Renewable Energy Technologies for Decentralised Rural Electricity Services

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SEI Climate and Energy Programme Report 2005-01

SEI STOCKHOLM ENVIRONMENT INSTITUTE

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The project "Information dissemination on energy and environment in developing countries" is supported by the Swedish International Development Cooperation Agency (Sida).

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Renewable Energy Technologies for Decentralised Rural Electricity Services

Report from an International Workshop held in Studsvik, Sweden 10–12 June 2004

A workshop report prepared as part of the project "Information dissemination on energy and environment in developing countries"

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February 2005

Sponsored by the Swedish Development Cooperation Agency (Sida)

SEI Climate and Energy Programme
Report 2005-01
Stockholm, Sweden

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Cover photograph: Family in the Gobi Desert, Mongolia by Anders Arvidson, SEI

This report is available on line (http://www.sei.se)

ISBN 91 975237 0 4

Printed in Stockholm, 2005

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Preface

Sida has decided to support the implementation of an information dissemination programme focusing on energy and environment in developing countries through support to the Stockholm Environment Institute (SEI) in implementing the project "Information dissemination on energy and environment in developing countries". One component of this project is a workshop series in which the first workshop focused on power sector reforms and in the second workshop emphasis was placed on the delivery mechanisms and the organisational aspects of rural electrification. This workshop, the third in this series, has set focus on the choice of technology when providing renewable electricity services in rural areas. In this way the individual workshops are contributions to a greater picture.

SEI contracted KTH International Education and Trading AB, to organise and lead a workshop on "Renewable Energy Technologies for Decentralised Rural Electricity Services." The present report summarises the results of the discussions at the workshop that was carried out in Studsvik, Sweden, June 10–12, 2004.

The Stockholm Environment Institute and KTH International Education and Trading AB are grateful to Sida for providing the financing for the workshop and to all the workshop participants who contributed by sharing their experiences. It is hoped that policy makers on different levels will find the recommendations useful.

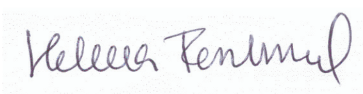
Other workshops organised as part of the project were:

- Public Benefits of Power Sector Reform (Stockholm, Sweden, May 2003)
- Delivery Mechanisms for Rural Electrification (Bagamoyo, Tanzania, October 2003)

Documentation from these additional workshops can be downloaded from the home page of Stockholm Environment Institute www.sei.se:

- Public Benefits and Power Sector Reform. Report from an International Workshop Stockholm May 12-13, 2003. SEI Climate and Energy Programme Report 2003-01
- Delivery Mechanisms for Rural Electrification. SEI Climate and Energy Programme Report 2004-1
- Some Public Benefit Policy Aspects in Reforming the Power Sectors in East and Southern Africa. Stockholm Environment Institute. Climate and Energy Programme Report 2004-3

Stockholm, February 2005
for Stockholm Environment Institute



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Executive summary

KTH International Education and Training AB and Stockholm Environment Institute arranged a workshop on "Renewable energy technologies for decentralised rural electricity services" held on June 10–12, 2004 in Studsvik, Sweden. Sida financially supported the workshop.

WORKSHOP OBJECTIVES AND ORGANISATION

The objectives of the workshop were:

- to evaluate experiences from the use of renewable energy sources for rural electrification in developing countries;
- to make recommendations for donor support to rural electrification projects using renewable energy sources.

The 24 invited participants came from government agencies, donor agencies universities and consulting companies, all with long experience of implementing renewable energy projects for decentralised electricity generation. The developing countries represented at the workshop were Brazil, India, Kenya, Mali, Mongolia, Nepal and Uganda.

After keynote presentations which covered the experiences of different renewable electricity generation technologies in selected developing countries, the participants discussed the role of electrification in rural development, needs for further technological improvements and the needs for development of government policies for promotion of renewable energy for electricity generation. Finally, the participants discussed and agreed on recommendations addressed to donor agencies in general, and to Sida in particular, for consideration when formulating a revised Energy Policy.

ELECTRIFICATION FOR RURAL DEVELOPMENT

Specific energy technology solutions need to be considered when the energy service needs contributing to development have been properly assessed and prioritised. Once the energy service needs have been identified, it can then be decided whether they can be attained through thermal energy, mechanical energy, electrical energy or renewable energy. Renewable energy technologies should only be considered when these offer more advantages than the conventional alternatives – grid connection or stand-alone diesel generators. Such advantages may be lower costs, better supply reliability, fewer adverse local environmental impacts or better possibilities for local income-generating activities. Local needs and priorities must determine the choice of technology.

Biomass-fuelled renewable technologies have a particularly strong potential in generating local economic activities compared to conventional supply options.

DESIRABLE TECHNICAL IMPROVEMENTS

Technologies for decentralised electricity generation using mini-hydro power plants, solar photovoltaics (PV), wind generators and biomass fuels are commercially available and are being applied in many developing countries. The limiting factors for further penetration of renewable energy are today linked to issues of cost, reliability, financing, service infrastructure, awareness of available technology and trust in the technologies from the perspective of entrepreneurs and end-users. To some extent there is a need for complementary resource assessments, but such studies shall only be done when there is a commitment to use the renewable energy source if the potential is adequate and the cost for exploitation is acceptable.

One important limiting factor related to cost, is the capacity range within which each technology can compete with the conventional options. PV systems are still only realistic for very small power demands, whereas technologies using biomass fuels are unrealistic for small power demands with low load factor. Mini-hydro and wind systems can serve a wide load range, but require specific favourable on-site conditions.

Use of biomass fuels in a steam power plant is the obvious solution for power demands above 1 MW and a high load factor, when the necessary amounts of biomass fuels can be supplied in a sustainable way. For smaller power demands (down to15 kW), biomass gasification and use of the gas as fuel in an internal combustion engine is often the most realistic option. Both technologies are commercially available. Better fuel flexibility and reduced needs for service and maintenance are possible improvements of the biomass gasification process that would make this option more attractive in comparison with the diesel generator.

For wind generators and PV, energy storage is necessary in most applications. The development of storage systems with lower life-cycle costs would make these systems more competitive. Hybrid systems with diesel generators are an option that deserves more attention. Hybrid generation can also be cost-effective when biomass is used as fuel. Diesel generators can then be used for peak load supply and as reserve capacity.

GOVERNMENT POLICIES FOR PROMOTION OF RENEWABLE ENERGY

Governments in developing countries have many reasons for promoting the use of renewable energy for rural electrification, even if minimising greenhouse gas emissions is not one of them. Such reasons may include reduced import bills, improved self-reliance and creation of local employment opportunities.

There are several effective mechanisms for promotion of renewable energy for rural electrification. Promotion by strong commercial actors has proven very effective for PV, and to some extent for wind, but for biomass and mini-hydro such actors are not yet common. Support should be given for setting up local or regional organisations with the task of promoting these technologies where the local conditions are suitable.

Subsidies to electricity consumers in rural areas are justified for equity reasons and are also given in developed countries, mainly as cross-subsidies where urban users carry part of the cost for electricity supply to rural areas. The subsidies should be independent of the supply technology. Additional subsidies for electrification schemes using renewable energy can be justified for limited introductory periods when demonstration of the performance of the technology is necessary.

Governments should take a responsibility in workforce development to utilise the indigenous renewable energy potential. This includes training of the necessary labour force to ensure sustainable maintenance of renewable energy technologies.

RECOMMENDATIONS TO DONOR AGENCIES

- Donors should support development of national energy policies which include support to rural electrification using renewable energy technologies where this is economically justified. The economic evaluations should include consideration of local environmental costs and additional benefits that utilisation of renewable energy may result in, such as improved supply reliability, reduced vulnerability to international price fluctuations and the creation of local employment opportunities. The expected impacts on rural development and poverty alleviation should be the main basis for selection of rural electrification projects for financing. This means that the possibility of finding productive uses of the electricity should be very important for project selection.
- Donors should support the development of regulatory frameworks and institutions that incorporate the goals of improving the techno-economic efficiency as well as addressing social and environmental development goals in power sector reform processes.
- When renewable energy is economically justified, donors should support this option and be prepared to cover the transaction costs associated with introduction of a technology which has not been used earlier in the area, such as costs for workforce development. Also, electrification schemes using renewable energy which are more costly than conventional options may be given support, but in these cases the additional cost must be carried by the donor and not by the users.
- Donors should support the development, adaptation, testing and use of new technologies. This can stimulate business development, provide employment opportunities and generate more appropriate technologies. Donors need to accept a higher degree of risk in this context. Technologies should be developed in close cooperation and with a strong local ownership from researchers, institutions and the private sector in the countries where the technology shall be applied and in a context where electricity consumers are not exposed to any technological risk. A rural village in a developing country should not be a testing ground for unproven technology.
- Donors should support the local manufacturing of equipment for renewable energy, but only on strictly commercial terms.
- Donors should support institutions and capacity building of the actors as the electricity sector goes through restructuring. Support to national organisations which can act as advisors on legal, technical and administrative matters to small private or cooperative electric utilities, can be essential for the success of locally managed distributed electricity supply in rural areas. Significant participation of local consultants shall always be required in donor-financed projects.

1 Background

1.1 WORKSHOP OBJECTIVES

The objectives of the workshop were:

- to evaluate experiences from the use of renewable energy sources for rural electrification in developing countries;
- to make recommendations for donor support to rural electrification projects using renewable energy sources.

The timing of the workshop coincided with the process whereby the Swedish International Development Cooperation Agency (Sida) is formulating a revised Energy Policy. Therefore, an important focus of the workshop was to formulate recommendations for what the participants thought to be important activities in the energy sector of developing countries that Sida should support.

1.2 PARTICIPANTS

Participants with well-documented experience in the use of a particular renewable energy technology for decentralised electricity supply in rural areas in developing countries were invited to the workshop. Also invited were representatives of donor organisations and international consultants with experience from the field and selected participants from Swedish universities.

Table 1 shows how the participants were distributed between different categories.

Table 1 Participants in the workshop (number of female within brackets)

Affiliation	Sweden	International		Total
		Developing country	Other	
Organisers	4 (1)			4 (1)
Government		2		2
Donors		1 (1)	1	2 (1)
Universities	5 (3)	5		10 (3)
Consultants	5 (1)		1	6 (1)
Total	14 (5)	8 (1)	2	24 (6)

The developing countries represented at the workshop were Brazil, India, Kenya, Mali, Mongolia, Nepal and Uganda. Of the 24 participants in the workshop, six, or 25%, were female.

