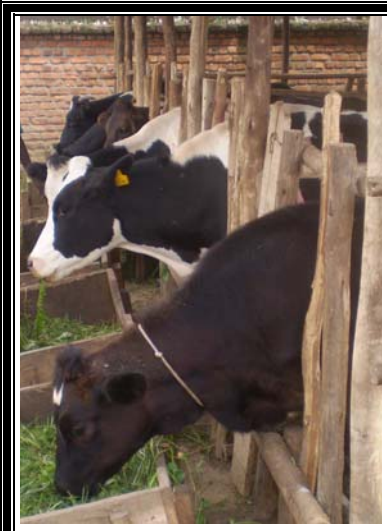

VALIDATION OF BASELINE AND METHODOLOGY, AND VERIFICATION OF THE COMPLETED DIGESTERS IN 2008 -2009 OF THE NATIONAL DOMESTIC BIOGAS PROGRAMME (NDBP) OF RWANDA

Final report

Dr. Oscar Kibazohi February 2010
Department of Chemical and Process Engineering
University of Dar es Salaam
Tanzania

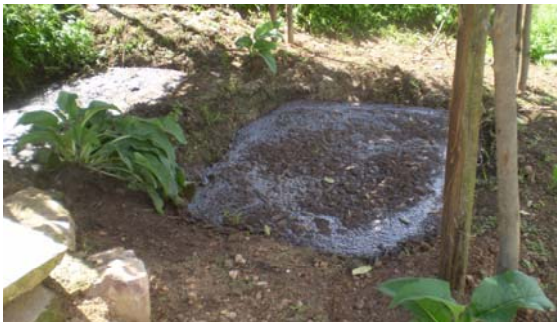

TABLE OF CONTENTS

ACKNOWLEDGEMENT

I am grateful to Hivos for offering me the opportunity to conduct validation and verification of this important project and for facilitating the exercise. Many thanks to all staff members at NDBP in particular Augustin Hategeka, Jean-Claude Uwizeye, Gerard Hendriksen, Philbert Kabanda, Joselyne Mutaganira, all field technicians and drivers for their hospitality, guidance logistical and other forms of support during verification exercise. The exercise was successful because of their support. Lastly my special thanks should go to Guy Dekelver and Dominique Owekisa of SNV for their input in the document and support during verification exercise.

EXECUTIVE SUMMARY

National Domestic Biogas Programmer of Rwanda was validated and verified successfully. Emission reduction was properly estimated; few errors in calculations were corrected and overall emission reduction re-evaluated. The programme is expected to achieve emission reduction of approximately 145,000 tCO_{2eq} by end of five years of operation. Thereafter, emission reduction of more than 74,000 tCO_{2eq} per year will be realised beyond fifty year provided the number of biogas digesters is at least 15000. Verification of randomly selected 25 biogas digesters out of 160 confirmed that biogas digesters claimed to have been constructed under NDBP indeed exist. All except one digester were in good working conditions and manure management was according to guidelines.

The Programme has, and will continue to make remarkable impact to communities in terms of sustainable development. Financial saving in terms of firewood, charcoal and kerosene reduction; improved kitchen cleanliness and reduction of indoor pollution; availability of light for studying; etc. and reduction of rate of deforestation are among the benefits accruing from the NDBP.

Although programme has not attained 1100 biogas digesters by end of second year, NDBP is in a position to gain momentum by implementing the following strategies. The programme is increasing number of staff, in particular field officers, from 3 to 20 by July 2010 for monitoring and certifying construction. Certified construction companied increased from 10 to 36 in July 2009 and training in March 2010 will increase the number to 51 companies. Credit arrangement was finalised and training of bank officers for issuing loan to farmers was being conducted in December 2009.

The programme is very important for Rwandese people in terms of providing better livelihood. It also reduces greenhouse gas emission, hence friendly to our mother earth. Besides, NDBP is keen in implementing the programme. Therefore, the NDBP should be strongly supported.

1.0 INTRODUCTION

In April 2008 Hivos Climate Fund of The Netherlands and the Ministry of Infrastructure of Rwanda (MININFRA) tentatively agreed to pursue the possibility of selling the Verified Emission Reductions of the first 5000 biodigesters produced under the National Domestic Biogas Programme (NDBP) of Rwanda to the Hivos Climate Fund.

In July 2009 the Ministry of Infrastructure of Rwanda submitted to Hivos a Project Identification Note, detailing the organisational set-up of the programme, information about the beneficiaries, the contents of the programme, the technology applied, the calculations of base-line emissions per source, calculations and estimates of emission reductions and monitoring system.

Hivos agreed to consider the purchase of the Verified Emission Reductions (VERS) of 2000 biogas digesters produced under the programme with the possibility to increase this number once the programme is certified to Gold Standard VER standards.

The NDBP of Rwanda has been in operation since 2007 and has gone through two phases: Pilot and phase I. A list of 160 biogas digesters currently in operation was available for validation in November 2009. Out of the 160 digesters, 45 were constructed during pilot phase and 115 were constructed during phase I of operation.

Hivos engaged a consultant to validate base-line emission calculations and estimated emission reductions of the programme; and to verify that the biogas digesters claimed by MININFRA as constructed under NDBP are indeed in existence and are used by the families where they are installed. Furthermore, the assignment included obtaining data on the gas use and manure management. Detailed terms or reference are attached in Annex 1.

2.0 METHODOLOGY

Validation was conducted in two phases. Phase one included desk review to validate baseline emission calculations and emission reductions, phase two included visiting Rwanda to verify that the digesters claimed by MININFRA indeed exist.

a) **Desk review:** During desk review, emission of CO_2 from firewood, charcoal, kerosene and animal waste management system were evaluated using Intergovernmental Panel on Climate Change (IPCC) emission factors of 1996 and 2006 and emission results compared with corresponding values in the Project Document. A consolidated CDM methodology no. ACM0010 was used to assess baseline methodology for GHG emission reductions from manure management system.

b) **Verification:** Verification of the actual biogas plants started with a briefing about the programme at MININFRA, where programme background, activities and administrative structure were explained and a list of installed and operating 160 biogas digesters was obtained. The digesters were grouped according to districts as shown in Annex 2.

Rwanda is comprised of 5 Provinces: Northern Province (Province du Nord), Eastern Province (Province de L'Est), Southern Province (Province du Sud), Western Province (Province de L'ouest) and Kigali City. A Province is divided into districts, a district is comprised of sectors, and a sector is composed of cells. A cell is comprised of approximately seven villages. A total of 25 biogas digesters were randomly selected for verification by the consultant who has no prior knowledge of their exact location other than districts as indicated in Annex 2. Provinces and their corresponding districts mentioned in Annex 1 are shown in administrative map (Figure 2.1).

To obtain a good distribution around the country, selection was based on a percentage of digesters in a province as shown in Table 2.1. Effort was made to spread biogas digester selection around a district by selecting sites from different sectors. If a district had digesters constructed during both pilot and phase I, a balance was considered by selecting digesters from both phases.

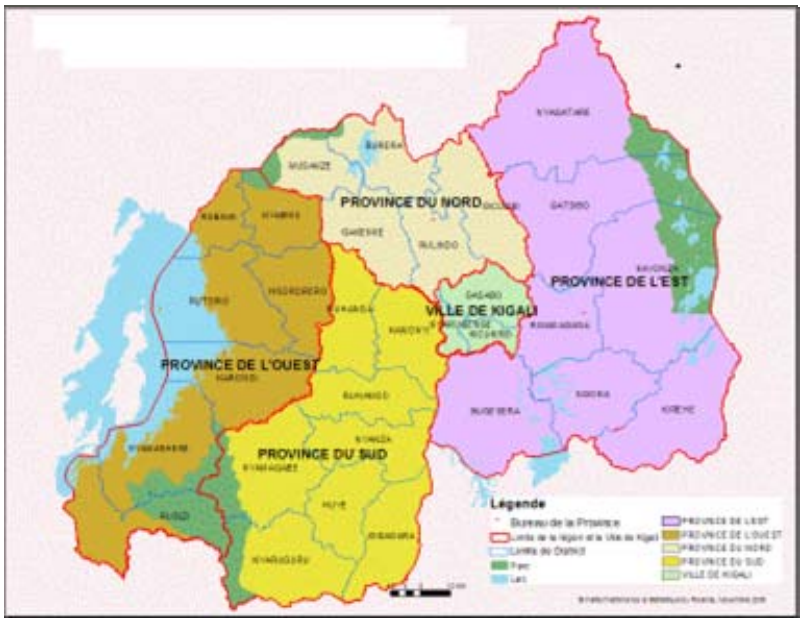

Figure 2.1: Administrative map of Rwanda

Table 2.1: Number of verified digesters inn each province

Province	Number installed digesters	Percentage of installed digesters	Number of selected digesters for verification
Northern Province	57	35.63	9
Eastern Province	32	20.00	5
Southern Province	33	20.63	5
Western Province	0	0.00	0
Kigali City	38	23.75	6

Following random selection, Field Manager informed field technicians the identities of selected digesters, in turn the technicians informed farmers of impending verification visit for them to be present on the day of visitation. Actual verification was conducted in five days between November 29 and December 3, 2009 as shown in the verification schedule in Annex 3.

3.0 RESULTS

3.1 ESTIMATION OF BASELINE AND EMISSION REDUCTION

Estimation of baseline emission and emission reduction are provided in sections E and F of the project document. In general, quantification of greenhouse gases and emission reduction are acceptable with proposed minor changes.

