



**Compilation and Analysis of Information on
Existing Rural Electrification and Renewable Energy Programs
in Kampong Thom Province**

(RESIREA – WP2)



FINAL REPORT

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Abbreviations and Acronyms

EAC	Electricity Authority of Cambodia
BCS	Battery Charging Station
CEC	Community Energy Cooperative
DIME	Department of Industry, Mines and Energy
kW	kilowatt
kWh	kilowatt-hour
MFI	Micro Finance Institution
MIME	Ministry of Industry, Mines and Energy
MV	Medium Voltage
PAGE	Potential Area for Grid Extension
RE	Renewable Energy
REF	Rural Electrification Fund
RGC	the Royal Government of Cambodia
REE	Rural Electricity Enterprise
REF	Rural Electrification Fund
SME	Small & Medium Enterprise

Exchange rate

1 US\$ = ~4100 Riel (2007)

EXECUTIVE SUMMARY

This report was prepared by SME Cambodia within the framework of the assignment “Compilation and Analysis of Information on Existing Rural Electrification and Renewable Energy Programs”. The objective of the work as laid out in the Terms of Reference is to support the identification of both favorable factors and barriers relating to the establishment and operation of decentralized rural infrastructures in Kampong Thom Province using renewable energy sources. A field survey was undertaken, interviewing the Kampong Thom provincial town electricity service provider, 12 Rural Electricity Enterprises as well as 78 electricity consumers.

The field survey of 12 REEs confirms the important role these services providers play in the provision of electricity in the rural areas, providing service to a total of 5189 households. Rural households not served by REEs typically rely on recharging of batteries for electricity. The number of REEs identified in Kampong Thom province has increased from 10 in 2000 to 12 currently.

Of the 12 REEs interviewed, 2 were using biomass gasification technology (although 1 of the 2 operators used his gasifier only for powering his ice factory, not for electricity production). In general biomass gasification and bio-diesel are considered to be the most suitable technologies for rural electrification of Kampong Thom province. No renewable energy experts seem to be present in the province.

Regarding the consumption of electricity, the priority applications powered by the grid seem to be lights, TV, fan and VCD (in that order). Appliances such as electrical cookers, irons, washing machines and computers are only being used once the consumption of electricity exceeds some 20 kWh per month.

The positive impact of electrification on the ‘quality-of-life’, public safety, provision of health services and education (especially private evening classes) is clearly visible. The positive impact of (new) media was mostly attributed to the provision of information and education about health care (HIV-aids, malaria, bird flue, drugs).

The effect of electrification on income generation cannot be easily specified. Some interviewees reported a positive effect, mainly credited to the ability to do business at night. Others who are not doing business reported higher energy expenses. New income generating activities reported were mainly shops/food stalls and entertainment.

Regarding future expansion of the rate of electrification in Kampong Thom province, areas within a 40 km radius of the provincial town are considered Potential Area for Grid Extension (PAGE, as specified in the ‘Master Plan Study on Rural Electrification by Renewable Energy’). Outside the PAGE, with a very low possibility of electrification by grid extension, electrification by mini-grids seems the most promising option for areas with sufficient population density. For (rural) areas with a low population density electrification by batteries will probably remain the only option for the short to medium term. Population density will be a key indicator for determining the economic feasibility of different kinds of electricity system (mini-grid or batteries). In order to meet the policy targets of the Royal Government of Cambodia (RGC) for electrification, private sector REEs will play an important role. Electrification of less profitable rural areas could potentially be implemented by (not-for-profit) Community Energy Cooperatives (CEC) although this will require various supports.

The options for rural electrification by renewable energy in Kampong Thom seem to be limited to biomass fuelled mini-grids in areas with sufficient population density, and solar PV systems (either Solar Home Systems or solar/biomass powered Battery Charging Stations) for electrification of areas with a low population density. Detailed (provincial) maps of Kampong Thom indicating population density, renewable energy resources and land use should be drafted. Identification of areas with potential for electrification by (biomass fuelled) mini-grids can be done based on the provincial maps followed by a more detailed, field analysis of those areas, in order to confirm the feasibility of grid electrification.

IMPORTANT NOTE:

The field survey of electricity service providers and households was performed to mainly provide qualitative data re: type and level of rural electrification. However, in order to clarify indications of size such as mostly, largely etc. numbers and percentages have been added. This kind of quantitative indication should be interpreted with caution: the universe of REEs in Kampong Thom is only 12, which does not allow for quantitative analysis with statistical significance. Regarding the household interviews, the sample was not a full random sample but a selection of electricity users around the market area. Furthermore, the data used for analysis was provided by the operators/households themselves, the accuracy of which could not be verified by the interviewer.

1. Rural electrification by grid extension from Kampong Thom provincial town

Electricity in Kampong Thom provincial town is provided by Chilbo Industrial (Cambodia) Co., Ltd., a Korean company established in 2001. The company holds a Consolidated License (electricity generation and distribution, license no. 012L) issued by the EAC and provides electricity in Steung Sen district, in the communes of Domrey Chornkhla, Kompong Thom, Kompong Rateh, Kompong Krabao, Prey Tahou and Achar Leak. During the field survey which took place in July, the manager of Chilbo was interviewed using the questionnaire given in Annex G.

1.1 Technical and operational aspects

Chilbo uses 4 diesel fuelled gen-sets, with a total capacity of 2210 kW, which run at different periods of the day. According to the "Report on Power Sector of the Kingdom of Cambodia for the year 2002" [EAC] the total installed capacity per 31 December 2002 was 1600 kW. This means an increase in total installed capacity of more than 600 kW over the last 5 years. Two of the gen-sets have been installed in 2007. All machines were purchased second hand.