The list of participants is included as Appendix 1.

1.3 PROGRAMME AND METHOD

The programme for the workshop is included as Appendix 2.

The first day was allocated mainly to presentations of experiences on the subject by six invited speakers. A visit to the thermal engineering laboratory of TPS was also included.

The second day began with a presentation of the results of an evaluation of a solar PV project in Zambia. The main part of the day was used for group discussions.

The discussions before lunch focused on technology issues and were organised in three groups:

- Solar PV and wind for decentralised electricity generation
- Mini-hydro power plants for decentralised electricity generation
- Biomass decentralised electricity generation

Each group discussed a number of issues identified by the organisers which had been communicated to the participants before the workshop.

After lunch, the discussion groups were re-organised and the discussions focused on three "across-the-board" topics namely:

- Organisation, financing and management of decentralised electricity generation
- Decentralised electricity generation and its contribution to rural development
- Policy issues related to decentralised electricity generation

Again, each group discussed a number of issues identified by the organisers which had been communicated to the participants before the workshop.

The discussion issues and the participants in the working groups are shown in Appendix 3.

After the group discussions, the moderators of the discussion groups summarised the conclusions from the discussions and these were presented to the participants in plenum in the morning of the third day. The discussion that followed before lunch on the third day resulted in several amendments to the conclusions and recommendations for further editing. The conclusions presented here in the following sections, have been edited by the organisers, distributed to the participants for further comments and then finally edited. In the few cases where conflicting views were brought forward by the participants in the workshop, this is reflected in the conclusions. The authors identified on the cover page take the full responsibility for the recommendations presented in sections 3 and 4 of this report.

2 Experiences presented by invited speakers

This section has been prepared by the organisers in an attempt to bring out the main messages in the presentations. The full texts are available for downloading at www.sei.se.

2.1 POLICY INITIATIVES IN UGANDA TOWARDS THE USE OF RENEWABLE ENERGY TECHNOLOGIES

The contribution was presented by Dr Mackay Okure of Makerere University in Uganda. It includes an overview of the energy situation in Uganda and a review of the recent policy initiatives related to use of renewable energy.

The situation with respect to rural electrification in Uganda is typical of most other sub-Saharan countries in Africa. Only a very small fraction of the population lives in electrified areas and the majority of the households without electricity supply can be found in rural areas. The main supply to the national electric grid comes from hydropower plants. Diesel generators are used in isolated supply networks.

There is some use of solar-PV in rural areas. There is also a potential for additional hydropower generation. Biomass fuel, in particular wood, is the dominating energy source and is mainly used for cooking.

The Government of Uganda has formulated a Rural Electrification Strategy and Plan, covering the period 2001–2010 and implemented a power sector reform, the Power Sector Restructuring and Privatisation Strategy (PSRPS) of 1999, which eliminated Uganda Electricity Board's (UEB) monopoly on the generation, transmission and distribution of electricity. These actions are part of a broad and comprehensive new energy policy for Uganda.

The general objectives of the rural electrification strategy are to promote, support and provide rural electrification programmes through public and private sector participation in order to:

- achieve equitable regional distribution access;
- maximise the economic, social and environmental benefits of rural electrification subsidies;
- promote expansion of the grid and development of off-grid electrification; and
- stimulate innovations within suppliers.

Rural electrification is seen as an integral part of the wider rural transformation and poverty eradication agenda. Farm and off-farm led economic growth are key pillars of anticipated broad-based growth, leading to an increase in rural incomes and quality of livelihood in rural areas.

Specific objectives of rural electrification are:

- to facilitate small and medium rural enterprises;
- to provide basic social services;
- to reduce use of sources of power that are expensive, of inferior quality and harmful to the environment;
- to support agricultural processing in rural areas; and
- to improve provision of rural healthcare by providing refrigeration for vaccines and enabling improved standards for operations.

A quantified target of the plan is to increase accessibility from 1% to 10% by 2010. It is projected that 400,000 additional electrified households will be serviced through:

- 15% from higher extensions to the existing national grid outside the urban triangle;
- 40% from extension to the interconnected grid;
- 25% from isolated grids; and
- 20% from PV solar home systems (SHS).

Barriers to using renewable energy technologies for rural electrification are:

- lack of funding for rural electrification projects and/or capacity to sponsor projects;
- lack of consumer awareness regarding modern types of energy and the associated conditions of supply, demand, tariff and management;
- lack of technical capacity in form of experienced qualified staff in the organisations or firms;
- lack of a specific financing framework; and

- unfavourable financial conditions manifested by the large up-front investment coupled with low initial sales.

Important policy instruments for promotion of rural electrification and use of renewable energy are:

- subsidies that can be used for helping create an appropriate institutional framework for supporting rural electrification, providing social equity to enable community electrification, reducing the up-front costs and increasing affordability and financing awareness and capacity building for the development of the supporting business infrastructure;
- a Master Plan including studies on resources and demand, a map of communities/areas and the most cost-effective sources of supply, estimates of investment requirements for each of the modes of rural electrification and a portfolio of viable rural electrification projects;
- a tariff policy that can be a tool to stimulate decentralised initiatives and projects that are commercially viable;
- capacity and awareness building focused on community level actors that have significant capacity building needs in terms of awareness, technical knowledge and business skills;
- regional equity measures, including bonus subsidy rates for the poor and under-served areas, especially intensive awareness raising and capacity building in under-served regions, subsidised PV-based community packages for schools, clinics, public lighting, water supply, etc. for areas to remain off-grid for many years;
- cross-sectoral linkages to maximise the economic, social and environmental benefits of rural electrification subsidies by coordinating the electrification programme with other Government programmes in rural areas, such as those in agriculture, communication, health services, education, water and transport; and
- standardised procedures for small power producers that can facilitate commercially based development of small-scale renewable energy power generation, utilising indigenous renewable energy sources by implementing a standardised transactional framework for contract, pricing and regulation.

A rural electrification fund has been created using a significant sum of money appropriated by Parliament. Other inputs to the fund will come from any surplus made from the operations of the Electricity Regulatory Authority (ERA), a 5% levy on transmission bulk purchases of electricity from generation stations, and donations, gifts, grants and loans acceptable to the Minister of Energy and Mineral Development and the Minister of Finance, Planning and Economic Development.

The new institutional framework defines roles for actors at different levels. The Rural Electrification Agency (REA) will be responsible for analysing rural electrification policy issues, planning rural electrification, monitoring the development of rural electrification in Uganda and information gathering and dissemination. Private companies, NGOs, local authorities and communities will be the primary initiators of projects. Legally recognisable entities, such as a cooperative or a company, must be formed in order to qualify for grant awards. The Rural Electrification Board shall discuss and approve the annual rural electrification report prepared by the REA for submission to the Minister of Energy and Mineral Development, define the policies for subsidy levels, project eligibility criteria and application processing and other procedures based on proposals made by the REA and in general oversee the management of the Rural Electrification Fund. ERA will license market participants, set tariffs, set and enforce minimum safety and service levels, encourage the development of uniform electricity standards and resolve disputes. Local Authorities shall help identify projects, mobilise the communities, for any small system with generation of less than 2 MW or annual sales of less than 4 GWh, and regulate them on behalf of the ERA.

2.2 EXPERIENCES USING MINI-HYDROPOWER PLANTS FOR RURAL ELECTRIFICATION IN KENYA

The contribution was presented by Dr Njeri Wamukonya representing UNEP. It included a brief description of the situation regarding rural electrification in Kenya and in-depth evaluations of experience of two mini-hydro projects which have recently been implemented for electricity supply to rural communities in Kenya.

As in most sub-Saharan countries in Africa, the majority of the population of Kenya do not have access to electricity. By the end of 2002 only 79,391 consumers, representing 3.8% of the rural population, had been connected at a total cost of 14.2M US$. The implementation of the Rural Electrification Programme has been based on grid extension, except for a few isolated stations in the northern part of Kenya. The programme targets rural factories (e.g. coffee and tea), market centres and public facilities. Influential people and politicians in the government have also targeted electrification to their home areas.

A Draft National Electrification Policy and Investment Plan was developed in 1997 to offer guidelines on the country's electrification, although it was never adopted and has recently been revised into an energy policy document which is currently awaiting adoption by Parliament. The Electric Power Act (EPA) was adopted in 1997 to amend and consolidate the law pertaining to generation, transmission, transformation, distribution supply and use of electrical energy for lighting and other purposes, and for connection purposes. The Act liberalises the electricity power sector and brings private players into the electricity market. Recently, the government reiterated its intention to review the EPA in order to open the electricity sector to individuals and organisations interested in distributing electricity.

Financing for rural electrification is through a 5% levy imposed on each electricity consumer's bill, which has since 1973 contributed 59% of the total costs. KPLC and donors have contributed 18% each and 5% has been collected from the consumers' connection fee. The expenditure for rural electrification has always exceeded the revenues by a factor of two to three.

A large share of the hydropower potential in Kenya consists of micro- and mini-hydro sites. A recent energy taskforce report estimates small hydro potential to be 3,000 MW. However, only a small proportion has been exploited for rural electrification: 28 MW installed capacity by the Kenya Electricity Generating Company (KPLC), and less than 1 MW for schemes owned by community and private enterprises.

The experiences of two recently implemented schemes illustrate the challenges involved in community based small scale hydropower generation. Table 2 includes basic information about the two projects.

Table 2 Basic information about two small hydro projects in Kenya

Project site	Mbuiru village, Tungu river	Thima community
Commissioned, year	2002	2001
Generator capacity	14 kW	2,2 kW
Organisation	Consumer association with elected committee for management	Consumer association with elected committee for management
Number of members	152	181
Number of consumers	At present only 6	160
Financing of the initial investment	UNDP GEF-grant 75% Members 25%	European Union 48% Members 52%
Usage of the electricity	Small business centre. Planned use also for water pumping.	Lighting, radios, TV
Tariff system	Flat rate for each of six entrepreneurs connected to the supply	Flat rate for "light packages" of 8W each.

At both sites there have been technical problems, caused by purchase of equipment of inferior quality. Unforeseen flooding of the power house occurred at one site, indicating that the planning was based on incomplete data. In both cases the local skills are not sufficient for technical management and maintenance and the operation is therefore dependent on technical support from the outside.