3.1.1 Quantification of Monitoring of Greenhouse gases

The three step procedure used to determine emission reductions suffices to quantify emission reduction as indicated below:

Step **1: Identification of activity volumes**, takes account of major sources of emission for the project namely: CO_2 emissions from fuelwood burning, CO_2 emissions from charcoal burning, CO_2 emissions from fossil fuel burning, and CO_2 emissions from Animal Waste Management Systems.

The NDBP baseline survey conducted in 2007 and Manure management systems baseline study provided basic information for identification and calculation of emission sources. However, data such as charcoal uses and fertilizer application in the manure management system report are based on average of few data points while a large number of "missing data are omitted", hence the averages should be used with care as they may not represent a true statistical situation of the whole population.

Step 2: Calculation of emission per source:

Using IPCC emission factors, specific emission factors were calculated and compared to those provided in the project document. For instance, emission factor for CO_2 from fuelwood was calculated as follows:

Data:

- Energy content of biomass fuels, default net calorific values for air-dry, dry zone wood = 16.6 MJ/kg (Revised IPCC 1996)
- CO_2 Emission Factor for Residential Stationary Combustion (kg/TJ on a net calorific basis) = 112000 kg/TJ (IPCC 2006)

CO_2 emission factor from wood is given by:

$$112000\ \frac{\text{kg}\,CO_2}{\text{TJ}}\ \text{x}\ \frac{1\,\text{TJ}}{10^6\,\text{MJ}}\ \text{x}\ 16.6\ \frac{\text{MJ}}{\text{kg Wood}}\ \text{x}\ \text{GWP}\,(CO_2) = 1.859\ \frac{\text{kg}\,CO_2}{\text{kg Wood}}$$

Other emission factors were calculated in a similar manner as shown in Annex 4. A summary of emission factors is shown in Table 3.1. Some of the emission factors are different from the one used in the project document. Justifications for differences are given in the last column of Table 3.1.

Table 3.1: Emission factors used for baseline and emission reduction calculations

S/N	Emission category	EF-PD	EF-C	S-EF	Units	Comments/Reason
1	CO_2 emissions from fuelwood burning	1.83	1.859	2.344	kg CO_2/kg wood	Suggested emission factor includes other emissions CH_4 and N_2O which were not included in Project document (see Annex 4)
2	CO_2 emissions from charcoal burning	11	3.360	7.031	kg CO_2/kg charcoal	Emission factor in the Project Document is too high. * (see Annex 4)
3	CO_2 emissions from fossil fuel burning - kerosene	2.54	2.542	2.754	kg CO_2/ litre	Suggested emission factor includes other emissions CH_4 and N_2O which were not included in Project document (see Annex 4)
4	CO_2 equivalent from CH_4 emissions from Manure management systems	4.586	-	4.586	kg CH_4 /head/year	Correct method used, correct MCF values of CDM methodology ACM0010 used and methane within limits of 1 – 20 kg/head/year (Mainly solid management system and a third being liquid system, temperature 15 -25 ^oC (IPCC).
		0.096		0.096	tCO_{2eq}/ head/year	
5	CO_2 equivalent from N_2O emissions from animal waste management systems	0.44	-	0.44	kg N_2O /head/year	Correct method used, correct MCF values of CDM methodology ACM0010 used and N_2O within limits.
		0.136		0.136	tCO_{2eq}/ head/year	
6	CO_2 equivalent CH_4 emissions from fugitive gas (15%)	1.49	1.392	1.392	kg CO_2/m^3	Biogas has 65% methane, calculations in the Project Document did not take into account percentage of methane in the biogas
6	CO_2 emissions from project vehicle	-	2.800	2.800	kg CO_2/l diesel fuel	Project vehicle is estimated to consume 560 l of diesel per month
7	CO_2 emissions from project motorcycles	-	2.340	2.340	kg CO_2/l petrol fuel	Project have motorcycles each consuming approximately 56 l per month

EF-PD Emission factor in the Project Document, EF-C Calculated Emission factor, S-EF Suggested Emission Factor if different from EF in the project Document

* Calorific value for woods is around 16.6 MJ/kg while that of charcoal is 30 MJ/kg. i.e. wood produces half amount of energy than charcoal, also 6 kg of wood produces 1 kg of charcoal. Since emission factor is based on amount of energy produced, twice amount of wood is needed for the same mass of charcoal. If wood emission factor is used to estimate charcoal emission factor, it should be multiplied by 3 (not 6 as it is in the PD). Suggested emission was obtained by multiplying suggested wood emission factor (S/N. 1 above) by 3.

3.1.2 Emission reduction

Emission reduction is calculated by subtraction emission under project activity from baseline emission. However, in this case, emission from composting of manure under aerobic conditions to CO_2 is not clearly detailed in IPCC. As such it is assumed that CO_2 emitted by aerobic decomposition/compositing of manure is compensated by both CO_2 produced in the digester (35%) and CO_2 produced when biogas is burnt during lighting and cooking. Hence, emission reduction was estimated by considering the following emission reductions:

1. Reduction of CO_2 from fuelwood replaced by biogas cooking,
2. Reduction of CO_2 from charcoal replaced by biogas cooking,
3. Reduction of CO_2 from fossil fuel - kerosene replaced by biogas lighting,
4. Reduction of CO_{2eq} for CH_4 from Animal Waste Management System (AWMS) replaced by biogas production,
5. Reduction of CO_{2eq} for N_2O from Animal Waste Management System (AWMS) replaced by biogas production.

New source of emission subtracted from emission reduction include:

1. CO_{2eq} from 15% methane leakage from biogas digester,
2. CO_2 emission from fossil fuel – diesel and petrol from project vehicles and motorcycles.

Emission reduction calculations were properly documented in the project document. The values were modified and reproduced in Table 3.2 using suggested new emission factors. Project emission from fossil fuels (diesel and petrol) from project vehicles and motorcycles was also included. Annual emission reduction in tCO_2 is revised in Table 3.3. The project is expected to reduce a total of **145,215 tCO_2eq** in its first five years (until 2012) of operation. Since biogas digesters are estimated to last for 20 years, NDBP is expected to continue reducing 74,118 tCO_2eq per year for approximately 15 more years (until 2027).

Table 3.2: Gas production per household

S/N	Emission Reduction Category	Emission Factor	Units	Other factors to considered	Total (tCO2/ year.hh)
EMISSION REDUCTIONS FROM PROJECT ACTIVITY					
1	CO_2 from fuelwood	2.344	kg CO_2/kg wood	6.43 kg firewood use per day, per hh, 80% reduction in fuel	4.401
2	CO_2 from charcoal	7.031	kg CO_2/kg charcoal	6.5 kg charcoal use per day, per hh, 6.5% of households using charcoal, 90% reduction in fuel	0.540
3	CO_2 from fossil fuel - kerosene	2.754	kg CO_2/kg/ litre	0.23 litres per day, per hh	0.231

4	CO_{2eq} for CH_4 from AWMS	0.096	tCO_{2eq}/head/year	3.5 cows per hh	0.336
5	CO_{2eq} for N_2O from AWMS	0.136	tCO_{2eq}/head/year	3.5 cows per hh	0.476
	TOTAL REDUCTION PER HOUSEHOLD				**5.765**
PROJECT EMISSIONS FROM PROJECT ACTIVITY					
6	CO_{2eq} from 15% methane leakage	1.392	kg CO_2/m^3 biogas	1.614 m^3 biogas per day, per hh	0.820*
7	CO_2 emission from fossil fuel (diesel)	2.800	kg CO_2/l diesel fuel	560 l per month, one project vehicle, (all households)	18.816
8	CO_2 emission from fossil fuel (petrol)	2.340	kg CO_2/l petrol fuel	56 l per one project motorcycle, per month	1.572

* Value used in the project document is approximately 10 times because: a) a factor of 65% methane content in biogas was not considered, b) factor of 10% leakage was used twice in the emission factor (Step 3, section E) and in calculation of total annual emission from digesters (6^{th} table of Section F) in the project document.

Table 3.3: Revised summary of emission reduction per year

	No. hh	**No motorcycles***		**Total reduction (tCO2/year)**
Total reduction in year 1	75	3	75 x (5.765 - 0.820) - 18.816 - 3 x 1.572 =	347
Total reduction in year 2	1100	3	1100 x (5.765 - 0.820) - 18.816 - 3 x 1.572 =	5,415
Total reduction in year 3	4325	3	4325 x (5.765 - 0.820) - 18.816 - 3 x 1.572 =	21,362
Total reduction in year 4	8900	10	8900 x (5.765 - 0.820) - 18.816 - 10 x 1.572 =	43,972
Total reduction in year 5	15000	20	15000 x (5.765 - 0.820) - 18.816 - 20 x 1.572 =	74,118
Total reduction after 5 years				**145,215**

* In additional to one programme vehicle (Toyota double cabin truck), the programme is currently having three motorcycles for three field officers. The programme will purchase additional motorcycles for newly employed field officers, increasing the number to 10 and 20 in January and July 2010, respectively.

3.2 VERIFICATION RESULTS

A total of 25 digesters were verified. Various information including family name and size, number of animals, biogas size and hours of biogas use for cooking and lighting, wood and kerosene saving, availability of water and general impact to the family/community were collected. A summary of the finding and computed results are included in Annex 5.

3.2.1 Number of Biogas digesters

Digesters in use: According to data at MININFRA, there were 180 digesters which were successfully constructed and were currently in operation. However, only 160 were listed in the database as operational as shown in Annex 2. There were additional 23 digesters that were completed but data had not been filed with MININFRA. It was further revealed that there were 311 more digesters under construction. In addition, there were 73 fibreglass digesters which were imported from China, increasing the total number to 254 biogas digesters. Evaluation indicated that fibreglass digesters were expensive and hence excluded from the programme.