Power is being distributed to the clients through an MV system, with meters installed for each connection. Technical problems with the distribution system leading to service interruptions are experienced rarely; however both problem solving and maintenance often need external assistance from a technician from outside.

1.2 Level of service and client relations

Chilbo provides electricity service for 24 hours per day, 7 days per week. According to the interviewee complaints regarding the quality of the service provided are received rarely. Chilbo provides electrical power to some 4050 households (some 3.2% of total households in Kampong Thom province), 20 schools, 30 small businesses and 8 public institutions. Compared to 1 year ago, this number has increased for all types of clients. Five years ago, the company provided service to some 3100 household clients.

Billing of the household clients is done on a fortnightly basis. Payments are being collected by an employee. Problems with collecting the payments are rarely experienced. In the case of delayed payments penalties or interest on the amount outstanding are not being charged. The main method of billing is according to the actual consumption as indicated by meter. The tariff currently charged to all clients is 1600 Riel/kWh. Compared to 1 year ago the price for household clients has increased. According to the "Report on Power Sector of the Kingdom of Cambodia for the year 2002" [EAC], the tariff in December 2002 was only 950 Riel/kWh. No contribution from the authorities to the cost of operation and maintenance of the electricity service is being received.

For new household customers a connection fee of 195.000 Riel is being charged. This connection fee covers only the cost of the electric meter; the costs for wiring up to the house, wiring inside the house and any fixtures are to be covered by the new client.

1.3 Expansion plans

Within the current distribution service area there are still households currently not connected to the electricity network. These households are being regarded as potential clients and investments over the next 12 months are being considered in order to expand operations to serve these new clients.

Furthermore Chilbo has plans to expand their licensing zone (service area) towards Thnal Baek village. As can be seen in Annex A, the REE previously serving this area has ceased operation. For this expansion a request has already been submitted to the EAC.

1.4 Renewable Energy awareness

The interviewee responded positively to the question whether he had heard of renewable energy. He claimed to have financial knowledge of hydropower, solar PV, wind power, biogas digestion and bio-diesel. However, with none of these renewable energy technologies he had any experience himself. The interviewee considers both solar PV and biomass gasification suitable technologies for rural electrification of Kampong Thom province. As far as the interviewee is aware, there are no renewable energy experts in the province. Only for biomass gasification technology the interviewee knows where to find technical expertise.

2. Rural electrification by mini-grid systems

Outside the boundaries of the licensing zone of Kampong Thom provincial town power supply, some 12 so-called Rural Electricity Enterprises (REEs), registered with either EAC (6) or DIME (6) were identified (see Annex A). REEs are isolated mini-grid operators providing electricity to customers through wired networks in areas of sufficient population density. During a field survey which took place in July, all 12 REEs were interviewed using the questionnaire given in Annex G. Additional to these 12 suppliers, during an interview with DIME officials it was mentioned that 2 more REEs were operational in Kampong Thom province, details of which could not be provided at the time.

2.1 Structural and typological features

Classification of typology

The REEs as listed in Annex A are classified as small-scale electricity service providers with a fixed system (network) which are mostly but not necessarily private sector business operators. All 12 REEs identified are of the "Independent Type", meaning that they are not physically linked to a larger utility, but rather have their own power source (generator). Next to the typical REE, there are likely a number of individual 'operators' not registered with either one of the above-mentioned authorities, running a (diesel) generator for a limited number of hours per day providing power to themselves as well as a number of neighboring households through extension cords. These 'operators' are neither listed nor surveyed during the field work due to the limited relevance in the provision of rural electrification services.

Population served

The 12 REEs surveyed provide service to a total of 5189 households. Compared to the 127.716 families living in Kampong Thom province [source: 'Exhaustive List'] this means that on average some 4.1 % of the population of Kampong Thom province is provided with electricity through an REE. On the other hand, in the villages that are served by one of the 12 REEs, on average 37 % of the households in those villages are connected to the mini-grid. A complete list of villages electrified by the REEs, including the electrification rate per village, is provided in Annex B.

Per individual operator the number of household clients varies between 83 and 1754, with an average of 432 household connections per operator. On average 1 school, 3 small business, shops and restaurants and 3 public institutions are provided with electricity service per REE. Compared to 1 year ago the number of household clients has increased (for 67% of REEs), remained stable (for 25% of REEs) or declined (for 8% of REEs) respectively. Compared to 5 years ago (or since year 1 for the REEs being in business for less than 5 years) the average number of households served has increased by 54 %.

Business features

All 12 REEs are micro-enterprises, the large majority being sole proprietorships. Even in this case co-ownership is often present with husband and wife sharing the responsibilities. The year of establishment of the 12 REEs varies from 1987 till 2007 with most business established before 1998.

