level.

Possible uses and availability of biomass

In Laos, biomass in the form of wood is the most important energy source for cooking and for self-sufficiency, particularly in rural areas. Unlike diesel generators, which are often connected to inefficient battery-charging systems, there is effectively no upper limit on the use of wood as an energy source. In addition, the availability and use of biomass does not involve large investments in equipment, and it is also not necessary that operators obtain an additional qualification in order to be able to install and operate equipment. Cutting tools such as axes or machetes are available everywhere and are all one needs to be able to harvest the fuel required. Biomass can be easily stored with no losses after it is harvested, and simple measures are sufficient to dry the biomass so that it will have as low a moisture content as possible. However, biomass cannot be used to directly generate light or to run modern consumer electronics devices. Biomass cannot be converted directly into mechanical energy, such as that necessary to drive machinery. For that reason, the use of biomass is currently limited to food preparation and heating in the colder regions of the country.

Alongside the main sources of chunky, solid biomass such as timber and waste from wood processing, other forms of biomass that are generated in large quantities as waste products during food production can also be used locally for heat generation – for example rice husks from rice mills.

The rocket stove – high-tech made from traditional materials

In Laos, cooking is generally carried out using so-called 'rocket stoves'. These ovens have significant advantages over the open ovens and fires that were traditionally used: The burning process includes primary and secondary combustion, as in a gasification boiler for split logs, meaning that rocket stoves produce the same heat output for cooking using less wood and give off significantly less smoke and airborne ash. The reduction in emissions also contributes to the improvement of the general health of the population. Respiratory complaints caused by soot inhalation are a major problem in Laos, as people traditionally cook in closed rooms and a large amount of ash, soot and condensate is given off by conventional fires.

The design of the first generation of simple rocket stoves, as dealt with during a practical seminar at the university in the capital Vientiane, has since been further developed. During our visit in November, we came across a range of already assembled and tested oven variants whose design has been simplified and improved, generally with the aim of reducing the amount of labour and costs involved in manufacturing the ovens.

Nowadays, discarded oil cans are most often used for the housing of the ovens. Pot skirts made from round steel shaped into a triangular form are placed in the top opening of the oil can. The combustion chamber and the fuel gas pipe are made out of a mixture of clay and rice husks. The rice husks serve as a skeleton that is then burned away when the oven is used, thus leaving behind a uniform porous structure in the fired clay matrix. Something similar to porous concrete is the result. Not only does this provide excellent thermal insulation and result in a high degree of efficiency for the oven, it also reduces the amount of material necessary and thus also reduces the weight of the oven. The burnt-out, highly porous clay matrix also has good mechanical properties, being relatively ductile and showing good impact resistance. Another positive is that it can be worked on and shaped using a simple wood saw, which is an advantage when it comes to small series production of the oven. The best results with regard to stability, robustness and workability were achieved with a mixture consisting of roughly 50 % clay and 50 % rice husks.

Heat output comparable to that of gas ovens

At the bottom of the oven base, there is a storage/reaction chamber that is easy to open and close and can be filled with small, dry pieces of biomass and then lit. An air duct is used to control the reaction chamber and to regulate the amount of air entering; the chamber serves as a gas generator. The air is blown into the reaction chamber using a 12 V axial fan (similar to those used in power units in computers) that is fitted on the outside part of the duct. The fan uses between 10 W and 20 W of electricity, and the power level of the fan can be controlled using a simple, robust control device with potentiometer. The wood gas that is generated passes from the reaction chamber into the interior of the oven and is direct upwards, where it passes through a set of jet nozzles arranged in a ring and is then burned adding secondary air. The gas generated by the oven is of good quality and burns consistently with a bluish flame without giving off any soot or smoke. The amount of heat generated by some models is impressive to see and is comparable with that of the gas ovens that we are more familiar with.

The electric fan means that the rocket stove continuously operates with a slight overpressure, and the ability to control the fan level means the volumetric flow rate and pressure gradient inside the oven can be adjusted. This has a number of advantages: firstly, slight problems with fit or minor leaks which arise during oven manufacture are not a major problem, and, secondly, changes which may occur over the service life of the oven (such as a closing cap that no longer fits exactly due to thermal expansion effects) can be compensated by adjusting the fan level. In addition, the adjustable fan can also be used to set the oven output to the desired or required level.


Participants in the five-day biomass workshop in Laos

"High-end versions" of the rocket stove

The first generation of ovens can now be manufactured at a cost that is low enough to be commercially viable, but the second generation is still some way removed from achieving this. The amount of labour and costs

"High-end" versions of the rocket stove – cooking using rice husks and an external 12 V fan

involved in the manufacture of newer ovens makes it unlikely that they will be used in small private homes soon. The complexity of operating them and the technical requirements for operation – such as a high-power 12 V electricity source and a sufficient amount of dry grain husks – are barriers to the quick and widespread use of the new system. Even if one were to assume that almost every simple rural household has a 12 V car battery that can be charged regularly at central charging stations, cooking with the rocket stove would still involve higher costs for rice husks and greater labour. As a simplification, one can assume that one ampere-hour of battery charge per day is necessary to operate the oven.