The verification of randomly selected 25 digesters revealed the following:

- All 25 digesters indeed existed;
- Twenty four digesters were in good working condition, indicating that at least 96% of all digesters registered as functioning are currently in use. No major problem was reported on malfunctioning of digesters;
- One digester had been abandoned; the owner (husband) was facing legal problems and was in detention. Children and wife had lost interest on the biogas digester. During verification visit the family was encouraged to restart it;
- Majority of digesters were 6 m^3 in size. Only 7 (28%) and 3 (12%) digesters were of size 8 and 10 m^3, respectively.

Digesters not in use: Seventeen (17) digesters constructed mainly during pilot phase were no longer in use because farmers had relocated of moved cows to another place. These digesters were not included in the list of 180 digesters. The abandoned digester discovered during verification increased the number of abandoned digesters to 18. High number of abandoned digesters might have been attributed by lack of financial contribution from farmers during the pilot phase, hence lack of ownership. Now that farmers request for biogas digesters and financially contribute to the project, cases of abandoned digesters are expected to be relatively fewer.

According to the construction schedule, a total of 1100 biogas digester should have been constructed by end of the second year (2009). This was in part caused by few certified constructed companies, and few (only 3) field officers. However, the programme is expected to gain momentum after hiring up to 20 field officers by July 2010. Furthermore, NDBP conducted a second training for masons and supervisors in July 2009 increasing the number of certified construction companies from 10 to 36 (NDBP Progress Report, Review Mission Nov 2009). More training programmes are planned for the near future; next training to be conducted in March 2010 will increase the number of construction companies to 51. Training strategy is expected to provide a considerable momentum in digester construction.

3.2.2 Number cattle and pigs used for feeding digesters

Number of Cows: According to a survey of 25 digesters, the number of cows used to feed the digester ranged from 1 cow to 40 with an average of 5.92 per household. The average was greater than the project design average of 3.5 cows per household because two households had 19 and 40 indigenous breed cows which significantly increased the average. The average number of cows dropped to 3.84, which is within the range of the project design average of 3.5 when the 19 and 40 indigenous cows were assigned a project average of 3.5. The averages above excluded calves whose average was 1.8 per household.

Number of pigs: Due to a very small number of pigs, it can be generalised that all biogas digester were fed with cow dung only. Among the 25 farmers visited, only two farmers, both located in the Southern province had pigs. Nevertheless, pig waste was not used as a feedstock to digesters. There were no pigs found in Kigali City, Northern, or Eastern provinces.

3.2.3 Number of Biogas stoves and lamps and duration of use

Most household owned one biogas stove and one biogas lamp provided at construction stage. Very few farmers had taken initiative to increase a number of stoves to two. Out of 25 verified digesters, only four (16%) farmers; two from Northern Province and two from Eastern Province had increased number of stoves to two. Among the four only one farmer had a 6 m^3 biogas digester, the remaining three had 8 m^3 digesters.

Stoves were use for cooking morning breakfast, afternoon and evening meals. A total number of hours for which the stoves are used was obtained by summing the three (morning, afternoon and evening) cooking durations. If two stoves were used simultaneously, the duration was multiplied by two. Biogas stoves are used for an average duration of 4.24 hours, with a minimum and maximum of 1 and 9 hours per day, respectively. Cooking duration of abandoned digester was based on previous experience.

A good number of households did not use biogas for cooking beans due to high demand of energy which meant high biogas demand. In this case, famers reverted back to fuelwood when it came to cooking beans.

Among 25 surveyed households, each of 24 household own one biogas lamps provided at construction stage, one household did not own biogas lamp. None of the 25 verified farmers had taken initiative to increase a number of lamps. It was observed that famers with electricity connection to their houses either used biogas lamp in the kitchen for cooking or never used the lamp at all. Biogas lamp was found to be popular among farmers without electricity as a substitute for kerosene. Due to immobile nature of the lamp, famers who relied on biogas lamp for lighting used candles to more around in other rooms.

Biogas lamps are used for lighting for a duration ranging from 0 (for farmers with electricity) to 5 hours, with an average of 2.44 hours. Duration of use increased with activities ranging

from cooking; cooking and general lighting; and cooking, general lighting and studying. As detailed in the sustainable development section, students who got more hours to study due to availability of light from biogas lamps improved significantly in school in terms of grades and ranking.

3.2.4 Firewood and charcoal reduction

Firewood is used by majority of households as the main fuel for cooking and boiling/pasteurising milk. Approximately 24% (6 of out 25) of farmers use both firewood and charcoal, while only one (4%) used charcoal alone. In Rwanda, firewood is measured in terms of ster. Quantification of firewood use was made in terms of volume, the ster. However, when the volume was converted to kg using an average density of 350 kg/ster (NDBP baseline study report) average fire wood consumption before installation of digester was 43 kg/day per household. On the other hand, NDBP baseline study, and manure management baseline study report average value of 27 and 17.5 kg/day, respectively. Study in Brazil reports 2.53 kg/person/day and study in Nepal reports 0.8-2.6 kg/capita/day. Value used in the project document is 6.34 kg/day/hh of firewood.

For the uncertainty indicated above, firewood reduction was reported in terms of percentage reduction which is based on ratio and has less error. There was a significant reduction in the use of both firewood and charcoal after installation of biogas digesters. Average firewood reduction was 72.36% and as high as 100% in several cases. Project document estimated a reduction of 80%; this value, is higher than, yet close to the average observed during verification, hence acceptable. Furthermore, awareness and knowledge in managing digester and biogas energy (e.g. reducing gas flow once food starts boiling) should be increases for better firewood saving. Based on design value of 6.34 kg/day/hh of firewood used in the project document, observed average saving in firewood per days is 4.59 kg/day/hh.

Average charcoal reduction was 92.11%. It was observed that charcoal was the first to be phased out by most farmers using both charcoal and firewood. Charcoal is measured in terms of bags. Assuming 50 kg weight for a bag, average consumption was 5.28 kg/day/hh, reduction was 4.48 kg/day/hh.

3.2.5 Kerosene reduction

Among 25 verified households, only 14 use kerosene for lighting, 11 (44%) have electricity connection and did not use kerosene. Low percentage of kerosene users is reflected in the average consumption of 0.087 l/day compared to 0.23 l/day used in the project document. Average reduction in kerosene consumption was 83.92%; reduction of 100% was achieved in several households. High value is possible if farmers are encouraged to buy more biogas lamps.

3.2.6 Fertiliser application

Generally, manure application is acceptable. It was observed that 11 household out of 25 (44%) applied manure in a liquid form after digester effluent has been stabilised; 12 (48%) households mix stabilised digester effluent with biomass, mainly weed before applying it in the farm. One households use manure in both liquid and solid form while one household wait for stabilised manure to dry before it is applied in the farm. In one case, non-stabilised manure, still emitting gas, was discharged from stabilisation section into nearby grass/lawn.

It was interesting to find out that, biogas manure became another source of income. Two farmers from Gicumbi, and Musanze districts, Northern Province sold biogas manure at a price of FRW 800 (USD 1.4) per 20 l or FRW 15,000 (USD 26) for a small truck. Another indirect income is from reduction in use of artificial fertiliser. In Musanze district, Northern Province, one farmer completely replaced 20 kg of artificial fertilizer per year with biogas manure for growing maize, while another farmer scaled down fertiliser consumption from 50 kg to 12.5 kg per year.

Biogas fertilizer is used for growing maize, wheat, cassava, cow forage, potatoes, tomatoes, beans, vegetables, etc. All farmers using biogas fertiliser reported positive improvement in their crops in terms of harvest if they owned biogas plants for more than a year or in terms of plant health if they had recently owned biogas plants. Few farmers pointed out that, biogas liquid fertilizer served both as fertiliser and irrigation water.

3.2.7 Other observations

Water availability: almost all cows used for biogas production are of improved breed fed in a stable. One cow drinks approximately 20 l of water. Average water consumption for a digester was 46 l with a maximum of 160 l per day. Main sources are tap water, water harvest, and stream or well. Distance to a water source varies from zero to 3.5 km with an average of 700 m. In the Northern Province (Gicumbi and Musanze districts) where rainfall is abundant, tap water and water harvesting reduce distance to a water source (stream) to almost zero. Longer distances to water source were observed in Southern province. For a successful biogas programmes, especially in the Southern Province, water availability and management should be considered.

In reducing water use, innovative idea of using cow urine for preparing digester slurry feed (mixing with cow dung) is practised in several households. As high as 80 l of urine, is collected from cow shed and used for preparing slurry. Two cases where water for slurry preparation was completed replaced by cow urine were spotted. Such innovative idea should be encouraged. However, its effect on quality and quantity of biogas and N_2O emission, a greenhouse gas with high global warming potential should be evaluated.

Education: Students living in houses without electricity connection study using kerosene lamps which have dim light and emit smoke. In some cases, parents imposed limit to study duration in order to minimize expenses on kerosene. Biogas lighting is such households

tremendously improved student performance; grade and ranking improved as shown in the Table 3.4.

Use of human waste as biogas feedstock: although biogas digesters are equipped with inlet for toilet connection, none so far had been connected due to negative sentiment arising from using and handling digester effluent as fertiliser. However, one farmer expressed interest of having his toilet connected. Although biogas production from human waste had been achieved at institutional level (penitentiary), more awareness is needed before toilet connections to digester are achieved at household level.