The impacts of the electrification schemes vary as a result of the differences in the types of load connected. In Mbuiru, where the electricity is used for a business centre, four enterprises have been started which would not have been there without electricity. The planned use of electricity for water pumping to the village has not yet been realised even though this appears to have been a strong motive in the villagers' support for the project. In Thima, where all the electricity is used for residential lighting and entertainment, electricity users have reduced their total energy bills since electric lighting is cheaper than lighting with kerosene and fewer dry cells for radios are needed.

At both sites, the revenues are less than the total costs, see Table 3. In Mbuiru not even the operating costs can be recovered due to the low flat rate which is charged. In Thima, the revenue would ideally be 3,015 US$/year but is in reality only 1,169 US$, because over 35% of the customers are not getting power due to technical problems. Therefore, in Thima also the revenues are less than the operating costs.

Table 3 Financial analysis for Mbuiru and Thima

Scheme	Mbuiru	Thima
Rated power output (kW)	14	2.2
Total capital investment (USD)	71 297	8 923
Specific investment USD/kW	3 960	4 055
Annual costs (USD)		
Capital costs (20 years, 15% interest)	11 389	1 425
Operation and maintenance	7 130	1 987
Total	18 519	3 412
Annual revenue if all consumers pay (USD)	369	3 015
Annual profit (USD) if all consumers pay	- 18 150	- 397
Possible electricity generation (kWh/year)	122 640	19 272
Possible consumption with connected load (kWh/year)	50 005	12 719
Plant Factor (%)	0.4	0.66
Unit energy cost (USD/kWh)	0.37	0.26

Assumptions

For Mbuiru project it is assumed that the project incurs 10% of total annual running costs. In Kathamba and Thima they are actual costs.

Interest rates of 15% have been used in calculating the annual capital cost, based on average commercial banks base lending interest rates in Kenya (Source: Central bank of Kenya).

Possible generation is based on the assumption that the generator is running continuously for 8,760 hours over the year. This is not the real situation.

Energy consumed in Thima and Kathamba is based on 16 hours per day assuming all households are fully utilising the power. In Mbuiru, it is based on power rating of electrical loads of micro-enterprises and hours of operation.

The generation costs are higher than the tariff for grid electricity, that is 0.13 US$/kWh in Kenya, but much lower than for solar PV-generation, diesel generators and use of lead-acid batteries. In fact, with a higher plant factor, the generation cost would approach the cost of grid electricity.

The experience derived from these two projects demonstrates the possibilities in mobilising rural communities to contribute significant parts of the initial investment for electrification schemes. The need for a commitment to pay for a significant part of the cost of the electricity used is also demonstrated. In Thima this has been achieved whereas in Mbuiru the tariffs paid are unrealistically low.

At present these schemes are operating within a policy vacuum. They are running based on ad-hoc agreements through “special permits” awarded by the Minister of Energy to generate and distribute power. Project beneficiaries had to form an association, register with the Department of Social Services at district level, apply for water use permits from the District Water Apportionment Board, and seek power generation and distribution permits from the Minister of Energy. The problem with this structure is that it is not provided for in the Electric Power Act 1997 and several actors who might influence or affect the development of these schemes further have been surpassed, for example, the roles of ERB and local authority.

Since the communities lack necessary technical and managerial capability for developing the schemes the role of intermediary organisations like ITDG and Ministry of Energy became necessary to bridge the gap between the technical, financial, implementation and management areas through participation and consultative process. In fact, the support given appears to have been inadequate since both projects have suffered from serious technical problems.

The level of success experienced is largely attributable to the level of institutional organisations formed to develop the project with the key institutions being the community electricity association for Thima and the society for Mbuiru. In Thima, the electricity association had long existed for the purpose of connecting the community to grid electricity. In Mbuiru, they had earlier on been organised to develop a water project for the area. This reinforces the view that working with or strengthening established institutions is likely to lead to sustained service, rather than the ambitious attempt to create new and untested local institutional arrangements.

Creating useful partnership with the beneficiary is the most important factor for the sustainability of a project. An open approach to constraints and respect for communities can be instrumental in the success of a project. The ability of the community to find solutions on land issues as well as scheme ownership indicates innovativeness and willingness to manage their own problems.

Though technology can be imported, it is an advantage if it can be found in the country. In any case it must be compatible with local conditions. Mechanisms for accessing affordable spare parts and service should be identified prior to project implementation. The demand for technicians trained for servicing small hydropower plants is at present low and dispersed. Hence financial subsidies will be required initially to sustain reliable and expedient service. Possibilities for establishing a technology centre to serve the region should be explored.

2.3 ISSUES AND OPTIONS FOR DECENTRALISED POWER SUPPLY IN MONGOLIA

The contribution was presented by Dr Namjil Enebish from the Ministry of Infrastructure of Mongolia. It includes an overview of the problems related to electricity supply in Mongolia, mainly in small population centres and rural areas, and a discussion of what could be done to provide electricity to all people in Mongolia, using renewable energy sources.

Today, one-third of the population of Mongolia lacks access to modern energy services. Needless to say, the situation is worse in rural areas and electricity access has in fact reduced from 46.1% in 1995 to 22.5% in 1998. The special conditions in Mongolia make rural electrification particularly challenging. The population density is low and a large part of the population lives in tents (gers), where many are migrating herders who live for part of the year near an urban area and camp out part of the year near their herds. Some ger households are permanently settled around cities or villages, but continue to live in their ger.

Seventeen of the 22 provincial centres are supplied from the main electric grids. The other five are supplied by diesel generator plants. Of the 314 village centres, 142 are connected to the main grids and the others rely on diesel generators with capacities in the range 60–100 kW. The total installed generation capacity in such isolated grids can be estimated at 40–50 MW. The service in the isolated grids is unreliable and many of the village power plants operate only for 3–4 hours at night. A general problem with all the diesel supplied electricity is that not even the full operating cost is recovered by the tariffs. Surveys to find out the willingness and ability to pay have not been carried out. The results of such surveys could form the basis for more appropriate tariffs.

A new energy law was enacted by the Parliament of Mongolia in February 2001 and it went into effect in April 2001. The law is a great improvement over the old law as it is fully based on economic principles. It describes rights and obligations for both the industry and consumers based on commercial relationships. This law, if fully applied, will fundamentally change the operations of the energy sector. Separate generation, transmission, dispatch, distribution and supply companies will now exist that need to obtain licences for operation. Power and district heat operations are now separated. The Ministry of Infrastructure's responsibility is now mainly limited to energy policy matters. The law establishes the creation of an independent regulatory agency, the Energy Regulatory Authority (ERA). ERA, will, amongst other things, issue licences and approve tariffs, approve and regulate commercial relations between companies, and provide consumer protection.

Mongolia is endowed with ample energy resources, both fossil and renewable. Coal deposits with proven reserves of about 5 billion tons exist. Although most of the deposits are lignite with a calorific value of between 10.4 and 14.6 MJ/kg, substantial volumes of bituminous coal have also been found with a calorific value of about 21.2 MJ/kg. *Petrol* was found in Mongolia, but is not actively being developed. One American company is continuing the exploration and organised pilot extraction. It is unlikely, however, that petroleum will contribute in a significant way to solving rural access problems.

Geothermal Energy. Resources are found in the central and western part of the country. There are about 42 known small hot springs. There are limited resources where the water flow has sufficient thermal capacity and is located close to a potential demand centre. Some hot springs are used for heating purposes.

About 70 % of all *hydro energy* resources are concentrated in the Mongolian Altai ranges, in the Tagna and Khan Khukhii ranges, in the mountainous areas of Khuvsgul, Khangai, Khentii and Khalkh gol river. More than 1 GW of potential hydropower capacity has been identified, and some 250 MW are planned to be built. In addition, there is much potential for mini-hydropower plants of up to 1MW capacity, which could be used to supply village centres with electricity, as an alternative to diesel plants. Several locations have been studied. One complicating factor is that many rivers freeze over during the winter and cannot provide year-round electricity. The construction of a 12 MW plant was started in May 2004 for supply to the Western System and to reduce Russian electricity imports. The construction of another 11 MW plant is planned to start soon to supply the two non-interconnected provincial centres of Altai and Uliastai which now operate diesel plants. There is a call for developing a hydropower master plan.

The land of eternal blue skies enjoys a favourable solar energy regime, ranging from a low insolation of 4.5 kWh/m^2 per day and fewer than 2,600 sunshine hours in the northern parts, to a high of 5.5–6.0 kWh/m^2 per day with a sunshine duration of 2,900–3,000 hours in the steppe and Gobi desert area. The Institute of Physics and Technology of the Mongolian Academy of Sciences began research and development of photovoltaics in the late 1970s and this has resulted in the establishment of a 1.5 MWp/year capacity state-of-the-art PV module manufacturing facility. This is now supplying PV modules (from 12 Wp to 55 Wp) for solar home systems and other applications on a commercial basis. At present, more than 50,000 solar home systems are reportedly in use by herders for operating radios, TVs and satellite dishes.

Wind energy resources vary from low in the northern part of the country to high in most of the southern parts. Average wind speeds of 3.5 m/s are obtained for less than 3,000 hours per year. The Gobi desert zones (some 40% of the territory) enjoy high wind energy resources with intensities of 150–200 W/m^2. Average wind speeds of some 5 m/s are obtained for 4,000–5,000 hours per year. Intermediate wind energy resources of 100–150 W/m^2 are found in the steppe zone. Average wind speeds of 4.5 m/s are obtained for 3,000–4,000 hours per year. Over 4,500 wind generators with capacities mainly between 50 and 200W are reportedly also in use in rural areas. A wind resource map for Mongolia which indicates how much potential energy is available throughout the country has recently been produced.

In fact, the only way that herders will ever get electricity is from the wind and the sun. Alternatives, such as small petrol and diesel generators, although technically possible, are cost-prohibitive, as they require regular and expensive supplies of fuel from urban areas. In 1999, the Mongolian Government launched the "100,000 Solar Ger" national programme to provide electricity to nomadic livestock herders. The programme covers the period 2000 to 2010, and its main purpose is to provide electricity to households in rural areas through Solar Home Systems.

The main activities are:

- to introduce 100,000 photovoltaic power systems to satisfy the basic energy needs of nomadic livestock herding families;
- to set up a "PV Technology Development Centre" which will provide testing, commissioning and the development of an infrastructure for marketing and after sales operation and maintenance support of photovoltaic systems;
- to carry out an evaluation and detailed socio-economic analysis of the impact of large-scale applications of photovoltaic technologies on the improvement of quality of life for inhabitants living in rural areas;
- to establish technical, institutional and economic confidence in usage of photovoltaic technologies to meet the energy demand of the nomadic livestock herding families;
- to prepare financial and technological evaluation reports of the activities for the period 2000–2005 and a rural electrification plan of Mongolia by the year 2010;
- to promote large-scale commercialisation of photovoltaic technologies and development of national programme electrification of all village centres in the rural areas of Mongolia.