2.2 Technical and operational aspects

Fuel Source

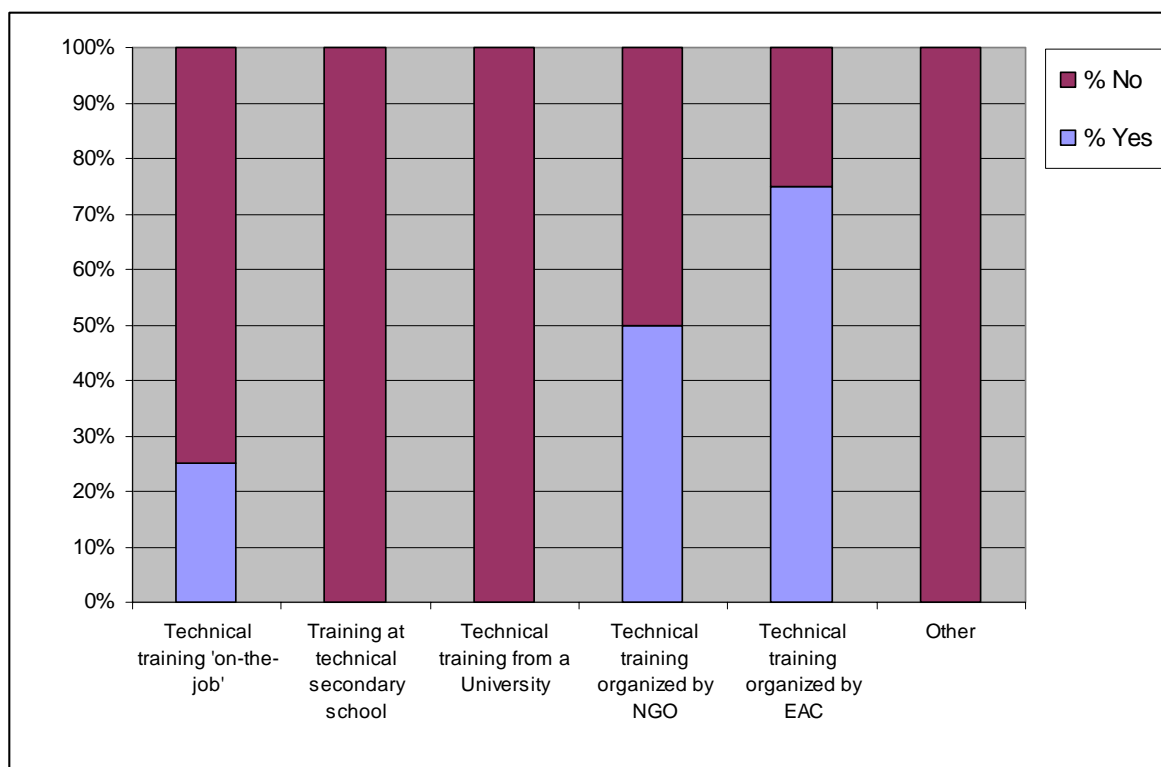
All REEs in Kampong Thom use diesel fuelled engine-generator sets to generate electricity. In 1 case (Prasat Sabour district) a locally made biomass gasifier using wood is used to produce gas which in turn fuels a diesel engine in dual fuel mode.

Installed capacity

A large share of the REEs (75%) makes use of multiple engine-generator sets, all purchased secondhand, using different capacity equipment to cope with the varying demand (base load versus peak load). The installed capacity of the generators has increased from 46 kW on average at the initial installation to 164 kW total current installed capacity. The electricity produced is distributed through single phase (33%) or 3-phase (67%) distribution systems. 58% of REEs uses MV transformers to improve the quality and efficiency of the electricity distribution.

Operation and Maintenance

Internal problems leading to service interruptions is experienced rarely (92%) or not so often (8%) respectively. Technical problems are usually fixed without external assistance (75%). Maintenance of the lines, poles, generators etc. is usually performed by the internal technician (58%) or the co-owner/manager (17%) and requires on average some 12 man-hours per week. Of the interviewees, 83% had received some form of technical training, as indicated below.



Graph 1. Training received by REE interviewees.

2.3 Level of service and client relations

All REEs provide electricity service 7 days per week. The number of hours per day varies from 4 hours for the smaller operators to 24 hours for the largest one. Most REEs (50%) receive complaints regarding the quality of the service every now and then. The only complaint from customers expressed by the REE in Sandan district was about the voltage fluctuations causing damage to lights and TV.

Billing, fee collection and tariff

Billing of the household clients is usually done on a monthly (67%) or fortnightly (25%) basis, mostly by the (co-)owner or a family member. No REEs experience problems with collecting the payments. In the case of delayed payments penalties or interest on the amount outstanding are rarely charged. For 83% of REEs the main method of billing is according to the actual consumption as indicated by meter. The prices currently charged to household clients range from 2000 Riel/kWh to 4500 Riel/kWh with an average of 2900 Riel/kWh. Compared to 1 year ago 8 of the 12 REEs have increased the tariff. 3 REEs kept their tariff more or less the same. None of the 13 REEs receive any contribution from the authorities to the cost of operation and maintenance of the electricity service.

Connection fee

Eight of the 12 REEs charge a connection fee to new household customers of on average 106.000 Riel. This connection fee covers mostly only for the cost of the electric meter.

2.4 Market and competition

With regards to the future, only 1 of the 12 interviewed REEs think it will be 'likely' or 'extremely likely' that grid extensions from the provincial town electricity grid will be able to service clients currently serviced by those REEs.

Within the distribution service area of all REEs there are households currently not connected to the network. However, only 11 of these regard these households as potential clients. The remaining REE does not regard these households as potential clients as they do not have money to pay for the services plus he currently doesn't have money to establish the new connections (is waiting for REF support).