Table 3.4: Improvement is education from biogas lighting

HH	Student gender	Class	Average grades before	Average grades after	Ranking Before	Ranking After
HH1	F	Standard VI	60	90	24	13
	F	Form I			30	20
HH2	F		55	75	12	5
	M		62	62	9	6
HH3		Form III			>10	7
		Form VI			>10	5
HH4	M	Standard VI			8	4
HH5	F	Standard III			20	8
HH6	F	Standard V			1	1
HH7	F	Form II	63	80	15	6
	F	Form V	54	72	22	12

Energy management during cooking: Energy management during cooking is needed to economise gas. Once boiling starts maintaining vigorous boiling wastes energy. If boiling is reduced to a minimum by decreasing flow of biogas, cooking is still achieved within the same duration and energy is saved resulting in more reduction in firewood. Several households practiced energy saving techniques, others did not. Awareness, with proper instructions should be disseminated to all biogas digester owners.

3.3 IMPACT

Biogas plants have brought a lot of relief to the owners. All biogas plant owners are very happy with a number of benefits from their biogas plants. The project meets sustainable development criteria. The following are benefits that have accrued from biogas to the community:

1. Biogas resulted in financial saving by reducing or eliminating firewood and charcoal for cooking;
2. Biogas resulted in financial savings by reducing or eliminating kerosene for illumination;
3. Indoor pollution was reduced by eliminating smoke. Comments like “my wife no longer have running tear during cooking”, “my wife’s eyes are beautiful” are

appreciations due to substantial improvement in indoor pollution, making cooking environment more comfortable. All women using biogas were extremely happy with biogas cooking;

4. Time for productive activities increased. Before biogas, a considerable amount of time was used for collecting firewood and cooking with firewood was slow. With biogas, no or little time is used for collecting firewood, and cooking is fast. Time saved is used other for productive activities.
5. Biogas is a cleaner fuel than charcoal and firewood, resulting in general cleanliness of pots and kitchen. In one incidence, a biogas owner testified that he no longer needed a houseboy for cooking, thanks to biogas which is fast and clean, he can do the cooking himself;
6. Biogas fertilizer improved crop production. Crops were reported to be healthier than before. In some cases, biogas manure had replaced or reduced organic fertilizer. In other cases, biogas manure was sold to neighbours for cash.
7. **Education**: In household where children used biogas lamp for studying, grades and ranking improved tremendously. In one case, children from one family used to walk 1 km during the night to a centre for studying under electric light bulb, they are now studying at home.

3.4 MONITORING

Monitoring is only done during the construction and first year of operation as described in the project document. Thereafter, there is no credible monitoring process in place. In order to quantify CO_2 reduction annually, a regular and continuous monitoring is required through out the entire period of project life time. Changes such as increase/decrease in a number of cows, malfunctioning of digester may alter the quantity of emission reduction. Biogas owners should be supplied with biogas logbook in which they should record regularly (preferably monthly), the status of biogas digesters and other parameters including current number of cows, etc.

There will be 20 field technicians from July 2010. Monitoring a large number of biogas plants can be demanding; assistance from extension officers who are in close contact with farmers will make monitoring exercise easy and successful. Information from extension officers can be passed over to a field technician (at a district level) who keeps a database of his/her district and regularly transmit changes to programme headquarters of record keeping.

ANNEX 1: TERMS OF REFERENCE

Validation of Base-line and Methodology and Verification of the completed Biodigesters in 2008 of the National Domestic Biogas Programme of Rwanda.

1. Introduction

In April 2008 Hivos Climate Fund of The Netherlands and the Ministry of Infrastructure of Rwanda (MININFRA) tentatively agreed to pursue the possibility of selling the Verified Emission Reductions of the first 5000 biodigesters produced under the National Domestic Biogas Programme (NDBP) of Rwanda to the Hivos Climate Fund.

In July 2009 the Ministry of Infrastructure of Rwanda submitted to Hivos a Project Identification Note, detailing the organisational set-up of the programme, information about the beneficiaries, the contents of the programme, the technology applied, the calculations of base-line emissions per source, calculations and estimates of emission reductions and monitoring system.

Hivos agreed to consider the purchase of the Verified Emission Reductions (VERS) of 2000 biogas digesters produced under the programme with the possibility to increase this number once the programme is certified to Gold Standard VER standards.

This paper provides the Terms of Reference (ToR) for a validation and verification assignment of the programme for the Hivos Climate Fund.

2. Objective of the assignment

The objective of the assignment is twofold:

a) to validate base-line emission calculations and estimated emission reductions of the programme; and

b) to verify that the biodigesters claimed by MININFRA as constructed under NDBP are indeed in existence and are used by the families where they are installed. Furthermore the assignment will be used to obtain data on the gas use and manure management.

3. Activities and validator/verificator

The validation and verification will be carried out by a consultant appointed by Hivos

The validator/verificator will check the applied methodologies, formula, calculations and parameters to approved CDM methodologies (AMS 1E and AMS IIID) and relevant IPCC data and default values. This is a desk study.

For verification, the validator/verificator will visit a random selection of 25 biodigesters and besides checking if the biodigester exists and is in use at the address indicated on the list the validator/verificator will check the number of stoves and lamps in use per family as well as the number of cattle and/or pigs that are used to feed the digester.

Furthermore the. validator/verificator will check if the digested slurry is used and, if so, in what manner it is stored and applied.

All information for verification will be obtained through structured interview and observation.

4. Expected output

At the end of the assignment, it is expected that the validator/verificator will submit a comprehensive but concise report of no more than 15 pages, excluding annexes, which will provide:

- An opinion on the correct use and interpretation of the CDM methodologies, formula, calculations and IPCC default values in the Project Identification Note and, where necessary, suggestions for changes;
- Number of plants not in existence or not in use. If a plant is not in use the reason must be stated;
- Number of cattle and/or pigs used for the feeding of the plants;
- The average number of biogas stoves per plant and the hours the stoves are used per day;
- Estimated reduction of firewood and or charcoal use per day because of biogas utilisation;
- The average number of biogas lamps per plant and the hours the lamps are used per day;
- Manner of slurry application (none, wet, dry) and storage (none, pit, compost hut)

5. Time frame

After the signing of the validation/verification contract with Hivos, the draft report will be submitted to NDBP-MININFRA and Hivos within 20 working days after the starting date of the assignment. NDBP-MININFRA and Hivos will give their comments on the report within 15 working days after which the consultant will submit the final version within another 10 working days.

Further information can be obtained from:

Mr. Augustin HATEGEKA, NDBP Coordinator, email: ahategeka@yahoo.fr, and augustin.hategeka@mininfra.gov.rw

Mr. Guy Dekelver, Biogas Advisor SNV Rwanda, email: gdekelver@snvworld.org

Hivos, The Netherlands
02/10/2009

ANNEX 2: LIST OF 160 DIGESTERS, THEIR OWNERS, TELEPHONE CONTACTS, LOCATIONS DOWN TO VILLAGE LEVEL, TYPE OF DIGESTER, SIZE, PHASE IN WHICH THEY WERE CONSTRUCTED AND NAME OF COMPANIES THAT CONSTRUCTED THEM

Digesters physically verified are highlighted in blue

Status		District		Names	Sector	Cell	Village	Tel	Size (m^3)	Type	Phase	Company
	180											
			36									
In use		Gasabo		Ahishakiye J.Bosco	Jabana				6	Maçonnerie	Pilote	ENVIROTECH
				Bamurange Donatha	Jabana	Ngiryi	Uwanyange		6	Maçonnerie	Pilote	CRET
				Bimana Jean Bosco	Jabana	Ngiryi			6	Maçonnerie	Pilote	GLAS
				Bizimungu Andre	Bumbogo	Kinyaga	Akaraza	08464144	6	Maçonnerie	Phase 1	GLAS
				Hakizimana Damien	Jabana	Kidashya	Mubuga	0783495152	6	Maçonnerie	Pilote	GBTC
				Kalinda Michel	Jabana	Kidashya	Mubuga	0788612093	6	Maçonnerie	Pilote	GBTC
				Kamana Helmas	Jabana	Ngiryi	Agahama	0783784828	6	Maçonnerie	Pilote	ENVIROTECH
				Kamanzi Gaspard	Bumbogo	Ngara	Uwaruraza	08441471	8	Maçonnerie	Phase 1	GLAS
				Kamuzinzi Gaspard	Jabana	Akamatamu	Mukeyeri	0788213595	8	Maçonnerie	Pilote	TURWUBAKE
				Kantarama Droceile	Jabana				6	Maçonnerie	Pilote	CRET
				Mataranga Manasseh	Jabana				6	Maçonnerie	Pilote	ENVIROTECH
				Matarataza E!ie	Jabana				6	Maçonnerie	Pilote	CRET
				Mujawimana Martine	Jabana				8	Maçonnerie	Pilote	ENVIROTECH
				Mukabaruta Melanie	Bumbogo	Kinyaga	Rubungo	0875223	6	Maçonnerie	Phase 1	GLAS
				Mukagakwandi Veneranda	Jabana				6	Maçonnerie	Pilote	ENVIROTECH
				Mukakabano Judith	Jabana			0788613962	6	Maçonnerie	Pilote	CRET
				Mukakiberwa Yolanda	Jabana	Ngiryi	Rubona	0783867734	6	Maçonnerie	Pilote	GLAS
				Mukandirima Mary	Jabana	Ngiryi	Rubona	0785470737	6	Maçonnerie	Pilote	GLAS
				Mukansanga Marie	Jabana				6	Maçonnerie	Pilote	ENVIROTECH
				Murindabigwi Martin	Remera	Nyabisindu	Nyabisindu	08522174	10	Maçonnerie	Phase1	GLAS