Energy in particular is a key catalyst for economic development: without energy access, people do not have power for agricultural and livestock production and processing, for human and livestock watering, for household lighting, for non-farm income generation and micro-enterprise development, for medical refrigeration, etc. There have been many technological advances in the last decade, and the challenge to rural electrification is no longer technological, but the ability to develop an enabling environment, by institutional, policy, regulatory and financial means, that ultimately fosters rural electrification. Addressing this challenge will require raising awareness and developing the links between energy and rural development. It will also require creating markets for electricity delivery in areas that have been neglected until now.

Renewable energy activity is growing rapidly. Present progress shows that renewable energy could make a major impact on the provision of energy services to the rural population of Mongolia in next decade. In addition to coal and oil, Mongolia is rich in renewable energy resources such as solar and wind power. If Mongolia can provide the rural population with solar photovoltaic systems it will not only help improve social welfare but will also lead to a decrease in fuel import costs thereby reducing outflow of foreign currency. It will also enable Mongolia to contribute to the protection of the global environment.

2.4 DECENTRALISED RURAL ELECTRICITY IN NEPAL

The contribution was presented by Dr Madan B Basnyat of the Alternative Energy Promotion Centre in Nepal. It is focused on experience in the use of micro-hydro and solar PV electricity generation in rural communities in Nepal.

In Nepal, about 74% of the households are not at present supplied with electricity. Due to the mountainous terrain, for many rural communities connection to the national grid requires very large investments. Nepal is, however, rich in water resources and has long sunshine hours. Decentralised electrification schemes using renewable energy resources, and in particular micro-hydro power generation and Solar Home Systems thus seem to be the most viable for electrification of these rural communities.

Micro-hydro is the first renewable energy technology that was explored to electrify rural parts of Nepal almost 25–30 years ago. To date, 1.65% of all households are connected to micro-hydro schemes. The number of micro-hydro electrification schemes installed in mid 2003 was 429 with a total capacity of 7,472 kW. Also, about 940 so-called Peltric[1] sets have been installed with a total capacity of 1,638 kW.

The micro-hydro market is gradually growing. About 22 companies have been pre-qualified for the supply and installation of micro-hydro equipment. Fifteen of these are manufacturing companies that produce turbine, penstock pipe, trash rack, electronic load controller, ballast heater, sluice gate, and several electro-mechanical components. However, generators are imported from other countries. The most widely used turbines in Nepal are of the cross-flow and pelton types whereas use of propeller turbine is still in the demonstration phase. The efficiency of turbines claimed by the manufacturers is 70–72% for cross flow turbines and 75–80% for pelton turbines. Most of the projects are designed at an overall efficiency of 50–55%. Investments required for the micro-hydro schemes are site-specific. However, the average investment is within US$ 1,915 per kW to US$ 2,183 per kW.

Solar energy in Nepal has great potential. About 78% of the country lies in the high potential solar insolation areas. The monthly average daily global solar irradiation varies from 120 W/m^2 to 260 W/m^2 with annual sunshine duration ranging from 1,900 to 2,500 hours. In November 2003, 34,459 Solar Home systems [SHS] with a total capacity of 1,279 kW had been installed in 71 different districts under the Solar Home System Dissemination Programme. This means that about 1% of the households have been electrified with Solar Home Systems.

The solar PV industry in Nepal is an assembling type industry only. Solar PV modules are imported from USA, India, Japan and Spain. Support structures, DC lights and controllers are the few components manufactured locally. Batteries for Solar PV are imported from Bangladesh, USA and India. At present 13 industries manufacture lights locally or use lights manufactured locally by other industries. About 14 manufacturing companies have been pre-qualified by AEPC-ESAP.

With the view of electrifying rural areas with the renewable energies, the government of Nepal has set targets in its 10th five year plan to generate electricity equivalent to 10 MW from micro-hydro schemes and to electrify 52,000 households using Solar Home Systems. This would provide access to off-grid electrification for 12 % of the population. The government,

1 A Peltric set is a generation unit consisting of a pelton turbine and an induction generator which is manufactured in Nepal. The capacity range is 100 W to 40 kW.

through the Alternative Energy Promotion Center (AEPC), is providing attractive subsidies for encouraging adoption of the electrification services from the renewable energy sources. The aim of the government subsidy policy in general is to assist rural development with special attention to the economically deprived sector. However, there are still many challenges which need to be addressed and considered before the decentralised electrification programme will succeed.

Most of the rural people are too poor to afford the electricity services even with the subsidy. The majority of rural population in Nepal is beneath the poverty line, illiterate and technically ignorant. The rural electricity consumption pattern of Nepal seems to be more consumptive than productive. This is hindering the overall development of the rural economy. This may be due to insufficient knowledge regarding end use and its role in boosting the economy. In most cases, providing a poor household with better services results in a drain on its financial resources making it even poorer. Household commitment towards electricity services depends not only on their affordability but also on access to credit facilities. Poor people are still unable to afford clean energy technology even with the government subsidy, as there is limited access to credit facilities for rural people

Often, low-income and disadvantaged groups in rural society are discriminated against by the so-called rural rich. This discrimination is also apparent in the construction of community-based energy projects such as micro-hydro projects. In these projects, the cash and labour contributions required are the same regardless of the expected electricity consumption. Normally, however, the power demand of a rich household is about 10 times that of a poor household. Hence, compared to rich households (with hotels and lodges), poor households are paying more per unit electricity (kWh). Also, the tariff system is in effect discriminatory, since the rate for lighting for normal households and that for businesses and hotels and lodges is the same or only marginally different.

There is a lack of efficient technical and managerial manpower in rural areas, creating problems for the regular repair and maintenance of the energy technologies. Lack of appropriate research on low cost technologies of local interest and lack of real technological transfer are two of the factors which hinder sustainable access to better energy services for the poor.

It has become evident from experience that the constraints identified as hurdles for the anticipated development of rural electrification should be properly addressed.

Intense focus should be given to productive end uses to maximise the plant utilisation factor and improve economic development. Complementary programmes have to be introduced into the electrified areas to support end use activities. Poor people should be involved in those productive end use activities directly or indirectly. Soft loans and easy credits need to be made available to the rural people to start up end use activities. Rural people should have market access for their end use product. Energy technologies such as briquette production can be tied in with micro-hydro to maximise the plant utilisation factor.

With the current level of the subsidy and at the present price of the technology, energy technologies such as micro-hydro, solar PV and biogas, cannot benefit the poorest of the poor. Hence, low cost energy technologies appropriate for poor people must be developed and demonstrated. The proven technologies must be subsidised and disseminated for the poor. The low cost technologies identified during the study were pedalling generators, bio cells, and plastic biogas digester, low cost solar drier and batch type solar water heating systems. However these technologies are still in a primitive phase. Intense research has to be done to make the products/technologies saleable.

Much improvement is needed in the skill standards of locally owned workshops, and therefore skill upgrading training is of major importance. In order to provide low cost technologies to the consumers, local technologies can be modified to suitable engineering technology. Research is to be carried out to develop such engineering designs that fit both technologically and economically to the local environment. For the sustainable operation of the technologies, operation and management training must be provided to develop trained manpower at local level.

The design and implementation of subsidies should be viewed as part of a dynamic process. Subsidies should be assessed by their relative efficacy, sector efficiency and cost-effectiveness in the course of time. Subsidies should be made more poor-oriented. Tariffs should include cross-subsidies for the poor households using electricity for normal lighting purposes from the households or hotels and lodges who are using it for business lighting purposes, in order to minimise social discrimination.

2.5 VILLAGE ENERGY SECURITY – BIOMASS GASIFICATION

The contribution was presented by Dr S Dasappa of the Indian Institute of Science, Bangalore. It includes a discussion of the possibilities of using biomass gasifiers for fuelling internal combustion engines with special focus on the progress made at the Indian Institute of Science in Bangalore, for application of this technology for rural electrification.

Biomass gasification is of interest in India because it can be used for decentralised generation of high quality electricity with use of local renewable resources. Even though the national grid reaches far into rural areas in India, there remain many villages that cannot realistically be electrified by grid supply as a result of the large investments required and the difficulties in maintaining a reliable service to rural areas in the present system.

The use of biomass gasifiers for the fuelling of engines is an old technology that dates back to the 1930s. It was used extensively during the Second World War, in particular in Europe, to keep motor vehicles running when petrol was scarce and needed for military purposes. After the war, when petroleum fuels were again available at affordable prices, the technology was abandoned and almost forgotten until the oil price shocks in the 1970s again made it interesting to find alternative fuels for small internal combustion engines.

The principle is simple. Reasonably dry biomass is gasified by partial combustion with air in a simple reactor, operating at about atmospheric pressure. The gas obtained contains CO, H_2 and CH_4 mixed with CO_2, H_2O and N_2 and is combustible with a heating value of about 4.5 MJ/ kg. After relatively simple cleaning to remove particles and tars, the gas can be used as a fuel in spark ignition or compression ignition engines after simple modifications of the fuel system of the engine. Petrol used in spark ignition engines can be 100% substituted by the gas. Compression ignition engines need a small pilot injection of diesel fuel for each power stroke to ignite the gas and the resulting substitution of diesel fuel is therefore less. For direct injection engines the substitution can be 80–90%.

Many types of biomass, including agricultural residues, can be used as feedstock for the gasifier but generally, the same gasifier design cannot necessarily be used for any kind of biomass.

The Indian Institute of Science in Bangalore has been studying and developing the technology since the early 1980s and is now one of the research institutes worldwide with the longest experience in this field. About 300 person-years of development work is behind the present designs. The operating experiences include more than 100,000 hours of operation with gasifiers of different capacities, with different feedstocks and applications. The technology has been transferred to four manufacturers in India and two overseas.

The system developed by the Indian Institute of Science in Bangalore consists of an open-top downdraft gasifier with air supply from the top and through air nozzles at an intermediate level in the reactor vessel. High temperature zones are insulated using high temperature and high alumina materials to avoid chemical corrosion.

Stainless steel is used in gas contact zones. Gas cleaning is achieved with a cyclone and a series of scrubber-coolers. The resulting gas is clean with contents of tar and particulates below 5 ppm. More details can be found in Appendix 3.