2.5 Investments and finance

The total amount of capital invested in the business ranges from 6.000 US\$ to 240.000 US\$. The average capital intensity is some 150 US\$ per client served. The biggest share of this investment is for the distribution system (66%) and generators (33%). The main method of financing these investments is by money contributed by the owner (81%). Ten of the interviewees responded that they were considering an investment in fixed assets over the next 12 months, the main purpose of this investment being expansion of the operation in order to serve new clients.

2.6 Renewable Energy awareness

Eleven of the 12 interviewees responded positively to the question whether they had heard of renewable energy. Four interviewees claim to have technical knowledge of hydropower, 5 of solar PV systems, 4 of wind power, 9 of biomass gasification, 4 of biogas digestion and 5 of bio-diesel. Knowledge of the operational aspects of these technologies is much more limited; only 2 respondents have knowledge of the operation of a biomass gasification system, 1 of biogas digester and 5 of the use of bio-diesel. Knowledge of the financial aspects of Renewable Energy technologies is limited to only 2 respondents for biomass gasification technology, 1 for biogas digestion technology and 5 for bio-diesel. Ten of the interviewees consider biomass gasification, 1 biogas digestion and 3 bio-diesel suitable technologies for rural electrification of Kampong Thom province. As far as all of the

interviewees were aware, there are no renewable energy experts in the province. Only for biomass gasification technology (3) and Bio-diesel (1), interviewees know where to find technical expertise.

The REE in Sandan district operates a biomass gasifier to power an ice plant which he also runs. The gasifier is a copy of the Ankur Gas-9 unit in Anlong Tamey, Battambang, and was built by the REE himself in August 2006. The entrepreneur spent about \$2800 to build the unit with an estimated capacity of 25 kVA. The feedstock is wood which he purchases for \$6 per m³. The gas produced in the gasifier can substitute about 60% of the diesel fuel of the engine driving the compressor, and is operated 12-14 hours per day. Dual fuel operation of the diesel engine requires cleaning of the valves every 10 days.

2.7 Conclusions

The REEs in Kampong Thom are relatively well established, typically family-owned businesses, having been in business for an average of 9 years. The field survey of 12 REEs confirms the important role these services providers play in the provision of electricity in the rural areas, serving on average 37 % of the households in those villages within the servicing zone of the REEs. Rural households not served by REEs typically rely on recharging of batteries for electricity.

Compared to a mapping and survey exercise of REEs performed in 2000/2001 [SME Cambodia], the number of REEs identified in Kampong Thom province has increased from 10 in 2000 to 12 currently. This trend shows the opposite from the trend on a national basis, where the amount of REEs identified countrywide has decreased in the same period from an estimated 600+ REEs, down to anywhere between 300 and 400 REEs.

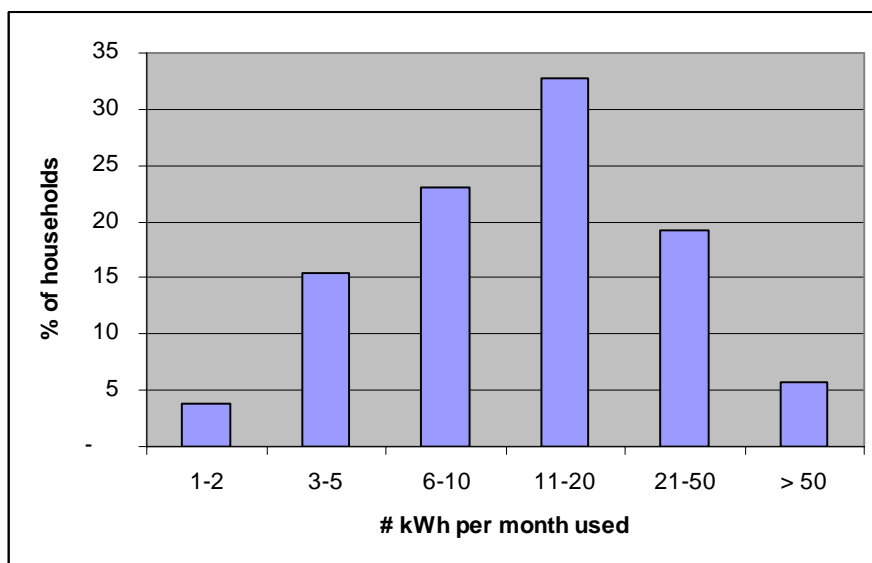
Regarding Renewable Energy technologies, many REEs claim to have knowledge (mostly technical) of a number of RE technologies. Operational experience is limited to 2 REEs, using a biomass gasifier (although 1 of the 2 operators is using his gasifier only for powering his ice factory, not for electricity production). Biomass gasification and bio-diesel are considered to be the most suitable RE technologies although no expertise seems to be available in the province.

3. Household energy use

During the field survey of REEs and provincial town electricity provider, in each location 6 households were interviewed regarding their use of electricity or other forms of energy for lighting, as well as their socio-economic status. Out of the sample of 6 households interviewed in each location, 4 of these households were connected to the local grid, the remaining 2 not connected to the local grid. Since most of the REEs were located around market areas, the 4 households surveyed with an electricity connection were all selected around the market area. The 2 households surveyed without electricity were mostly selected further from the market area, in the fields.

3.1 Households connected to a (mini-)grid

Of the 53 households interviewed who are connected to an electricity (mini-)grid, the amount of electricity used on a monthly basis is shown in graph below.



Graph 2. Monthly household electricity consumption

With an average tariff charged by the REEs of 2900 Riel/kWh this means that the average monthly budget spent on electricity is some 12.20 US\$ per month.