Status	District		Names	Sector	Cell	Village	Tel	Size (m^3)	Type	Phase	Company
			Musanabera Francine	Jabana				6	Maçonnerie	Pilote	ENVIROTECH
			Mutabaruka Augustin	Bumbogo	Musave	Rebero	0788738946	8	Maçonnerie	Phase 1	GLAS
			Ndagijimana Sylvestre	Jabana	Ngiryi	Rubona	0788450921	6	Maçonnerie	Pilote	ENVIROTECH
			Ngurinzira Prudence	Jabana	Ngiryi	Nyarubuye		6	Maçonnerie	Pilote	ENVIROTECH
			Nkundayezu Noel	Rusororo	Kabuga II	Cyanama	03049868	8	Maçonnerie	Phase 1	GLAS
			Nsengiyumva Eugene	Jabana	Kidashya	Mubuga	0783597665	8	Maçonnerie	Pilote	TURWUBAKE
			Nyirabagenzi Leocadie	Jabana	Ngiryi		0783436051	6	Maçonnerie	Pilote	GLAS
			Nyirakamana Agnessinne	Jabana	Kidashya	Agasekabuye	0788289317	6	Maçonnerie	Pilote	TURWUBAKE
			Nzigiyimana Fabien	Jabana	Kidashya	Mubuga	0788758432	6	Maçonnerie	Pilote	GBTC
			Rushari Marceline	Jabana	Kidashya	Amasangano	0788546395	6	Maçonnerie	Pilote	TURWUBAKE
			Rutinywa Jean Paul	Rusororo	Mbandazi	Cyeru	08485982	6	Maçonnerie	Phase 1	GLAS
			Rwakayigamba Anthere	Jabana	Bweramvura	Akinyana	0788450766	6	Maçonnerie	Pilote	TURWUBAKE
			Seturinka Martin	Bumbogo	Musave	Rugando	03725785	6	Maçonnerie	Phase 1	GLAS
			Sindikubwabo Ange	Jabana	Ngiryi	Uwanyange	0788550529	6	Maçonnerie	Pilote	CRET
			Uwambajimana Matilde	Rusororo	Mbandazi	Cyeru	08595729	10	Maçonnerie	Phase 1	GLAS
			Uwanyirigira Emmanuel	Jabana	Ngiryi	Jun"e	0788673957	6	Maçonnerie	Pilote	GLAS
		6									
In use	Gatsibo		Murasa Anther	Kabarore	Karenge	Nyarubuye	08493466	8	Maçonnerie	Phase 1	ACSES-I
			Niyonzima Evariste	Kiramuruzi	Akarusizi	Gipangu	08840942	6	Maçonnerie	Phase 1	ACSES-I
			Rudakubana Eugene	Kiramuruzi	Gakenke	Akarusizi	0865772	6	Maçonnerie	Phase 1	ACSES-I
			Rugiranka Rigati Gaspard	Kabarore	Kabarore	Kabarore I	08810843	6	Maçonnerie	Phase 1	ACSES-I
			Rutubana Athanase	Kiramuruzi	Gakenke	Gipangu	08324099	8	Maçonnerie	Phase 1	ACSES-I
			Utumuriza Betty	Kabarore	Kabarore	Kabarore I	08615922	8	Maçonnerie	Phase 1	ACSES-I
		38									
In use	Gicumbi		Buhirwe Helene	Byumba	Nyamabuye	Nyiragasuruba	3139557	6	Maçonnerie	Phase 1	MBA
			Birushya Christophe	Kaniga	Rukurura	Kamushure	8674727	6	Maçonnerie	Phase 1	MBA
			Bizimana Emmanuel	Rubaya	Muguramo	Centre Rubaya	783055754	8	Maçonnerie	Phase 1	MBA
			Byamungu Jean de Dieu	Mukarange	Cyamuganga	Burambira	8768153	6	Maçonnerie	Phase 1	MBA
			Byanone Lucien	Rushaki	Karurama	Centre Rushaki	8540451	6	Maçonnerie	Phase 1	MBA
			Cyomuhangi Wherny	Byumba	Gisuma	Ruhashya	8473915	6	Maçonnerie	Phase 1	MBA

Status		District		Names	Sector	Cell	Village	Tel	Size (m^3)	Type	Phase	Company
				Habyarimana Leonard	Mukarange	Rugerero	Rurembo	3171822	6	Maçonnerie	Phase 1	MBA
				Hajabagabo Jean Marie Via	Cyumba	Nyakabungo	Remera	788454872	8	Maçonnerie	Phase 1	MBA
				Harerimana Jean Baptiste	Byumba	Nyamabuye	Murara	8473987	8	Maçonnerie	Phase 1	MBA
				Harindintwali Cyprien	Byumba	Nyamabuye	Nyiragasuruba	3474685	6	Maçonnerie	Phase 1	MBA
				Kabahire Judith	Byumba	Murama	Gacaca	8684969	6	Maçonnerie	Phase 1	MBA
				Kaburame Emmanuel	Byumba	Nyamabuye	Agatete	8818437	6	Maçonnerie	Phase 1	MBA
				Kamuzinzi Ernest	Kaniga	Bugomba	Kajevuba	8852910	6	Maçonnerie	Phase 1	MBA
				Mugiraneza Fran90is	Kageyo	Nyamiyaga	Mutobo	8404866	8	Maçonnerie	Phase 1	MBA
				Mugiraneza Robert	Kageyo	Nyamiyaga	Gatare	8536251	6	Maçonnerie	Phase 1	MBA
				Mujyarugamba Frederic	Byumba	Nyamabuye	Gasiza	8481811	6	Maçonnerie	Phase 1	MBA
				Mukagahutu Xaverine	Cyumba	Muhanbo	Kiliba	3107069	6	Maçonnerie	Phase 1	MBA
				Mukamukiza Anne Marie	Byumba	Nyamabuye	Mugonero	5109206	6	Maçonnerie	Phase 1	MBA
				Mukangiruwonsanga Agnes	Byumba	Ngondore	Kimirimo	5151545	6	Maçonnerie	Phase 1	MBA
				Munyaneza Leonidas	Shangasha	Nyabubare	lrembo	8864378	6	Maçonnerie	Phase 1	MBA
				Mutuyimana Josephine	Byumba	Nyamabuye	Nyiragasuruba	3384681	6	Maçonnerie	Phase 1	MBA
				Ndamage Daniel	Byumba	Nyarutarama	Nyande	8454856	6	Maçonnerie	Phase 1	MBA
				Ndangurura Bernard	Byumba	Nyarutarama	Nyande	3429922	6	Maçonnerie	Phase 1	MBA
				Ndegeya J.ean	Byumba	Rebero	Gisuma	8510298	8	Maçonnerie	Phase 1	MBA
				Ndengeyingoma Anadet	Byumba	Kibali	Mugorora	8308972	10	Maçonnerie	Phase 1	MBA
				Niyonsaba Faustin	Bwisige	Mukono	Akavuza	8746849	8	Maçonnerie	Phase 1	MBA
				Njekumurata Innocent	Byumba	Gacurabwenge	Gacurabwenge	8413666	6	Maçonnerie	Phase 1	MBA
				yirabagirishya Felicite	Cyumba	Nyakabungo	Remera	788444865	6	Maçonnerie	Phase 1	MBA
				Ramazani Jean Claude	Cyumba	Rwankonjo	Rukizi	8455285	8	Maçonnerie	Phase 1	MBA
				Rulibikiye Joseph	Byumba	Nyamabuye	Mugomero	8596545	6	Maçonnerie	Phase 1	MBA
				Singirankabo Etienne	Byumba	Gacurabwenge	Rwasama	8895587	6	Maçonnerie	Phase 1	MBA
				Tirwomwe Issa	Cyumba	Rwankonjo	Gatuna	8765358	6	Maçonnerie	Phase 1	MBA
				Twahirwa Faustin	Byumba	Nyamabuye	Umurara	8303953	8	Maçonnerie	Phase 1	MBA
				Twine Dacien	Mukarange	Mutarama	Rugeshi	8868516	6	Maçonnerie	Phase 1	MBA
				Uwamahoro Jeanne d'Arc	Byumba	Gisuna	Rebero	8459658	6	Maçonnerie	Phase 1	MBA
				Uwamahoro Mediatrice	Mukarange	Rushaki	Rushasha	8624185	6	Maçonnerie	Phase 1	MBA
				Uwamariya Josee	Byumba	Nyamabuye	Rwabukoko	8470545	6	Maçonnerie	Phase 1	MBA
				Uwumuremyi Wellars	Cyumba	Nyambare	Gipandi	8461238	6	Maçonnerie	Phase 1	MBA