If a conventional wet lead-acid battery is used, it needs to be recharged every two to three weeks. The battery would have to be removed and brought to the charging station, which would also be costly. The high discharge level, the increased number of cycles and the mechanical vibrations caused during transport would reduce the service life of the battery, meaning that batteries would have to be replaced more often. This would raise the operating costs for the oven and would also cause increased environmental pollution, as there is no comprehensive recycling system for used batteries in place.

Town gasworks for developing countries

The "high-end versions" of the rocket stove are thus suitable for regions with good infrastructure, and can also be used in canteen kitchens, schools, orphanages or clinics that are connected to the electricity grid or have their own photovoltaic equipment which makes them energy self-sufficient. The advantages of this version of rocket stove – including the easily adjustable and very high oven output, the short response times, the ease of operation and the long burning time for each batch of fuel – could then be exploited. These ovens could also be used in the catering industry.

Essentially, the high-end version of the rocket stove is a simplified wood gas generator with a gas burner attached to it. This type of equipment is familiar in the western world from the gasworks that used to generate so-called 'town gas' from coal and coke and feed it into the town gas grid. By analogy with the town gas process, wood gas could be used for other applications apart from cooking – e.g. to generate mechanical energy or light. Inspired by the design of commercially available camping gas lamps, bright street lights or lights for the home (as is already done using biogas) could be fuelled. The burner in the upper part of the oven would have to be replaced by an appropriate arrangement with a gas mantle, glass cylinder, reflector and cover.

A lamp like this could be designed in such a way as to achieve a long operation time, which could even be as long as a whole night from a single batch of grain husks. It is also conceivable that a single gas generator could supply a number of gas lamps – for a town square, for example – or provide lighting for sanitary facilities, assuming a pipe network for the synthesis gas is present. However, the electricity necessary to run the electric fan would have to be provided by a battery or some other power source. A small photovoltaic unit would also suffice.

Wood gas to provide mechanical energy

If it were possible to develop inexpensive, simple and robust biomass gasification units, this would be another major step towards the provision of mechanical energy and the finding of substitutes for fossil fuels, as well as towards smaller, more economical photovoltaic units with battery storage. If designed

Funnel-shaped fuel silo from a 200-litre oil barrel for the purpose, a wood gas generator alone can continuously power a small combustion engine with a drive output of several kilowatts.

Simple engines with simple control operating over a large range of RPM could be used to drive conventional 12 V or 24 V car or truck generators, which would then be used to charge batteries, thus replacing diesel-operated and petrol-operated generators.

Systems like this could also feed directly into the accumulator level of the 12 V or 24 V DC circuit of a photovoltaic unit, meaning low power loads could be catered for using the solar modules and high loads met using the generator along with an inverter, if needed. Also conceivable is the direct driving of mechanical loads such as water pumps and fixed harvesting equipment.

Practical modules on wood gasification units

The sourcing of materials locally was envisaged as part of the first practical module on wood gasification in Laos in November 2008. It transpired that not all components and materials were available exactly as specified, meaning that the design of the wood gasification unit had to be adapted accordingly. In general, there were no problems sourcing fresh clay, rice husks, sheet metal, sectional steel, oil barrels, simple tools and other materials such as wood, welding wire, silicone sealants or sturdy Chinese-made fans on the market in Vientiane. This was followed by the module introducing the theory behind wood gasification. A wood gasification unit was then designed and assembled at the university campus in Laos.

First results and outlook

The enthusiasm of the Laotian participants for the whole duration of the workshop was remarkably strong. However, it could be seen that the great willingness to work and the creativity shown were not always accompanied by the necessary degree of safety awareness. For example, the use of ear protection when carrying out loud tasks such as abrasive grinding seemed to be either unknown or else frowned upon. We observed that participants tried to carry out such procedures without protective glasses or gloves and even while barefoot.

We therefore decided to focus more attention in future workshops on safety and health risks and to offer a course unit on the use and handling of mechanical equipment.

It is important that the workshop participants receive a broad training, since the commercial success of biomass gasification units later on depends very much on how well they are adapted to regional conditions. Here we will borrow a few ideas from the automobile industry and present them in an easy-to-understand manner so that they can be taught in short theoretical modules which include practical exercises.

For example, we plan to disassemble the gasification unit that has been built after it has been in continuous use for a few months and then to examine it for signs of use and wear, so that we can decide on design changes and improvements for future variants. These will be documented in a construction manual and then implemented in a new prototype. Issues regarding operating safety for customers and users will be dealt with, alongside matters relating to production and costs.

In addition, we will also be focussing on the design and assembly of a battery-charging module. This module is to consist of a small simple combustion engine that will use the wood gas produced by the biomass gasification unit as its fuel and will drive a 12 V car generator. Subsequently, this design can then be adapted for other applications, such as irrigation pumps.

Jens Berkan, Jan Kai Dobelmann

Wood gas generator with gas cooler and attached fan

The authors:
Jens Berkan: Founder and CEO of Innowatt Energy Pty. Ltd. in Australia developing bioenergy systems. Innowatt accompanied the training within the REEPRO project (www.reepro.info).
Jan Kai Dobelmann: Construction engineer and President of the German Association for Solar Energy. Active in bioenergy, he accompanied several bio and wood gas projects in Laos.