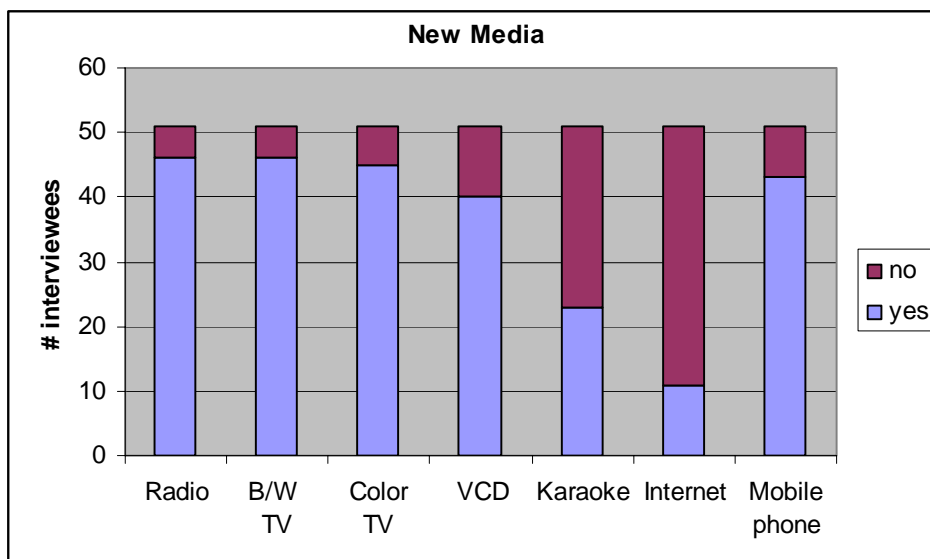
Appliances used include fluorescent lamps (100% of households), color TV (87% of households), VCD player (45% of households), fans (55% of households), electrical iron (9% of households) and computers (6% of households). Of these appliances fluorescent lamps (92%), color TVs (59%), VCD players (29%) and fans (34%) have been used since the beginning of the electrification. The use of the remaining appliances such as electrical irons (100%) and computers (67%) have been started later.

Energy use before electrification

The main type of energy used for lighting before enjoying the (mini-)grid connection was by batteries (59%), kerosene lamps (30%) and electricity generated by own generator (11%). Households previously using their own generator were using this to power fluorescent lamps (83% of households), color TV (83% of households) and VCD players (50% of households). One interviewee was previously using their own generator to power 2 sewing machines. The generator was running on average 4 hours and 10 minutes per day, using 60 liters per month of diesel fuel equaling some 42 US\$ per month (at \$ 0.70 per liter). Households previously using batteries for electrification were recharging these on average every 5.3 days spending 1200 Riel per charge equaling 1.7 US\$ per month. Households previously using kerosene or candles for lighting were spending on average 0.62 US\$ and 0.46 US\$ per month respectively.

Impact of village electrification

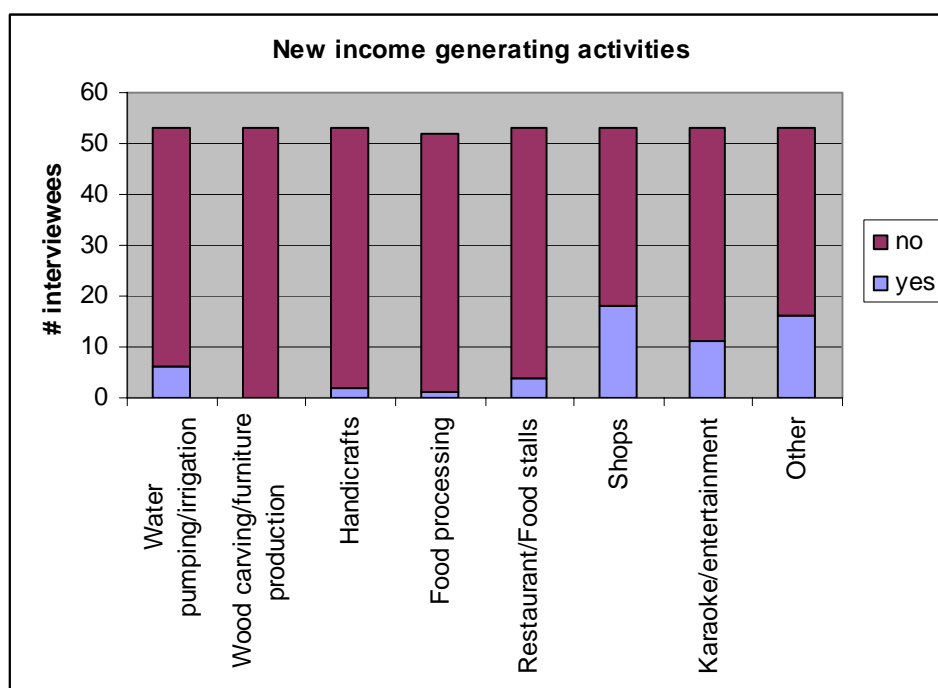
When asked whether there was any change in the education system in the village after electrification, 68% of respondents responded positively, specifying that students were taking English and computer classes given in after school hours during the evening. 52% of the respondents answered that a literacy campaign was organized in the village. 58% of respondents said the local health center had electricity. On the question whether the local health center has a refrigerator for keeping vaccines etc., only 40% responded positively. 43% of respondents said that electrification had an impact on the health supply service in the village, specifying the provision of health services during the nighttime as well as good quality medicine as the biggest change. New media in the village, not available previous to the electrification are indicated in graph below. The effects that these new media had on life in the village were specified as the provision of information and education about health care (HIV-aids, malaria, bird flue, drugs).