Status	District		Names	Sector	Cell	Village	Tel	Size (m^3)	Type	Phase	Company
		10									
In use	Kamonyi		Bitero Sylvere	Nyamiyaga	Mukinga	Mbayaya	783002850	6	Maçonnerie	Pilote	BETRAP
			Mukamazimpaka Epiphani	Nyamiyaga	Ngoma	Munyinya	783741175	6	Maçonnerie	Pilote	ATCR
			Muneza Edouard	Mugina	Mbati	Kigorora	788735971	6	Maçonnerie	Pilote	BETRAP
			Ndayambaje Etienne	Mugina	Mbati	Mikamba	788565663	6	Maçonnerie	Pilote	BETRAP
			Nyirimpuhwe Telesphore	Mugina	Mbati	Kigorora	788443709	6	Maçonnerie	Pilote	BETRAP
			Nzeyimana Mathias	Mugina	Kabugondo	Cyeru	785059220	6	Maçonnerie	Pilote	ENVIROTECH
			Paroisse Mugina	Mugina	Mbati	Mikamba	78880819	8	Maçonnerie	Pilote	REC
			RFTDC Ruyumba	Nyamiyaga	Mukinga	Mbayaya	788433756	6	Maçonnerie	Pilote	1st BTMT
			Rugambage Charles	Mugina	Mbati	Mikamba	788483019	6	Maçonnerie	Pilote	BETRAP
			Sibomana Simon	Mugina	Mbati	Kigorora	783824917	8	Maçonnerie	Pilote	CRET
		7									
In use	Kayonza		Bizimana Viateur(Padiri)	Kabarondo	Cyabajwa	Kabarondo	3027075	8	Maçonnerie	Phase 1	ACSES-I
			Butera patrick	Gahini	Urugarama	Umwiga	8532919		Maçonnerie	Phase 1	ACSES-I
			Kayumbu Innocent	Gahini	Urugarama	Nyagitabire	788668968	6	Maçonnerie	Phase 1	ACSES-I
			Mukandori Genevieve	Kabarondo	Kinzovu	Minini	788440380	8	Maçonnerie	Phase 1	ACSES-I
			Nsanzumuhire Denis	Kabarondo	Cyabajwa	Cyabajwa	8678328		Maçonnerie	Phase 1	ACSES-I
			Rurangirwa Ismail	Rwinkwavu	Gacaca	Mbarira	788357253	10	Maçonnerie	Phase 1	ACSES-I
			Shyaka Daniel	Gahini	Urugarama	Kabeza	788413181	6	Maçonnerie	Phase 1	ACSES-I
		2									
In use	Kicukiro		Kashugera Faustin	Masaka	Gako	Rugende	788300645	10	Maçonnerie	Phase 1	GLAS
			Musine Godefroid	Gatenga	Nyarurama	Nyabikenke	788760756	10	Maçonnerie	Phase 1	GBTC
In use	Musanze	20	Bajeni Mpumuro	Muhoza	Ruhengeri	Byimana	8503471	8	Maçonnerie	Phase 1	ECOGED
			Gatambiye Etienne	Muhoza	Ruhengeri	Byimana	8403527	6	Maçonnerie	Phase 1	ECOGED
			Habiyaremye Callixte	Musanze	Cyabagarura	Bukane	8502685	6	Maçonnerie	Phase 1	ECOGED
			Habyarimana Emmanuel	Cyuve	Kabeza	Gashangiro	8619231	6	Maçonnerie	Phase 1	ECOGED
			Havugimana Faustin	Muhoza	Ruhengeri	Bushozi	8429036	6	Maçonnerie	Phase 1	ECOGED
			Kalisa Justin	Muhoza	Ruhengeri	Byimana	8590816	8	Maçonnerie	Phase 1	ECOGED
			Karegeya Appolinaire	Nyange	Cyivugiza	Terimbere	788652175	6	Maçonnerie	Phase 1	ECOGED
			Karekezi Apolinaire	Kimonyi	Kivumu	Nyamugari	8565308	6	Maçonnerie	Phase 1	ECOGED
			Manene Ladislas	Muhoza	Ruhengeri	Burera	788756592	8	Maçonnerie	Phase 1	ECOGED

Status	District		Names	Sector	Cell	Village	Tel	Size (m^3)	Type	Phase	Company
			Maniragaba Fidele	Nyange	Cyivugiza	Gasoroza	788865580	6	Maçonnerie	Phase 1	ECOGED
			Mbonigaba Murigo	Cyuve	Rwebeya	Cyuve	8558299	6	Maçonnerie	Phase 1	ECOGED
			Mukampunga Christine	Muhoza	Ruhengeri	Muhe	8670170	10	Maçonnerie	Phase 1	ECOGED
			Munyankaka Cyprien	Cyuve	Kabeza	Kungo	8472274	6	Maçonnerie	Phase 1	ECOGED
			Munyantwari Adam	Cyuve	Rwebeya	Nyarubande	8871396	6	Maçonnerie	Phase 1	ECOGED
			Mutibagirwa Athanase	Musanze	Cyabagarura	Ruvumu	8822847	6	Maçonnerie	Phase 1	ECOGED
			Neretse Sostene	Cyuve	Kabeza	Bueuzi	8747812	6	Maçonnerie	Phase 1	ECOGED
			Nkurunziza Gaspard	Muhoza	Kigombe	Kavumu	8428680	6	Maçonnerie	Phase 1	ECOGED
			Nzabonimpa Laurent	Muhoza	Kigombe	Nyamuremure	8670809	6	Maçonnerie	Phase 1	ECOGED
			Sibomana Joseph	Nyange	Cyivugiza	Terimbere	788525674	6	Maçonnerie	Phase 1	ECOGED
			Uwamusindi Eugene	Cyuve	Kabeza	Karunyura	8840070	6	Maçonnerie	Phase 1	ECOGED
		17									
In use	Ngoma		Bushayija Francis	Rukira	Buliba	Rurama	8456673	8	Maçonnerie	Phase 1	ACSES-I
			Gasana Samuel	Rukira	Nyaruvumu	Nyagataba	8560056	6	Maçonnerie	Phase 1	ACSES-I
			Gasarabwe Sylvestre	Kibungo	Gahima	Gasoro	8469820	10	Maçonnerie	Phase 1	ACSES-I
			Habiyakare Jacques Martin	Murama	Rurenge	Gitaba	788503259	6	Maçonnerie	Phase 1	ACSES-I
			Kamugabo Jean	Rukira	Buliba	Rurama	8879886	6	Maçonnerie	Phase 1	ACSES-I
			Karangwa Issa	Remera	Kinunga	Nyarugenge	8865946	6	Maçonnerie	Phase 1	ACSES-I
			Mudenge Seleman	Kibungo	Karenge	Musamvu	8460165	8	Maçonnerie	Phase 1	ACSES-I
			Munyaneza Frederic	Rukira	Kibatsi	Gatare	8877457	8	Maçonnerie	Phase 1	ACSES-I
			Mutuyemariya Verena	Rukira	Nyruvumu	Terimbere		6	Maçonnerie	Phase 1	ACSES-I
			Nakabonye Veronique	Rukira	Buliba	Rurama	8677227	6	Maçonnerie	Phase 1	ACSES-I
			Narpahungu Augustin	Rukira	Buliba	Rurama	8673774	8	Maçonnerie	Phase 1	ACSES-I
			Ndisabira Jean de Dieu	Rukira	Kibatsi	Gatare		6	Maçonnerie	Phase 1	ACSES-I
			Nkurunziza Landuald	Rukira	Kibatsi	Rusenyi	3110957	8	Maçonnerie	Phase 1	ACSES-I
			Nyakarundi Telesphore	Rukira	Nyinya	Rwagakobe	8758258	8	Maçonnerie	Phase 1	ACSES-I
			Ruhumuliza Jean	Rukira	Buliba	Rurama	8688512	6	Maçonnerie	Phase 1	ACSES-I
			Rupiga Fran<;is	Rukira	Buliba	Rurama	8837245	8	Maçonnerie	Phase 1	ACSES-I
			Sekabera Celestin	Rukira	Buliba	Rurama	3243201	6	Maçonnerie	Phase 1	ACSES-I
		1									
In use	Nyagatare		Ngarambe Deogratias	Karangazi	Mbare	Ryabega	788653128	10	Maçonnerie	Phase 1	ROOFING
		5									