The gasifier installation in the village of Hosahalli can be used to illustrate the practical experiences. The project was started in 1988. Hosahalli is a previously unelectrified hamlet located in a semi-arid area. The hamlet consists of 45 houses and has a population of about 220. Initially, a 5 kW generator set with a gasifier was installed. The electricity was used for domestic and street lighting, pumping of drinking water facility and flour milling activities. The system was upgraded to a 20 kW dual fuel system in 1999 to also allow for pumping of irrigation water.

The operation is managed by a committee with representatives from the village. Flat rate tariffs are used for light points, water taps and flour mills, whereas pumping of irrigation water is charged per hour. Tariff recovery in 2002 was above 99%. Fuel is obtained from a 2 ha plot of village land and also some agro residue grown in the village.

The reliability of the electricity supply in Hosahalli is acceptable (downtime less than 5%) and much better than nearby villages supplied by the grid where downtime can be about 40%. Also the voltage level is kept more consistently at the specified 210 V in Hosahalli. The generation cost in 2002 was 4.67 Rs/kWh (0.105 US$/kWh) in dual fuel mode.

A new project, Bio Energy for Rural India (BERI), using biomass gasifiers is planned for implementation in 2004–06. The objective is to provide all the energy needs of a village by using locally available biomass in about 25 villages in Karnataka. Clusters of five villages have been chosen to provide electricity using biomass gasification in 400 kW power plants. The existing national grid will be used to energise the line (with grid electricity as a back-up) to provide domestic lighting and drinking and assured irrigation water to all the households.

The strengths of biomass gasification as a technology for decentralised village electrification are obvious. It strengthens self-reliance, for instance, by using a locally available fuel. It is also environmentally sound because it can replace fossil fuels. The main weaknesses are that the replicability is not yet proven, the capital investment is larger than for diesel generators, the fuel is dispersed, there is no standardisation of technology and the knowledge about safe operation and maintenance of this type of system is almost non-existent in the villages, even though skills are available. Many projects failed during the 1980s due to bad planning and incomplete understanding of the technology and the requirements for specially qualified operators, which gave the technology a bad reputation.

The mentioned BERI project will certainly serve to demonstrate the great potential of the technology and be a good example for others to replicate in all developing countries.

2.6 HYBRID PHOTOVOLTAIC/DIESEL SYSTEMS IN REMOTE AREAS IN BRAZIL

The contribution was presented by Professor Edson Bazzo of the Federal University of Santa Catarina, Florianopolis, Brazil. It includes a brief presentation of the energy situation in Brazil and a discussion of the technical and economic feasibility of hybrid photovoltaic-diesel systems for electricity generation in remote communities in the Brazilian rainforest.

In Brazil there are about 100,000 small isolated communities with an average population of 150 inhabitants per village, without access to electric energy services. Overall, just 30% of the rural properties are supplied with conventional electrification. The access to electricity varies between different regions. The infrastructure is least developed in the northern region, where only 7% of the population living in rural areas has access to electricity services. This northern region also has no connection with the main transmission grid. A total amount of about 460 MW is generated by diesel engine generators for supplying more than 350 small villages provided with local isolated mini-grids. The typical nominal capacity of the diesel generator sets is well below 1 MVA. In many cases, the isolated communities can only be reached by boat or dirt roads, and diesel supply is therefore costly and unreliable. To reduce the impact of the high generation costs to the end-user, the Brazilian government, through a so-called "National Fuel Consumption Account" or "CCC-Conta Comum de Combustível", subsidises diesel used for this purpose.

The well-known hybrid photovoltaic/wind/diesel systems should be reliable alternatives for electricity generation for supplying the remotest communities. In Brazil, a very small hybrid system was first installed in 1994, in the site of Joanes (state of Para). It is a 52.5 kVA diesel, 10.2 kWp solar PV and 40 kW wind farm. Since 1999, two other small hybrid power plants were also installed in Para. A hybrid 7.5 kVA diesel, 25 kW two wind turbines 10kW/15 kW system and a 30 kVA diesel 127/220 V, 2 kW solar PV panels, two wind turbines 10kW/10kW system are in operation in Ponta de Pedras (Marajó Island) and Marapanim, supplying electricity energy for about 125 and 190 people, respectively. Since 2001, a 300 kVA diesel and 20.48 kWp solar PV panel system is in operation in Vila Araras-Nova Mamoré, located in the state of Rondonia. More recently, since 2003, a 20 kVA diesel, 3.2 kWp solar PV and 10 kW wind turbine system is in operation in São Tome-Maracanã, in the state of Para.

Presently, the government is financing renewable energy projects, including use of energy sources like wind and solar, to offset the cost burden and environmental consequences of diesel consumption. Considering the high levels of insolation available in these regions (typically above 2000 kWh/m^2/year on average), photovoltaic solar energy conversion, on a hybrid configuration with the diesel generator sets already in operation at these sites, is a potential candidate as a reliable, clean and renewable energy source.

Based on the electricity demand profiles of a typical village in the rainforest, a 24 kW photovoltaic system on a hybrid configuration with a 150 kVA existing diesel generator is proposed for analysis. Based on current costs, the analysis shows a payback time which is still too long and not economically attractive without government subsidies. However, with the declining costs of photovoltaic technology predicted for the next few years, the continuously increasing costs of diesel and the end of the National Fuel Consumption Account in 2022, hybrid photovoltaic-diesel systems may become economically viable, thus representing a huge potential in the future.

The diesel genset includes a diesel engine, which is coupled to a synchronous generator that delivers AC electrical power at 220 V and 60 Hz (true sine-wave). The diesel genset is rated at 150 kVA and is responsible for base load supply at all times in this installation. The PV array is an auxiliary energy source, designed to offset diesel consumption at high solar irradiance periods, and is rated at 24 kWp DC. The PV system is parallel connected to the diesel genset by means of a DC-AC converter (inverter), which is synchronised by the diesel generator. To avoid the islanding effect, inverters were chosen, which automatically disconnect the PV array in the case of grid failure or disconnection, to prevent the grid being energised unintentionally.

Most hybrid PV/diesel systems described in the literature use battery storage, which represents additional installation costs and maintenance, as well as the inconvenience and extra costs of periodic replacement due to the batteries' reduced lifetime. In this respect the present design offers a more energy-efficient approach since batteries are not used and the PV system is feeding in real time to the mini-grid all the power produced. Diesel genset performance data, real electricity demand profiles and solar radiation data are available for typical isolated communities in the Brazilian rainforest.

Three small villages located in the state of Acre (Porto Walter, Thaumaturgo and Santa Rosa) have been first considered as candidates for using the hybrid system. All three villages are located close to the Bolivian and Peruvian borders. There is no connection by road. The diesel transporting is done by ship along existing rivers. Sometimes the access to the site is possible only by small planes. The electricity is generated by a set of diesel engines coupled to AC generators. Usually, an additional diesel generator is provided as a back-up unit, for preventing power shortages in the event of generator breakdown. The diesel system is then connected to a local mini-grid to serve the respective village 24 hours per day.

The economic analysis presented here is focused on the Santa Rosa power plant. The daily electricity demand profile shows a more or less steady load of about 30 kW and a peak period reaching about 45 kW between 17 hours and 22 hours. The total annual power generation is 280 MWh.

The financial feasibility has been evaluated for preliminary investment cost at around 4 US$/Wp (PV system part), interest rate of 6% and the assumption that 50% of the investment is financed with loans. Two fuel price scenarios were considered:

Scenario 1: Fixed diesel cost (30 US$-cent/litre).

Scenario 2: Increasing diesel cost of 5% per year.

The economic viability of the hybrid system is strongly dependent on government subsidies. For scenario 1, the project is attractive only for government subsidies greater than 45% (Payback<22 years; IRR>12%). For scenario 2, the project is attractive for government subsidies greater than 15% (Payback<23 years; IRR>12%).

In fact, using an existing legal mechanism in Brazil, a refund of up to 75% of the global investment would be possible. With this, the investment will be very attractive, with Internal Rate of Return close to 20% and a payback smaller than 3 years. Whatever the case, the continuously increasing cost of diesel, as planned by the Brazilian government for the next few years, and considering environmental taxes as proposed by international environmental commitments, such as the Kyoto Protocol, hybrid systems can become economically attractive without such subsidies. For environmental taxes[2] fixed above 40 US$/tonne CO_2, and taking

2 In Sweden, the CO_2 tax is currently about 140 US$/tonne CO_2 for light fuel oil used for heat generation. (Editor's remark)

into account current diesel prices in the Brazilian market, there is no need for government subsidies to install hybrid photovoltaic/diesel systems. With the declining costs of photovoltaic technology predicted for the next few years and the continuously increasing costs of diesel, the hybrid photovoltaic-diesel systems may soon become economically viable, thus representing a huge potential in the near future.

3 Conclusions from workshop discussions

3.1 RURAL DEVELOPMENT AND RURAL ELECTRIFICATION

As a basis for the discussion on the possible effects of use of renewable energy technologies on rural development, the discussion group agreed upon the definition of rural development as follows in Robert Chambers, Rural Development Putting the Last First (page 147):

> *"Rural development is a strategy to enable a specific group of people, poor rural women and men, to gain for themselves and their children more of what they want and need. It involves helping the poorest among those who seek a livelihood in the rural areas to demand and control more of the benefits of development. The group includes small-scale farmers, tenants, and the landless."*

The links between rural development, rural electrification and use of renewable energy were discussed by all the discussion groups. The conclusions can be summarised as follows:

A significant percentage/part of the rural population in developing countries lives in areas where electricity services from the main electric grid cannot be provided in the foreseeable future for economic reasons. Access to electric power is important for economic development, development of community services (i.e. clean water supply, health care and education). Financial support from donors such as Sida for provision of electricity services in such areas will therefore contribute to the general development goals of poverty reduction.

In many developing countries the electricity sector is undergoing restructuring which includes elimination of previous monopolies, breaking up of national parastatal utilities into separate generation, transmission and distribution companies, and encouraging private entrepreneurs to engage in electricity supply. It is too early to judge if the restructuring will facilitate rural development by electrification or act as an obstacle. It is, however, unrealistic to expect that rural electrification projects using renewable energy will attract many private investors unless initial negative cash flow is covered by government or donors. Also, since the interests of the private investors are profit-driven, one can question whether the rural population will be better serviced on a deregulated market, given their typically low consumption and limited paying ability.