Graph 3. New media in the village.

Asked whether electrification had any effect on gender issues, 92% of respondents replied that electrification had an impact on the lives of women in the village, specifying it makes the work women do more easy and the possibility for the women to do business at night as the main change. Regarding the impact on the lives of men in the village, 83% of respondents replied that electrification had an effect, specifying access to information through TV and reading the newspaper as the main change.

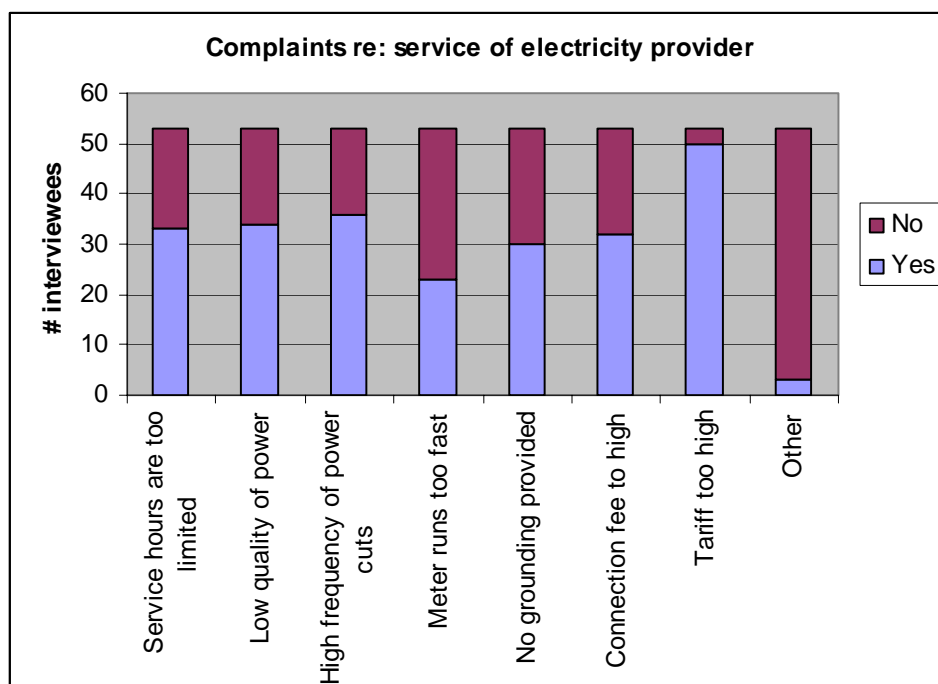
Only 25% of respondents answered positively on the question whether electrification had lead to any change in the organizational/local administration, specifying improved security in the village as the biggest change. According to 98% of interviewees there has been no effect of access to electricity on rural to urban migration. The effect of electrification on new income generating activities is indicated in graph below.



Graph 4. New income generating activities using electricity.

When asking for the respondent's opinion whether the average income in the village had changed since the access to electricity only 36% responded positively, specifying the opportunity to do business (at night) using electricity as the major change. Regarding the effect on their own household income, 32% of respondents answered positively specifying the same reason as above ("Can do business at night").

Complaints ventilated by respondents regarding the service provided by the local electricity provider are indicated below.



Graph 5. Complaints from household electricity users regarding the service provided by their electricity provider

3.2 Households not connected to a (mini-)grid

Of the 25 households interviewed who are not connected to an electricity (mini-) grid, 0 use their own generator for lighting, 22 use batteries, 3 use petroleum lamps and 0 use candles. Households using batteries for electrification are recharging these on average every 5.2 days spending 1275 Riel per charge equaling 1.6 US\$ per month for powering mainly fluorescent lamps, color TVs, VCD players and B/W TVs. Households using only kerosene for lighting are spending on average 1.7 US\$ per month.

Demand for electrification

The main reason for respondents not being connected to the (mini-) grid is that they either cannot afford to pay for the connection fee (38%) or for the electricity itself (38%). 21% of respondents replied that their house is outside the service area of the grid. All respondents plan to be connected in the future. As the main reason for wanting to be connected was given "To use electricity for convenience/improved quality of life" (74%) and "To use electricity for productive use/business" (22%).

3.3 Household socio-economic status

The interviewed households consist on average of 5.6 household members. When asked about the total household income it was found out during the analysis of the collected data that net household income was often mixed with business revenue (for households enjoying income from doing business) so an average net household income could not be determined. The total monthly domestic energy expenditure of the interviewed households is on average

12.6 US\$ per month, spent mainly on electricity from the grid (33%), charcoal for cooking (24%), fuel wood for cooking (20%) and LPG for cooking (10%). Therefore, some 54% of the energy expenditure is for cooking fuel and 46% is for electricity/lighting.

3.4 Conclusions

The average monthly electricity expenditure of the interviewees (\$12.20) seems high. However, it needs to be noted that most interviewees were located around the market area, some of which were using electricity for business purposes. Cambodian micro-enterprises don't clearly separate household and business expenditure making it difficult to separate domestic electricity consumption and business related use.

The priority applications powered by the grid seem to be lights, TV, fan and VCD (in that order). Appliances such as electrical cookers, irons, washing machines and computers are only being used once the consumption of electricity exceeds some 20 kWh per month.