Status	District		Names	Sector	Cell	Village	Tel	Size (m^3)	Type	Phase	Company
In use	Nyanza		Biziyaremye Damien	Kigoma	Butansinda	Karama	8626842	6	Maçonnerie	Phase 1	REC
			Gakuba Augustin	Kigoma	Gahombo	Gisore	783440135	8	Maçonnerie	Pilote	REC
			Masozera Uzzia	Kigoma	Butansinda	Karama	8592364	6	Maçonnerie	Phase 1	REC
			Musoni Valens	Kigoma				6	Maçonnerie	Pilote	REC
			Uzabakiriho Faustin	Kigoma	Butansinda	Nyeshonga	788872852	6	Maçonnerie	Pilote	REC
		18									
In use	Ruhango		Bicurisha Leonard	Ntongwe	Kayenzi	Kanyete	783465145	6	Maçonnerie	Pilote	REC
			Gafirigi Valerie	Ntongwe	Gikomo	Gikumba		6	Maçonnerie	Pilote	ATCR
			Gasengayire Xaverine	Ntongwe	Cyemero	Nyabitare	788367866	6	Maçonnerie	Pilote	ATCR
			Hakizabera David	Mwendo	Gafunzo	Ruhamagariro	8546598	6	Maçonnerie	Phase 1	BETRAP
			Harerimana Boniface	Byimana	Mahembe	Nyagasozi	8561783	6	Maçonnerie	Phase 1	BETRAP
			Kaberuka Pascal	Byimana	Ntenyo	Kageyo	788548388	6	Maçonnerie	Phase 1	BETRAP
			Karangwa Eugene	Mwendo	Gafunzo	Nyamugabe	8551803	6	Maçonnerie	Phase 1	BET RAP
			Matabaro David	Ruhango	Kamusamu	Musamu	788986350	6	Maçonnerie	Pilote	ATCR
			Mukakarisa Agatha	Mwendo	Gafunzo	Gafunzo	8769023	6	Maçonnerie	Phase 1	BETRAP
			Mukarugambwa Eularie	Ntongwe	Gasunzu	Kibero		6	Maçonnerie	Pilote	REC
			Munyurangabo Emmanuel	Kinazi	Rutabo	Gitwa	788672768	6	Maçonnerie	Pilote	BETRAP
			Niyonsaba Philippe	Kinazi	Burima	Burima	788786667	6	Maçonnerie	Pilote	BETRAP
			Ntivunwa Theoneste	Byimana	Mahembe	Nyagisozi	788454640	6	Maçonnerie	Phase 1	BETRAP
			Nyirakanyana Balacille	Mwendo	Kubutare	Gashyogoshyo	3238868	6	Maçonnerie	Phase 1	BETRAP
			Paroisse Byimana	Byimana	Kamusenyi	Nyarusange	788434381	8	Maçonnerie	Phase 1	BETRAP
			Ruberandinda Phocas	Bweramana	Rwinyana	Karambi	8597312	6	Maçonnerie	Phase 1	BETRAP
			Urimubandi Mathias	Kinazi	Kinazi	Nyabinyenga	788600815	6	Maçonnerie	Pilote	BETRAP
			Uwimana Lambert	Kinazi	Rubona	Gako	788680717	6	Maçonnerie	Pilote	BETRAP
		19									
In use	Rulindo		Bangire Constance	Masoro	Kigarama	Gacyamo	788540010	10	Maçonnerie	Pilote	CRET
			Benda Theophile	Ntarabana	Kajevuba	Bikamba	788689629	8	Maçonnerie	Phase 1	GBTC
			Gahungu Gervais	Ntarabana	Kajevuba	Rukore		6	Maçonnerie	Pilote	MBA
			Habiyakare Faustin	Ntarabana	Kajevuba	Bikamba	788739642	6	Maçonnerie	Pilote	MBA
			Hitayezu Noel	Masoro			788464761	6	Maçonnerie	Pilote	GLAS
			Iryamukuru Isidore	Ntarabana	Kajevuba	Bikamba	783417137	6	Maçonnerie	Pilote	MBA
			Kagaba Anselme	Masoro			788464781	6	Maçonnerie	Pilote	GLAS

Status	District		Names	Sector	Cell	Village	Tel	Size (m^3)	Type	Phase	Company
			Karegeya Michel	Masoro			788445940	6	Maçonnerie	Pilote	GLAS
			Kayumba Theogene	Ntarabana	Kajevuba		8783196616	6	Maçonnerie	Pilote	MBA
			Kayumba Theogene	Ntarabana	Kajevuba	Nyarubuye	783196616	6	Maçonnerie	Pilote	GLAS
			Mukankusi Marie Fran<;oise	Masoro	Shengampuli	Rusine	783351737	6	Maçonnerie	Phase 1	GBTC
			Munyaneza Apollinaire	Masoro	j(jgarama	Rukurazo	783847490	6	Maçonnerie	Pilote	ENVIROTECH
			Munyegugu Leonard	Ntarabana	Kajevuba	Bikamba		6	Maçonnerie	Pilote	MBA
			Murenzi Laurent	Ntarabana	Kajevuba	Nyarubuye	783788778	6	Maçonnerie	Pilote	MBA
			Mushumba Phocas	Ntarabana	Kajevuba	Rukore	783858085	6	Maçonnerie	Pilote	MBA
			Mutuyimana Jerome	Ntarabana	Kajevuba	Bikamba	783317850	6	Maçonnerie	Pilote	MBA
			Nimugire Speciose	Ntarabana	Kajevuba	Rukore	750791984	6	Maçonnerie	Pilote	MBA
			Rutayisire Ephrem	Masoro	Shengampuri	Rusine	783241056	6	Maçonnerie	Phase 1	GBTC
			Sinamenye	Ntarabana	Kajevuba	Bikamba		6	Maçonnerie	Pilote	MBA
		1									
In use	Rwamagana		Butare Onesphore	Rusororo	Bisenga	Gasiza	788653620	6	Maçonnerie	Phase 1	GLAS

ANNEX 3: VERIFICATION SCHEDULE

DATE	**ACTIVITY**	**PLACE**
27 November 2009	Travelling to Kigali	-
28 November 2009	NDBP Briefing and planning verification schedule	MININFRA
29 November 2009	Verification – Central Kigali Province	Central Kigali Province
30 November 2009	Verification – Northern Province	Northern Province
1 December 2009	Verification – Northern Province	Northern Province
2 December 2009	Verification – Southern Province	Southern Province
3 December 2009	Verification – Eastern Province	Eastern Province
4 December 2009	NDBP Verification Briefing	MININFRA
	Travelling to Tanzania	-

ANNEX 4: EVALUATION OF EMISSION FACTORS

CO_2 from wood	112000 kg CO_2 / TJ	x	1 TJ / 1.0E+06 MJ	x	16.6 MJ / kg Wood	=	1.859 kg CO_2 / kg Wood	x	1	GWP	=	**1.859**	kg CO_2 / kg Wood	
CH_4 from wood stoves (258 - 2190 kg/TJ)	1224 kg CH_4 / TJ	x	1 TJ / 1.0E+06 MJ	x	16.6 MJ / kg charcoal	=	0.020 kg CH_4 / kg Wood	x	21	GWP	=	**0.427**	kg CO_2 / kg Wood	
N_2O from wood stoves (1 - 18.5 kg/TJ)	11.25 kg N_2O / TJ	x	1 TJ / 1.0E+06 MJ	x	16.6 MJ / kg charcoal	=	0.000 kg N_2O / kg Wood	x	310	GWP	=	**0.058**	kg CO_2 / kg Wood	
							TOTAL EMISSION FACTOR FOR WOOD BURNING IN CO2 EQUIVALENT					**2.344**	kg CO2 / kg Wood	
CO_2 from charcoal burning	112000 kg CO_2 / TJ	x	1 TJ / 1.0E+06 MJ	x	30 MJ / kg charcoal	=	3.360 kg CO_2 / kg Charcoal	x	1	GWP	=	**3.360**	kg CO_2 / kg Charcoal	
CH_4 from charcoal production	1000 kg CH_4 / TJ	x	1 TJ / 1.0E+06 MJ	x	30 MJ / kg charcoal	=	0.030 kg CH_4 / kg Wood	x	21	GWP	=	**0.630**	kg CO_2 / kg Charcoal	
CH_4 from charcoal combustion	200 kg CH_4 / TJ	x	1 TJ / 1.0E+06 MJ	x	30 MJ / kg charcoal	=	0.006 kg CH_4 / kg Wood	x	21	GWP	=	**0.126**	kg CO_2 / kg Charcoal	

CO_2 from charcoal production: data not available on IPCC website

TOTAL EMISSION FACTOR FOR CHARCOAL PRODUCTION AND BURNING IN CO2 EQUIV	**4.116**
TOTAL EMISSION FACTOR CAN BE ESTIMATED AS EMISSION FACTOR FOR WOOD x 3	**7.031**

NOTE: Charcoal contains twice amount of energy than wood but 6 kg wood produces 1 kg of charcoal, hence a factor of 3

Emission from Fossil Fuel Burning - Kerosene

CO_2 from kerosene combustion	71900	kg CO_2 / TJ	x	1	TJ / 1.0E+06 MJ	x	44.8	MJ / kg kerosene	=	3.218	kg CO_2 / kg kerosene	x 0.8 kg / L	x 1 GWP = **2.542** kg CO_2 / l kerosene
CH_4 from kerosene combustion - wick (2.2-23 kg/TJ)	12.6	kg CH_4 / TJ	x	1	TJ / 1.0E+06 MJ	x	44.8	MJ / kg charcoal	=	0.001	kg CH_4 / kg kerosene	x 0.8 kg / L	x 21 GWP = **0.012** kg CO2 / l kerosene
N_2O from kerosene combustion - wick (1 .2- 1.9 kg/TJ)	1.55	kg N_2O / TJ	x	1	TJ / 1.0E+06 MJ	x	44.8	MJ / kg charcoal	=	0.000	kg N_2O / kg kerosene	x 0.8 kg / L	x 310 GWP = **0.022** kg CO2 / l kerosene
										TOTAL EMISSION FACTOR FOR WOOD BURNING IN CO2 EQUIVALENT			**2.575** kg CO2 / l kerosene

Emission from Fugitive gas

10% biogas leakage per digestor, biogas has 65% methane, biogas density is 0.68 kg/m^3

CO_2 equivlqnt from methane fugitive emission	1	m^3 biogas / digester	x	0.1	x	0.65	m^3 CH_4 / m^3 biogas	x	0.68 kg CH_4 / m^3 CH_4	x 21 GWP = **0.928** kg CO_2 / digestor

Emission from Fossil Fuel Burning - Diesel fuel for project vehicles

CO_2 from diesel fuel, ligh duty vehicle, moderate controlled	280	g CO_2 / km	x	10	km / L diesel	x	1	kg / 1.0E+03 g	x	1 GWP = **2.800** kg CO_2 / l diesel oil
CO_2 from gasoline motorcycles, 4 stroke engine, > 50 cc	120	g CO_2 / km	x	19.5	km / L gasoline	x	1	kg / 1.0E+03 g	x	1 GWP = **2.340** kg CO_2 / l gasoline