There should be a stronger commitment to actually deliver electricity services to rural areas. It is too early to say if this will be easier to achieve by introducing new actors on the market or by changing the governance systems and the priorities of the present monopoly utilities. Opening the market to several actors and private interests should however be considered, primarily for two reasons. First of all, this opens new sources for financing. Secondly, the services provided so far, under state monopoly, to customers in rural areas have often been of poor quality, if provided at all. Any improvement of this situation is then positive.

Privatisation must be combined with measures for customer protection, to make sure that the rights of the consumers are not being violated. Also the provision of electricity for community services such as water supply, health care and street lighting must be ensured.

Electricity generation from renewable energy can support income generating activities, however, the choice of technology will decide to what extent and for what purposes. Of the available technologies, solar PV imposes most limitations on possible income generating activities, whereas in particular mini-hydro and biomass open the same possibilities as grid electricity or diesel generator sets.

Renewable energy sources for rural electrification could provide positive effects on rural development in addition to those resulting from grid extension or diesel generator sets, provided that either the cost of generation is lower or the use of renewables involves other benefits such as improved self-reliance, generation of local employment, reduced environmental stress or reduced vulnerability to price changes on the international fossil fuel market. The latter effect varies between different technology options. Biomass energy is possibly the option that, in comparison with conventional energy, generates most local employment opportunities. A significant part of the life-cycle cost for electric power from biomass is fuel costs and these expenses end up as revenues for local entrepreneurs and workers who are engaged in the fuel supply. This is in contrast with solar PV, wind or mini-hydro systems where the initial investment dominates the life-cycle cost and where most of this expense ends up far from the local community.

The gender aspects of rural electrification are mainly related to the ways in which the electricity is used and not so much to the generation technology as such. The limited usefulness of electricity from solar PV might be less of a problem for productive activities traditionally engaging women than for activities in which men may engage if electricity services that can support power demands in the kW range are available. Also, women may be those that most appreciate the benefits caused by savings of time and effort for domestic chores, made possible by the introduction of electric lighting. It follows that men may benefit less than women if only electricity from solar PV is provided.

A renewable solution that carries a higher cost than conventional energy (grid or diesel) should not be promoted just because of its positive global environmental effects if the local communities who only have limited resources have to carry this higher cost. When local environmental benefits like reduction of soil erosion or other social benefits like employment creation can be factored in, the local community should decide if the benefits are worth the higher cost.

3.2 GENERAL CONCLUSIONS REGARDING RENEWABLE ENERGY FOR DECENTRALISED ELECTRICITY GENERATION IN DEVELOPING COUNTRIES

The limiting factors for further penetration of renewable energy are today linked to issues of cost, financing, service infrastructure, awareness of available technology, trust in its practicability and reliability from the perspective of (rural) entrepreneurs and of the rural population as a whole and to some extent the need for complementary resource assessments.

In most developing countries, the potential for increased use of renewable energy for electricity generation is significant, even if the potentially most important renewable energy sources vary, depending on local conditions. Knowledge about the sustainable local potential for use of renewable energy sources, and about the variations in the potential that can be expected, is essential for the planning of electricity supply systems using renewable energy. Much data from resource assessments already exist, but complementary studies will nevertheless often be necessary before investment decisions are made. In most countries there is no need for additional general data gathering missions. Data collection should be limited to sites where project implementation appears feasible based on already available data and should focus on the needs of the project[3].

For isolated electricity users with low load requirements solar PV is clearly the most economic option for electricity supply. Increased self-reliance, minimising uncontrollable expenditure of foreign currency and improved security of supply will be gained by the use of solar PV, wind, mini-hydro or biomass. Biomass-based power generation in addition opens new employment opportunities and reduces the out-flow of cash from the local community.

Renewable energy technologies already make significant contributions to rural electricity services in some countries. In many cases diesel generator sets are still the most economic solution, at current oil prices, for provision of electricity services where the demand exceeds a few kW and where the service is required at any time. Diesel generator sets are financially unattractive mainly at sites with very favourable conditions for electricity generation with mini-hydropower and at sites where transport costs for diesel are very high.

Use of diesel generators leads to emission of CO_2, but developing countries have no obligations under the Kyoto Protocol to reduce their emissions of this greenhouse gas. Sida, however, like other donors in the developed countries, has an obligation to promote use of generation technologies that do not contribute unnecessarily to emissions of greenhouse gases.

Pioneer users of renewable energy need incentives to compensate for risks associated with bringing in a technology that is not adapted to local conditions and possibly brings initial difficulties with technical service and spare parts supply. Such incentives have been used in most countries where renewable energy for decentralised electricity generation has been successfully introduced. The incentives can be in the form of direct subsidies of part of the investment, provision of loans on favourable terms, or a guaranteed market with agreed tariffs.

In order to utilise the potential for use of renewable energy for decentralised rural electrification, it is essential to provide training for the end-users as well as for personnel who will be responsible for operation, repair and maintenance. Once a successful project is being implemented one should make sure there is a demonstration plan in order to ensure replication.

Clustering, i.e., concentration of installations in a limited geographical area with a reasonable infrastructure for transport and communication, facilitates the establishment and sustainable functioning of an adequate and cost-effective service, maintenance and fee-collecting system[4]. Clustering is therefore strongly recommended.

3 The need for data collection caused some discussion. It was suggested that "commercial" pilot projects in places where sufficient information and motivation is available will result in more useful information about feasibility and viability of rural electrification schemes based on renewables, than additional data collection schemes and studies. On the other hand it was suggested that site-specific data collection should always be part of the planning process since available data are seldom reliable enough for a serious project appraisal.

4 For example, costs of PV systems in some African countries are higher than in Asia, probably because of the limited size of the local markets in the African countries.

3.3 WIND AND SOLAR PV TECHNOLOGIES

Technologies for decentralised electricity generation with solar PV and wind are commercially available. In particular, solar PV is used extensively in many countries. Important features of solar PV and small wind generators are that they are modular, simple to use, reliable and often the cheapest alternative when the power demand is small.

Energy storage is important for both solar and wind systems. The solar radiation varies over the day and is not available at night. Wind speeds vary more irregularly but are often seasonal over the year. Therefore, some kind of storage or back-up system is necessary to ensure that electric power is available when required. For small individual systems, battery storage is often the preferred solution. Batteries are, however, a weak part of the system, with a lifetime much shorter than that of other components.

Optimisation of quality, simplicity, initial investment and life-cycle cost remains an issue for solar PV systems. Over-sizing or very high quality requirements lead to higher investments, which is an obstacle to implementation. Use of cheap batteries or other low quality components leads to high life-cycle cost. Different approaches to this are used in government programmes in different countries. Development and widespread publication of recommended system designs can be a method to avoid spreading of inferior designs.

Whether solar home systems or PV-supplied grid systems should be used depends on the local conditions. The grid approach opens up possibilities for cost-efficient wind/solar generation or cost efficient back-up with diesel generators.

To ensure sustainable availability of trained operators, service and spare parts, the number of installations in a geographical area should not be too small. As an example, in Mongolia, for a market of 40,000 households with solar home systems, about 500 technicians have been trained. These technicians have signed a contract to stay in a specific location for at least three years.

There is a serious risk that the private market dies when the government comes in with subsidised programmes for solar home systems which are bought on the international market. In Mongolia, the systems offered under the 100,000 Ger programme are about 20% less expensive than the systems on the local market, they are of better quality and warranty, and the capital can be repaid over two years. To reduce the negative impact on the local market supplying PV systems in Mongolia, the capital repaid for solar home systems goes into a revolving fund managed by the 100,000 Ger programme and it will be used to procure equipment on the local market.

Often, the local manufacturing of components such as charge regulators and solar panels, and the assembly of solar panels and other electronic equipment, cannot compete with the prices on the global market. Local manufacturing can make sense for things like supporting structures, wiring and auxiliary equipment.

3.4 MINI-HYDRO TECHNOLOGY

The technology for electricity generation utilising the kinetic energy in water flowing in rivers and streams of different sizes is well established for a wide range of capacities from below one kW to above 100 MW. There is a terminology for classification of hydropower plants according to size from “pico-hydro” (below 10 kW) and upwards, but here “mini-hydro” will be understood to include all hydropower plants with a capacity below about 1,000 kW.

Mini-hydro power generation should always be considered for provision of decentralised electricity services at locations where suitable hydrological conditions appear to exist. The technology is mature and there are numerous examples of successful use.

Before decisions about investments in mini-hydro schemes are made, site-specific hydrological studies are required. Such studies need to be optimised to achieve reasonable accuracy within a reasonable measuring period, for instance, by combining local data and general data on precipitation and hydrology. As a general recommendation, local data collection shall not require more than 12 months. In cases where only a small fraction of the available flow needs to be used, the data collection will not require large efforts. No major hydrological studies are then needed.

Seasonal and annual variations in precipitation and water flow must be taken into account when a generation system based on mini-hydro is designed. Daily and weekly mismatch between electric load and water flow can often be compensated by a dam for storage of water. Other approaches to matching of load and supply, such as wind or solar supported pumped storage and fly-wheels should also be considered. Back-up with diesel generators is often the cheapest way to ensure reliable electricity supply when the conditions on the site are not suitable for a dam and when the expected water flow is inadequate for the electric load for extended periods.

Mini-hydropower generation is associated with high initial investments and relatively low operating costs. It is unrealistic to expect that the beneficiaries of decentralised electricity services will be able to put up the necessary initial capital for a mini-hydro plant. Expanded use of mini-hydropower generation is therefore very dependent on the availability of external capital that can be provided from government funds, donors or private investors.

3.5 TECHNOLOGIES FOR ELECTRICITY GENERATION WITH BIOMASS

Wherever co-generation of electricity and industrial process heat from biomass fuel appears as a possibility, this possibility shall get first priority.

For stand-alone electric power generation with biomass fuel at capacities below about 1 MW(e), gasification of pre-processed biomass fuel and use of the gas as a fuel in an internal combustion engine is often the most realistic process. The steam process, having a considerably lower electric efficiency, may be more attractive in special cases, for instance when fuel supply is abundant and fuel price is very low or when there is a need for co-generation of electricity and heat at a heat-to-electricity ratio that is more suitable for the steam process.

Even though a suitable technology for biomass gasification power generation is available on commercial terms, the markets for the technology would be wider if gasifiers with better fuel flexibility, and pre-processing equipment suitable for small scale fuel preparation were available. Automatisation of the operation is not a necessity for most applications in developing countries, but gasifier systems shall be equipped with control systems that ensure safe operation without the need for operator intervention.