Prior to electrification, most interviewees were relying on batteries for power. It seems that the monthly electricity expense increases quite significantly (from \$1.70 to \$12.20) when people start using electricity. This is what can be expected although the sharp, 7-fold increase can also be largely contributed to the new, business related activities using electricity.

The positive impact of electrification on the provision of health services and education (especially private evening classes) is clearly visible. The positive impact of (new) media was mostly attributed to the provision of information and education about health care (HIV-aids, malaria, bird flue, drugs). Whether the arrival of all media reported 'new, due to electrification' can really be attributed to electrification seems doubtful.

The effect of electrification on income generation cannot be easily specified. Some interviewees reported a positive effect, mainly credited to the ability to do business at night. Others who are not doing business reported higher energy expenses. New income generating activities reported were mainly shops/food stalls and entertainment.

4. Private sector activities related to electricity supply

4.1 (Renewable) Energy companies

A complete list of all private sector electricity providers (or REEs) operating in Kampong Thom can be found in Annex A.

There are no private sector Renewable Energy companies with an office in Kampong Thom. SME Renewable Energy Ltd., selling biomass gasification systems, serves all provinces in Cambodia from its office in Phnom Penh. Up to date however no biomass gasifier has been installed in Kampong Thom by the company.

Two suppliers of solar systems in Cambodia are Khmer Solar and KC Solar. Khmer solar has offices in Phnom Penh, Battambang and Siem Reap and salesmen or representatives in other places as well. Service for systems installed in Kampong Thom will be provided from 1 of the 3 offices, of which Siem Reap is the one closest to Kampong Thom. Khmer Solar has currently sold some 13 systems (2 of which are for private clinics having 5 panels each) in Kampong Thom. KC Solar has offices in Phnom Penh, Battambang, Siem Reap and Kampong Cham. Service for systems installed in Kampong Thom can be provided from 1 their offices, of which either Siem Reap or Kampong Cham is the one closest to Kampong Thom. KC Solar has since 2006 sold and installed more than 10 systems in Kampong Thom.

4.2 Banks and Micro Finance Institutions (MFIs)

Of the commercial banks operating in Cambodia, only ACLEDA Bank has offices (8) in Kampong Thom province (see Annex E). ACLEDA Bank Plc. is currently a public limited company with 160

branch offices countrywide. Originally ACLEDA was founded in 1993 as a national NGO for micro and small enterprises' development and credit. In 2003 ACLEDA Bank was licensed by the National Bank of Cambodia as a Commercial Bank to enable it to provide full banking services. Today ACLEDA is offering Credit, Deposits, Local and International Money Transfer, Trade Finance, Cash Management, Money Exchange and other banking services.

More than 100 organizations in Cambodia are providing financial services to low income families. Only 38 of these are large enough to be registered with the National Bank of Cambodia and only 9 of these 38 are certified as fulfilling the capital and capacity requirements to be licensed MFIs. This small group dominates the microfinance sector. Eight of these are licensed MFIs ranging in size from 5,000 to 92,000 clients. The largest, and the market leader, is ACLEDA Bank, which has recently converted to commercial bank status. Another important MFI, PRASAC, which is registered as an NGO, has 5 branch offices in Kampong Thom, providing financial services such as credit services (group loans and individual loans) and savings (savings and time deposit) services to rural communities, households and small and medium size enterprises.

AMRET, the second largest MFI in Cambodia has 2 branch offices in Kampong Thom, Cambodian Entrepreneur Building (CEB) 3 branches, Hattha Kaksekar Ltd (HKL) 1 branch and Angkor Microfinance (AMK) also 1 branch. Details of these branch offices in Kampong Thom can be found in Annex A.

5. Existing/planned electrification programs and previous studies

The Ministry of Industry, Mines and Energy, Department of Energy Techniques has cooperation agreements with the following agencies:

- SIDA/AIT (1997 - 2005): "Renewable Energy Technologies in Asia, a Regional Research and Dissemination Programme"
- NEDO (2000-2005): Cooperation on Renewable Energy in Cambodia
- JICA (2005-2007): "The Master Plan of Rural Electrification by Renewable Energy in the Kingdom of Cambodia"
- WB-ESMAP (ongoing): "Rural Electrification & Transmission Project"
- Fraunhofer ISE (ongoing): Delta PRO-RES, RESIREA

Annex F provides a list of studies and documents on the topic of Rural Electrification and Renewable Energy. All documents mentioned here are available in electronic format (SME Cambodia can provide a copy).

6. Conclusions and Recommendations

The electrification rate by mini/micro-grid of Kampong Thom province (provincial town + rural areas) is about 7.2%. The tariff charged for the electricity is 1600 Riel/kWh in the provincial town and 2900 Riel/kWh on average in the rural areas, which is the same as the countrywide average tariff. The field survey of 12 REEs confirms the important role these service providers play in the provision of electricity in the rural areas, serving on average 37 % of the households in those villages within their servicing zone. Rural households not served by REEs typically rely on recharging of batteries for electricity.

In general, electricity service providers are interested to increase their customer base however, capital is often the limiting factor. Traditionally, investments are financed with the operators' own money. During a countrywide survey of REEs in 2006, only 26% of respondents said to consider borrowing money from a bank.