ANNEX 5: TABLE OF FIELD VERIFICATION RESULTS

S.No	Name	Total No. of Persons	No. of Children	No. of Adult Cows	No. of calves	No. of Pigs	Digester Size (m^3)	No. of Stoves	Hours of stoves	No. of lamps	Hours of lamp use/ day	Water need for cows (L/day)	Water need for digester	Adds urine to digester	Water source	Distance to water source (km)	Construction date
	Kigali, Gasabo District																
1	Uwambajimana Matilde	5	5	10	4	0	10	1	4.5	1	3	600	0	Yes	tap	0	Aug-08
2	Mukabaruta Melanie	7	3	3	2	0	6	1	6.5	1	4.5	200	45	Yes	WH & Tap	500	Mar-09
3	Murindabigwi Martin	12	5	10	8	0	10	2	9	1	0	480	90	No	tap	0	Nov-08
4	Bimana Jean Bosco	9	7	2	1	0	6	1	2.5	1	2.5	160	40	Yes	str	2500	Jun-07
5	Ngurinzira Prudence	10	7	1	1	0	6	1	2	1	3.5	160	10	Yes	str	3500	Jun-07
6	Kamuzinzi Gaspard	12	7	6	5	0	8	1	4	1	4	50	0	Yes 80L	tap		Dec-07
	Nothern P. Gicumbi District																
7	Cyomuhangi Wherny	11	5	3	1	0	6	1	5	1	0	40	60		tap	0	Nov-08
8	Kabahire Judith	6	3	2	1	0	6	1	3	1	2	80	80	Yes	tap	0	Nov-08
9	Mukagahutu Xaverine	7	5	2	1	0	6	1	3.28	1	5	120	60		WH & BUY	0	Apr-09
10	Uwamahoro Mediatrice	12	8	5	1	0	6	1	4	1	5	100	60	Yes	WH	0	Aug-08
	Nothern P. Musanze District																
11	Kalisa Justin	9	2	6	2	0	8	2	7	0	0	100	0	Yes 80L	tap & WH	0	Jul-08
12	Karekezi Apolinaire	11	7	10	1	0	8	1	3.25	1	1.5	300	0	Yes 40L	tap & WH	0	Jul-08
13	Munyankaka Cyprien	14	5	3	0	0	8	2	4.5	1	2	160	160	Yes	tap	0	Jun-08
	Nothern P. Rulindo District																
14	Kayumba Theogene	5	3	2	1	0	6	1	1.67	1	3.5	100	40	yes 60 L	well	200	Apr-07
15	Munyaneza Apollinaire	12	4	4	0	0	8	1	1	1	4.5	60	50		tap	500	Apr-07
	Eastern P. Ngoma District																
16	Gasarabwe Sylvestre	6	3	5	2	0	10	1	5	1	0	130	80	no	tap & WH	3000	Jan-09
17	Mudenge Seleman	10	1	19	4	0	8	2	3	1	2.5	0	40	Yes 40	tap	0	Apr-09
	Eastern P. Gatsibo District																
18	Rudakubana Eugene	8	0	2	2	0	6	2	5	0	0	20	0	yes 40	tap & WH	500	Feb-09
	Eastern P. Kayonza District																
19	Bizimana Viateur(Padiri)	5	0	3	2	0	8	1	4	1	0	20	80	yes	tap & WH	0	Dec-08
20	Mukandori Genevieve	10	0	2	2	0	8	1	4.5	1	2	60	90	yes	tap & WH	100	May-09

S.No	Name	Total No. of Persons	No. of Children	No. of Adult Cows	No. of calfs	No. of Pigs	Digester Size (m^3)	No. of Stoves	Hours of stoves	No. of lamps	Hours of lamp use/ day	Water need for cows (L/ day)	Water need for digester	Adds urine to digestror	Water source	Distance to water source (km)	Construction date
	Southern P. Ruhango																
21	Kaberuka Pascal	6	4	2	2	3	6	1	2.5	1	3	60	20	No	tap	300	Aug-08
22	Matabaro David	9	7	1	0	0	6	1	3.5	1	2	20	20	Yes 20	str	200	Jun-07
	Southern P. Nyanza																
23	Masozera Uzzia	10	4	3	1	0	6	1	6	1	5	60	30	Yes 30L	str	1000	Jul-08
	Southern P. Kamonyi																
24	Mukamazimpaka Epiphani	9	7	2	1	2	6	1	6	1	3.5	120	60	No	str	2000	Jul-07
25	Ndayambaje Etienne	9	2	40	0	0	6	1	6	1	2		40	No	str	2000	Jun-07
	Average	8.96	4.16	5.92	1.80	0.20	7.12	1.20	4.27	0.92	2.44	133.33	46.2			679.2	39607
	Minimum	5.00	0.00	1.00	0.00	0.00	6.00	1.00	1.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	39187
	Maximum	14.00	8.00	40.00	8.00	3.00	10.00	2.00	9.00	1.00	5.00	600.00	160.0	0.0	0.0	3500	39960
	Water source:	tap = tap water															
		WH = water harvest															
		Str = stream r well source															
	Fertiliser Management :	DRY = wait until dry before application															
		L = Applied in liquid form															
		MIX = Mixed with biomass, mainly manure and applied in field															
		RED = reduce application of artificial fertilizer															
		SEL = Sell biogas ferliser															
	Others:	BEF = Before															
		AFT = After															
		SAV = Saving															

S.No	Name	Savings in firewood ster/month			Value (USD)	Charcoal (bags)			Value (USD)	Savings in kerosene			Value (USD)	Fertilizer management
		BEF	AFT	SAV		BEF	AFT	SAV		BEF	AFT	SAV		
	Kigali, Gasabo District													
1	Uwambajimana Matilde	6	3	3	23.68					0	0	0	0	L, Poor
2	Mukabaruta Melanie	5	2.5	2.5	19.74					15	7.5	7.5	10.53	L
3	Murindabigwi Martin	0	0	0	0	7	0	7	85.96	0	0	0	0	L
4	Bimana Jean Bosco	4	1	3	23.68					4	1	3	4.737	MIX
5	Ngurinzira Prudence	0.5	0.25	0.25	1.974					2	0	2	3.158	MIX
6	Kamuzinzi Gaspard	15	1	14	73.68					5	1	4	4.912	MIX
	Nothern P. Gicumbi District													
7	Cyomuhangi Wherny	1	0.5	0.5	5.263	4	0	4	38.6	0	0	0	0	L
8	Kabahire Judith	4	2	2	21.05					0	0	0	0	L, SEL
9	Mukagahutu Xaverine	5	0.5	4.5	47.37					5	0	5	8.509	L
10	Uwamahoro Mediatrice	5	2.5	2.5	21.05					4	0	4	8.421	L
	Nothern P. Musanze District													
11	Kalisa Justin	1	0.333	0.667	8.191					0	0	0	0	L
12	Karekezi Apolinaire	2	0	2	24.56					0	0	0	0	MIX, RED
13	Munyankaka Cyprien	4	1	3	36.84					0	0	0	0	L, RED, SEL
	Nothern P. Rulindo District													
14	Kayumba Theogene	2	0	2	10.53					1	0	1	1.228	MIX
15	Munyaneza Apollinaire	8	1	7	55.26					20	0	20	42.11	MIX
	Eastern P. Ngoma District													
16	Gasarabwe Sylvestre	4	2.5	1.5	18.42					0	0	0	0	L
17	Mudenge Seleman	6	3	3	13.16	3	1.5	1.5	14.47	0	0	0	0	L
	Eastern P. Gatsibo District													
18	Rudakubana Eugene	1.5	0.3	1.2	5.263	1	0	1	10.53	0	0	0	0	MIX
	Eastern P. Kayonza District													
19	Bizimana Viateur(Padiri)	4	2	2	10.53					0	0	0	0	DRY
20	Mukandori Genevieve	1.67	0.33	1.33	7.02					0	0	0	0	L

S.No	Name	Savings in firewood ster/ month			Value (USD)	Charcoal (bags)			Value (USD)	Savings in kerosine			Value (USD)	Fertilizer management
	Southern P. Ruhango													
21	Kaberuka Pascal	2	0	2	28.07					2	0.5	1.5	1.842	MIX
22	Matabaro David	5	1	4	56.14					2	0	2	2.456	MIX
	Southern P. Nyanza													
23	Masozera Uzzia	3	0.25	2.75	33.77	1	0	1	7.895	4	0.5	3.5	6.14	L, MIX
	Southern P. Kamonyi													
24	Mukamazimpaka Epiphani	3	0.5	2.5	30.7					1	0	1	2.105	MIX
25	Ndayambaje Etienne	0.6667	0.333	0.3333	2.632	3	0	3	21.05	0.3	0	0.3	0.632	MIX
	Average	3.73	1.03	**2.70**	**23.14**	3.17	0.25	**2.92**	**29.75**	2.61	0.42	**2.19**	**3.87**	
	Minimum	0.00	0.00	**0.00**	**0.00**	1.00	0.00	**1.00**	**7.89**	0.00	0.00	**0.00**	**0.00**	
	Maximum	15.00	3.00	**14.00**	**73.68**	7.00	1.50	**7.00**	**85.96**	20.00	7.50	**20.00**	**42.11**	
	% Reduction			**72.36**				**92.11**				**83.92**		
	Firewood in kg, density of eucaruptus firewood 350 kg/ ster per month									**Average kerosine per day**				
	AVER	1,307	361	945						0.087	0.014	0.073		
	MIN	0	0	0										
	MAX	5,250	1,050	4,900										
	Firewood in kg/ day (density of eucaliptus firewood 350 kg/ ster													
	AVER	43.56	12.04	31.52		5.28	0.42	4.86						
	MIN	0	0	0		1.67	0.00	1.67						
	MAX	175	35	163.33		11.67	2.50	11.67						