The necessary pre-processing of gasifier fuel normally includes drying and sizing and sometimes also densification. Carbonisation of the biomass before gasification allows use of cheaper gasifier systems and facilitates operation, but implies loss of primary fuel energy unless the carbonisation heat can be utilised, for instance, for timber or crop drying.

Biomass-based electricity generation requires that a sustainable supply of a suitable biomass fuel can be assured. Evaluation of the fuel resource base, including consideration of competing uses for the biomass and the land used for producing the fuel, is therefore an essential part of a biomass energy project. Ensuring sustainable fuel supply is one of the first actions to take in the implementation of a bioenergy project.

If possible, biomass power plants shall be located so that the load factor becomes as large as possible. A combination of domestic lighting load with an industrial load or pumping for irrigation is clearly favourable.

Promotion of biomass-based electricity generation will be facilitated by performance and reliability guarantees from the supplier. Such guarantees will normally be reflected in the price of the equipment. When equipment is installed at remote locations where there are no, or few, similar installations close-by, the added price charged for the guarantees may be substantial. Donors should consider some risk sharing for pioneer users, for instance by committing funds for a reasonable fraction of the guarantee cost.

Decisions about starting local manufacturing of equipment for biomass-based power plants shall be based entirely on commercial considerations. Donors may give support to local capacity building for operation and maintenance of biomass power plants.

Biomass-based electricity generation is not modular, like solar PV, and this means that the expected load growth must be taken into account when the capacity for a new plant is decided. In most cases, this leads to under-utilisation during the first years of operation and low or negative net cash flow during these years. This must be taken into account when the need for working capital is estimated.

3.6 ORGANISATION AND FINANCING OF DECENTRALISED RURAL ELECTRIFICATION

The goals of power sector restructuring, to improve technical and economic efficiency and to mobilise investments for increased access to electricity, are desirable, but in many cases the process of restructuring appears not to have facilitated rural electrification, with or without renewable energy. To some extent, there have been increases in access levels and improvements in technical and economic efficiencies in urban areas, but not really in rural areas.

The timing when setting up the institutional framework for a restructured power sector is sensitive. A regulator that is not in place at the right time has had negative impacts.

From a historical perspective the involvement of the private sector has been instrumental in increasing access to electricity. In Europe, at the beginning of electrification 90% of the power was used by industry thereby contributing to economic development. Eventually the state came in and monopolised the electricity companies.

Specific support for rural electrification is necessary and has to be managed in a different way to that for urban electrification. To increase access in rural areas subsidies are needed. A cross-subsidy approach, where urban users cover part of the cost for the supply to rural areas, is often used. Mobilising investment capital has largely failed. Private investors are reluctant to come in unless the government guarantees an acceptable rate of return on the investment.

A subsidy to a renewable energy technology industry can be helpful or harmful, depending on its state of development[5]. Subsidies can be appropriate when supporting the growth of a market to a certain level to reduce costs of a renewable energy technology for pioneer users. However, it is difficult to set the level of subsidy as well as the length of the subsidy correctly. Pulling out too early or too late will have negative impacts.

Cultural differences and differences in legal traditions must be taken into account when rural electrification is organised. A successful example from Asia may not easily be replicated in Africa. The conditions and structures are different. Time and experience are needed for a sound system to evolve.

Local ownership and management of decentralised systems for electricity supply can be an effective way to achieve cost recovery and sustained operations. There are several examples of locally owned and managed small rural utilities that are more successful than national utilities to collect payment for the service and maintain high reliability.

Small private or cooperative rural electric utilities have difficulties hiring and paying for the legal, technical and administrative expertise that is needed for efficient operation. There is therefore a need for an organisation that can give advice on such matters. Such organisations[6] have been, and are still, important in industrialised countries.

Different types of financing are needed. Risk capital is needed to support private actors at the innovation stage. Operational capital is needed to scale up an idea to a realisable business. Finally, depending on the scale of the project, transaction finance is needed. Transaction finance is needed both for micro-lending to customers in order to grow a market as well as for risk sharing for bigger investments made by the private sector.

Micro- or end-user credits can be effective for promotion of solar home systems or for elimination of financial obstacles to grid connection when a local distribution grid exists. Micro-credits can play a role in enabling more customers to access the services/products and allow the industry to grow. Micro-credits are not meaningfully directed towards a particular company but to end-users of products and services from a company or an industry.

Concessions can work if all the actors want them to. Morocco has had good experience of rural electrification concessions largely because the utility is supporting this approach. In South Africa the experiences are less promising partly due to the lack of interest from the national utility.

3.7 GOVERNMENT POLICIES FOR RENEWABLE ENERGY IN RURAL ELECTRIFICATION

Governments in developing countries have many reasons to promote the use of renewable energy for rural electrification even if minimising greenhouse gas emissions is not one of them. Such reasons may include reduced import bills, improved self-reliance and creation of

5 Example from India:

In India a 55% capital subsidy was provided for solar PV systems in a market where private operators where already doing business. In an area the subsidy was limited to 1 000 systems per year where the annual demand was for 10,000 systems. The subsidy gave false signals to the customers about the real price of solar PV equipment and affected the relationship between the private operators and the customers.

6 In Sweden, Elverksföreningen has served this purpose and in USA, NRECA (National Rural Electrification Co-operative Association). For experiences from USA, see “Rural Electric Sourcebook” issued by NRECA in 1990 (ISBN 0-917599-02-0).

local employment opportunities. Renewable energy may in many cases be the most economic option particularly if the effects of reduced fuel import and creation of local employment are considered.

A government policy for renewable energy in rural electrification should be an integral part of the rural electrification policy and should focus on eliminating financial and institutional barriers that discourage utilities, cooperatives, private companies and individuals from using renewable energy for electricity generation where this would be desirable from a wider perspective. The policy should promote rural industries and income-generating activities in general. Since investments in renewable energy technologies often have long pay-back times, it is important that the legal and financial frameworks are stable and the long-term commitments of the government as regards renewable energy have high credibility.

There are several effective mechanisms for promotion of renewable energy for rural electrification. Promotion by strong commercial actors has proven very effective for solar PV and to some extent for wind. In developing countries there are no such actors for biomass and mini-hydro and donor support is needed to set up local or regional organisations to promote these technologies, and provide them with the resources to do so, in areas where there is significant potential. Other effective mechanisms are the use of GEF-funding for covering incremental costs and special incentives for pioneer users. The Clean Development Mechanism under the Kyoto Protocol is also a possibility, but it is probably mainly relevant for larger projects where transaction costs are manageable.

Taxes and levies on fossil fuel prices will lead to increased costs for electricity generation and are therefore not recommended. Regulation can also be effective but is also not recommended.

Governments should take a responsibility in developing the indigenous technical skills required for utilisation of the indigenous renewable energy potential. This includes training the necessary workforce to ensure sustainable maintenance of renewable energy technologies.

Donors can act in several ways to assist governments in the promotion of renewable energy for rural electricity generation. Donors can for instance:

- act as financiers with higher risk acceptance, by providing soft loans for financing of rural electrification schemes using renewable energy;
- give grants for feasibility studies, certification and resource assessments;
- support organisation of promotional actors;
- support training and educational programmes;
- support integration of renewable energy into the regulatory framework;
- support capacity building at various levels.

Subsidies to electricity consumers in rural areas are justified for equity reasons and are given also in developed countries, mainly as cross-subsidies where urban users carry part of the cost for electricity supply to rural areas. The subsidies should be independent of the supply technology, i.e. they should be the same if grid extension, local grids or organised individual solutions, such as solar PV-systems, are used to provide the service. Additional subsidies for electrification schemes using renewable energy can be justified for limited introductory periods when demonstration of the performance of the technology is necessary, or when a small number of installations leads to high costs for maintenance and service.

It is important that subsidised rural electrification is planned so that it brings benefits to all, even the poorest. Even with subsidies, poor households may not initially be able to enjoy electricity in their homes. They will still benefit if the electrification includes health centres, schools and other public facilities as well as provision of streetlights in all parts of a rural community. It is important that generation technologies that can support such services are selected.

4 Recommendations to Sida

4.1 GENERAL RECOMMENDATIONS

Sida needs to include energy issues as a key parameter in their programmes since access to energy is a significant tool in poverty alleviation.

Support for rural electrification, and in particular for rural electrification based on renewable energy, must be considered as a long-term commitment by Sida.

4.2 POLICY DEVELOPMENT

Sida should support development of national energy policies that include support for rural electrification and use of renewable energy for electricity generation where this is economically justified. The economic evaluations should include consideration of local environmental costs and any additional benefit that might be generated by utilisation of renewable energy, such as improved supply reliability and creation of local employment opportunities.

Sida should not only support master planning of energy infrastructure on a large-scale (e.g. on a national level) but also at the level of smaller entities (villages, communities, etc.) and be in harmony with the overall development plans for those areas/regions. Support for planning at lower levels should only be provided if commitment can also be made to support implementation, if the planning work indicates that the project meets predetermined acceptance criteria.

Sida should support the development of regulatory frameworks and institutions that incorporate the goals of improving the techno-economic efficiency as well as addressing social and environmental development goals in power sector reform processes.

4.3 PROJECT SELECTION

The expected impacts on rural development and poverty alleviation should be the main basis for selection of rural electrification projects for financing. This means that possibilities of finding productive uses of the electricity should be very important for project selection.

Projects financed by Sida should be designed to provide immediate benefits also to poor groups who cannot initially afford electrification of their homes.

4.4 TECHNOLOGY CHOICE

In the past, Sida has focused on supporting large hydro systems and rural electrification by grid extension. Sida should be more flexible as to plant size, and be open to support the application of decentralised smaller (pico, micro, mini) systems, as appropriate.

When generation using renewable energy is economically justified, Sida should support this option and be prepared to cover risk costs associated with introduction of a technology that has not been used earlier in the area and cover other costs for workforce development. Also, electrification schemes using renewable energy that are more costly than conventional options may be given support, but in these cases the additional cost should not be carried by the electricity consumers[7].

Sida should not require 100% supply from renewable energy sources in rural electrification schemes. In many cases, hybrid systems which use a diesel generator set as back-up and for peak load generation will be the most economical and, from a life-cycle perspective, even environmentally most efficient.

4.5 RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT AND DEMONSTRATION

In most developing countries, the potential for increased use of renewable energy for electricity generation is significant, even if the potentially most important renewable energy sources vary, depending on local conditions. Sida should provide support for assessment of the sustainable potentials for renewable energy where such data are still not available, but only after a decision has been taken to support electrification of a rural area.