From the side of the consumer, the priority applications powered by the grid seem to be lights, TV, fan and VCD (in that order). Appliances such as electrical cookers, irons, washing

machines and computers are only being used once the consumption of electricity exceeds some 20 kWh per month. Prior to electrification, most households were relying on batteries for power. The positive impact of electrification on the provision of health services and education (especially private evening classes) is clearly visible. The positive impact of (new) media was mostly attributed to the provision of information and education about health care (HIV-aids, malaria, bird flue, drugs). Whether the arrival of all media reported 'new, due to electrification' can really be attributed to electrification seems doubtful. The effect of electrification on income generation cannot be easily determined.

Regarding future expansion of the rate of electrification in Kampong Thom province, areas within a 40 km radius of the provincial town are considered Potential Area for Grid Extension (PAGE, as specified in the 'Master Plan Study on Rural Electrification by Renewable Energy', hereafter referred to as Master Plan). However, this does not mean that all villages within the PAGE will actually be electrified by grid extension even on the medium or long term. Most likely, areas with the highest population density (along main access roads, rivers etc.) will have the highest priority for electrification. Outside the PAGE, with a very low possibility of electrification by grid extension, electrification by mini-grids seems the most promising option for areas with sufficient population density. Mini-grids could be owned and operated by the private sector (such as the REE), be community (member) owned and operated, or a hybrid model of ownership and operation. For (rural) areas with a low population density, the likelihood that a private sector operator (REE) is interested to develop a mini-grid is low, as the investment per connection will be high and the revenue generated by selling electricity low (as traditionally the use of electricity in these areas is low). For these areas with a low population density, electrification by batteries will probably remain the only option for the short to medium term. Population density will be a key indicator for determining the economic feasibility of different kinds of electricity system (mini-grid or batteries). A map of Cambodia, indicating the population density is provided in Annex D, map 1.

In order to determine which of the available Renewable Energy technologies could be applied in Kampong Thom for rural electrification, a series of Renewable Energy resource maps of Cambodia are provided in Annex D. As can be seen in maps 7 and 8, the potential for hydropower in Cambodia is limited to mountainous or hilly areas in the eastern or south-western parts of the country. No sites with a potential for generation of hydropower in Kampong Thom have been identified in the Master Plan study. Map 9 indicates that the average wind speed in Kampong Thom is low. The average wind speed at 20m above ground is as low as 2.6 m/s [JICA Master Plan] making wind power for rural electrification only a feasible option in certain wind corridors. Cambodia is however blessed with abundant solar irradiation all over the country. The annual average of monthly minimum irradiation is 4.7 kWh/m²/day [JICA Master Plan]. This indicates the potential for solar PV systems. Maps 4-6 of Annex D show land use, sources of agricultural residues and soil fertility. These maps indicate that due to abundant solar irradiation, precipitation and land resources, biomass resources are abundant all over the country and biomass farming has good potential.

From studying the renewable energy resource maps it seems that the options for rural electrification by renewable energy in Kampong Thom are limited to biomass fuelled mini-grids in areas with sufficient population density, and solar PV systems (either Solar Home Systems or solar/biomass powered Battery Charging Stations) for electrification of areas with a low population density. Combining the maps of population density with the renewable energy resource maps on a more detailed, provincial level could give an indication which areas (villages) in Kampong Thom could potentially be electrified by mini-grid using biomass as a fuel source and for which areas Solar Home Systems or solar/biomass fuelled Battery Charging Stations seem a more feasible option. This however requires more detailed, provincial maps for population density, renewable energy resources and land use. Once such maps are available, a rough identification of areas with potential for electrification by

(biomass fuelled) mini-grids should be done followed by a more detailed, field analysis of those areas, in order to confirm the feasibility of grid electrification.

The Royal Government of Cambodia acknowledges that electrification of the Cambodian rural areas will not be feasible by (public) grid extensions only, and in order to meet the policy targets of electrification, other electricity service providers such as the private sector REEs will play an important role. The Master Plan recommends the electrification of as many villages (outside the PAGE) as possible with the minimum financial support to the REEs. One such support mechanism is the Rural Electrification Fund (REF), operational since April 2007. This World Bank funded program provides subsidies to licensed REEs for newly established electricity connections and investments in (Renewable Energy) power generating capacity (see also www.ref.gov.kh). Electrification of less profitable rural areas should according to the Master Plan be implemented by providing various supports to (not-for-profit) Community Energy Cooperatives (CEC). However, currently no such support mechanism exists. Battery charging services are being provided in Kampong Thom by a large number of private sector operators. A country-wide survey by SME Cambodia of some 20 Battery Charging Stations (BCS) in 2006 indicated that BCS are small family businesses, recharging on average about 30-50 batteries per day using diesel generator sets. The segment of clients served by the BCSs is often considered economically unattractive by grid operators due to their limited geographical concentration and/or low income level. The annual turn-over is on average some \$2000 - \$4000 per year with investment costs ranging from \$500 - \$2500. These figures indicate that conversion of diesel fuelled BCS to Renewable Energy (solar or biomass) powered BCS will require investments most likely far beyond the investment capacity of the operator.

Regarding the available expertise of different RE technologies, there are some 10 solar companies operational in Cambodia. Although services are provided in the various provinces, none of these companies have an office in Kampong Thom.

Regarding expertise in biomass gasification technology, there are at least 2 Cambodian made biomass gasification systems operational in Kampong Thom. The level of technological understanding of the both the operators as well as the constructors of the systems however is doubtful, as operating experience of Cambodian made gasifiers is so far not very successful. SME Renewable Energy Ltd., selling biomass gasification systems imported from India, has the expertise to perform feasibility studies and supply turn-key biomass gasification systems including the provision of operator training and after sales services.