Resource mapping should be part of an implementation project and not an activity that is pursued as excuse for not doing anything tangible. Resource mapping should be carried out using the latest technologies, but should also take into consideration locally available information.

Sida should support the development, adaptation, testing and use of new technologies. This can stimulate business development, provide employment opportunities and generate more appropriate technologies. Sida needs to accept a higher degree of risk in this context. Technology development should be undertaken in close cooperation with researchers in the countries where the technology shall be applied and in a context where electricity consumers are not exposed to any technological risk. A rural village in a developing country should not be a testing ground for unproven technology.

Sida should support the local manufacturing of equipment for renewable energy, but only on strictly commercial terms.

Sida should encourage public procurement competition schemes to stimulate the development of more cost- and energy-efficient technologies.

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7 The additional cost may have to be carried by Sida.

4.6 ORGANISATION AND FINANCING

For generation technologies that are not modular, such as solar home systems, the expected load growth must be taken into account when the capacity for a new plant is decided. In most cases this leads to under-utilisation during the first years of operation and low or negative net cash flow during these years. Sida should make sure that sufficient working capital is made available before decisions are taken to implement such projects.

Sida should support and stimulate the growth of organisations delivering renewable energy on a local level provided that the supply basis is sustainable.

The success rate for risk capital is often as low as 3–5%. Sida should be prepared to take risks when financing increased access to electricity services from renewable energy technologies. Another role that Sida should consider is supporting organisations, companies and institutions, by working in conjunction with them.

Sida should not shy away from partnering with private companies or supporting partnerships between the state and private sector.

Sida should help mobilise capital for private actors if the actor is providing public benefits and has an appropriate business plan.

Sida should share financial risks, not technological or private enterprise risks, but public risks.

4.7 CAPACITY BUILDING

Sida should support institutions and capacity building of the actors as the electricity sector goes through restructuring. Support to national organisations that can act as advisors on legal, technical and administrative matters to small private or cooperative electric utilities can be essential for the success of locally managed distributed electricity supply in rural areas.

It is recommended that significant participation of local consultants should always be a requirement in projects financed by Sida.

Appendix 1

LIST OF PARTICIPANTS

Name	Affiliation	Country
Al-mas Sendegeya	Makerere University	Uganda
Anders Arvidson	SEI	Sweden
Anders Ellegård	Swedpower	Sweden
Anna Perskaja	Stockholm University	Sweden
Badan B Basnyat	Alternative Energy Promotion	Nepal
Bernt Rydgren	Swedpower	Sweden
Björn Kjellström	Exergetics AB	Sweden
Bo Hektor	SLU /HPP	Sweden
Edson Bazzo	Federal University of Santa Catarina	Brazil
Elisabeth Ilskog	ÅF	Sweden
Elisabeth Undén	Chalmers Technical University	Sweden
Eric Usher	UNEP Paris	
Helena Forslund	SEI	Sweden
Hubert Stassen	BTG	Netherlands
Ivo Martinac	KTH	Sweden
Jenny Larfeldt	TPS	Sweden
Lisa Edin	Chalmers Technical University	Sweden
Mackay Okure	Makerere University	Uganda
Mikael Amelin	KTH	Sweden
Namjil Enebish	Ministry of Infrastructure of Mongolia	Mongolia
Njeri Wamukonya	UNEP Nairobi	Kenya
Ousmane Diawaras	Private Consultant	Mali
S Dasappa	Center for Sustainable Technologies, Indian Institute of Science	India
Sten Bergman	Stonepower	Sweden

Appendix 2

AGENDA

Wednesday 9th June 2004

Afternoon / evening	Participants arrive in Studsvik

Thursday 10th June 2004

08.00 – 09.00	**Breakfast**
09.00 – 09.30	**Opening of workshop: Explanation of objectives and programme** Mr. Anders Arvidson and Ms. Helena Forslund, SEI
09.30 – 10.15	**Policy initiatives in Uganda towards the use of renewable energy technologies** Dr Mackay Okure, Makerere University in Uganda
10.15 – 10.30	**Coffee**
10.30 – 11.15	**Issues and options for decentralised power supply in Mongolia** Dr. Namjil Enebish, Ministry of Infrastructure, Mongolia
11.15 – 12.00	**A Technical and Economic Analysis of Hybrid Photovoltaic / Diesel Systems for Remote Areas in the Brazilian Rain Forest** Dr. Edson Bazzo, Federal University of Santa Catarina in Brazil
12.00 – 13.00	**Lunch**
13.00 – 13.45	**Village energy security – biomass gasification** Dr. S Dasappa, Center for Sustainable Technologies, Indian Institute of Science
13.45 – 14.30	**Challenges facing rural electrification with RETs a Kenyan example** Ms Njeri Wamukonya, UNEP, Kenya
14.30 – 14.45	**Coffee**
14.45 – 15.30	**Decentralised rural electricity in Nepal** Mr. Badan B Basnyat, Alternative Energy Promotion Centre, Nepal
15.30 – 16.30	**Wrap-up discussion: Implications of the experiences presented for the further group discussions, organisation of discussion groups** Prof Björn Kjellström, Exergetics AB
16.30 – 18.00	**Visit to the Studsvik research center** Mr. Roland Olsson
18.30	**Reception**
19.00	**Dinner at Horsvik**

Friday 11th June 2004

08.00 – 09.00	**Breakfast**
09.00 – 09.45	**Presentation of Minor Field Study: Evaluation of the ESCO project – A comparison between electrification through grid extensions and PV systems in rural areas in Zambia** Ms. Elisabeth Undén and Ms. Lisa Edin
09.45 – 12.00	**Technology group discussions**

Group 1	PV & Wind: status and development	Mr. Anders Arvidson
Group 2	Mini-hydro: status and development	Ms. Helena Forslund
Group 3	Biomass: status and development	Prof. Björn Kjellström

12.00 – 13.00	**Lunch**
13.00 – 16.00	**Socio-economic group discussions**

Group A	Organisation, economy and financing	Mr. Anders Arvidson
Group B	Rural development	Ms Helena Forslund
Group C	Policy	Prof. Björn Kjellström

16.00 – 18.00	**Meeting of editorial committee for drafting of conclusions**
18.00	**Departure for Trosa**
19.00	**Dinner at Svalins spis**

Saturday 12th June 2004

08.00 – 09.00	**Breakfast. Distribution of draft conclusions and recommendations**
09.00 – 10.00	**Discussion of draft conclusions and recommendations** Prof. Björn Kjellström
10.00 – 10.15	**Coffee**
10.15 – 11.30	**Amendment of recommendations and conclusions** Prof. Björn Kjellström
11.30 – 12.00	**Final discussion and closing of workshop** Prof. Björn Kjellström
12.00 – 13.00	**Lunch**
Afternoon	**Departure from Studsvik**

Appendix 3

TECHNOLOGY DISCUSSION GROUPS FOR FRIDAY MORNING

Solar PV and wind		
SWE	FAC	Mr. Anders Arvidson
MON	GOV	Dr. Namjil Enebish
BRA	UNI	Mr. Edson Bazzo
UGA	UNI	Mr. Al-mas Sendegeya
SWE	UNI	Mr. Mikael Amelin
SWE	CON	Ms. Elisabeth Ilskog
SWE	CON	Mr. Anders Ellegård
SWE	UNI	Ms. Lisa Edin
Mini-hydro		
SWE	FAC	Ms. Helena Forslund
NEP	UNI	Mr. Badan B Basnyat
KEN	DON	Ms. Njeri Wamukonya
SWE	CON	Dr. Ivo Martinac
FRA	DON	Mr. Eric Usher
SWE	CON	Mr. Bernt Rydgren
SWE	UNI	Ms. Elisabeth Undén
Biomass		
SWE	FAC	Prof. Björn Kjellström
IND	UNI	Dr. S Dasappa
UGA	UNI	Mr. Mackay Okure
SWE	CON	Dr. Bo Hektor
NED	CON	Dr Hubert Stassen
SWE	CON	Mr. Sten Bergman
SWE	CON	Ms. Jenny Larfeldt
SWE	UNI	Ms. Anna Perskaja

FAC Facilitator
CON Consultant / Private company
DON Donor agency
GOV Government / Ministry
UNI University / Research organisation

SOCIO-ECONOMIC DISCUSSIONS GROUP FOR FRIDAY AFTERNOON

Participants took part in the discussion of their choice.

Theme discussion: “Organisation, economy and financing””		
SWE	FAC	Mr. Anders Arvidson
Theme discussion: “Rural development”		
SWE	FAC	Ms. Helena Forslund
Theme discussion: “Policy”		
SWE	FAC	Prof. Björn Kjellström

The Stockholm Environment Institute (SEI)

SEI is an independent, international research institute specializing in sustainable development and environment issues. It works at local, national, regional and global policy levels. The SEI research programmes aim to clarify the requirements, strategies and policies for a transition to sustainability. These goals are linked to the principles advocated in Agenda 21 and the Conventions such as Climate Change, Ozone Layer Protection and Biological Diversity. SEI along with its predecessor, the Beijer Institute, has been engaged in major environment and development issues for a quarter of a century.

Mission

SEI's mission is to support decision-making and induce change towards sustainable development around the world by providing integrative knowledge that bridges science and policy in the field of environment and development.

The SEI mission developed from the insights gained at the 1972 UN Conference on the Human Environment in Stockholm (after which the Institute derives its name), the work of the (Brundtland) World Commission for Environment and Development and the 1992 UN Conference on Environment and Development. The Institute was established in 1989 following an initiative by the Swedish Government to develop an international environment/development research organisation.

Climate and Energy Programme

For over two decades, SEI has worked with collaborators throughout Africa, Asia, Europe, and Latin America to support climate and energy strategies consistent with the goals of social equity, environmental sustainability, and efficient economic development. The geographical scope ranges from local village-scale activities, to regional initiatives, to national analyses, to global negotiations. The Energy and Climate Programme conducts research, develops tools, and implements energy projects. Through capacity building and outreach, the programme has broadened the participation of stakeholders and civil society in energy and climate issues. The programme focuses on sustainable energy planning, with a special interest in biomass energy, and promotes sound environmental assessment and management practices that fully account for the externalities of energy production and use. The programme analyses and advocates policies and measures to reduce the climate change threat, including the crafting of an effective and equitable global climate regime.

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ISBN 91 975237 0 4