Project Design Document for Eritrea Dissemination of Improved Stoves Program

2003-01

This project design document is formulated consistent with the official outline provided by UNFCCC documents.

1. *The provisions of this appendix shall be interpreted in accordance with the annex above on modalities and procedures for a CDM.*
2. *The purpose of this appendix is to outline the information required in the project design document. A project activity shall be described in detail taking into account the provisions of the annex on modalities and procedures for a CDM, in particular, section G on validation and registration and section H on monitoring, in a project design document which shall include the following:*
    a. *A description of the project comprising the project purpose, a technical description of the project, including how technology will be transferred, if any, and a description and justification of the project boundary.*

Project Description

Background, Justification, and Project Purpose

Eritrea is a new country located in the Horn of Africa , which has joined the community of nations after UN supervised referendum in 1993.Its total land area is 124,320 square km and its population was 3.2 million in 1999. Its geographical location is in the arid/semi-arid Sahelian region of Africa.

In April 1995, Eritrea accessed to the UN Convention on Climate Change whose ultimate objective is to stabilise human-induced greenhouse gas emissions at a level that is not too dangerous for the environment.

The National Energy Sector

Fuel wood is the main source of energy in Eritrea and will continue to play a dominant role to fulfill the energy demand of rural households for the foreseeable future. According to the national energy survey of 1998 (DoE, 1998), the total final energy consumption was estimated to be around 619,580 toe of which 68% was by the household sector, 16% by the commercial/public sector, 13% by transport and 3% by industry. The sources of energy were 66.3% biomass based (fuelwood, dung, charcoal, agri- residue), 31% oil products and 2% electricity that is all generated by thermal means using oil products. It is also noted that 98% of the rural population and 20% of the urban residents do not have access to electricity. Over 80% of the energy needs of rural enterprises is met by biomass or animate/human labour. Biomass, including wood, dung and crop residues, was the source for 95% of the energy consumption by rural households in Eritrea in 1998. With a predominantly rural population and undeveloped economy, Eritrea's per capital electricity consumption is among the lowest in the world at only about 50 kWh/year. But when modern energy sources are covering less than 33% of total national energy consumption, the repercussions on forest resources are to be considered extremely serious.

National Energy Policy Context

The objective of national energy programs in the rural sector is to help increase the standard of living for the rural communities in Eritrea through the delivery of modern energy services while protecting the environment. Of the various intervention options being initiated by the Government for realising this objective include:

1. rural electrification through grid extension,
2. improvement of biomass energy resources through various afforestation and reforestation programmes,
3. dissemination of improved stoves which is the aim of this project, and
4. assessment of the potentials of renewable energy resources for eventual development.

All of the above programs have contributed to decreasing the over exploitation of biomass resources and especially the forest products, fuelwood and charcoal. Reduction of biomass harvesting is pursued using the following three-pronged approach for this important effort.

5. Physical reduction in use of wood, through substitution with other energy sources
6. Incentive-driven tree planting initiatives on individual family basis
7. The development, wide distribution and use of efficient traditional wood stoves

Other Efficiency and Renewable Energy Programs

The household stove efficiency research has been performed as one part of an integrated national program of sustainable energy development. Since independence in 1991, the Department of Energy and other governmental, the private sector and NGOs have installed over 500 kW capacity of solar PV systems for high value educational, water supply and medical end-uses in over 300 villages throughout Eritrea. Furthermore an aggressive wind energy development program is being implemented that is evaluating and planning grid-connected, stand alone or hybridised wind energy plants for electricity supply. The renewable energy development efforts are combined with investments in the power generation and distribution infrastructure that improve both the efficiency of the power plants and decrease transmission losses in the electrical grid. Rural electrification is also progressing at an encouraging pace and within the coming two years over 100 villages are expected to become beneficiaries.

It is currently our conclusion from our short, but rich experience in integrated renewable energy and energy efficiency development that the most cost-effective investment that can currently be made in expanding and improving the efficiency of the energy sector is in the rural household sector where fuel use efficiencies are less than 10%, where 80% of national energy is currently consumed, and where cash investments in non-local materials can be leveraged with local contributions of labour and materials.

Introduction to the Technology

Eritreans have been cooking, the staple food, injera, using the traditional mogogo stoves for centuries. Nearly all households in the villagised settlement areas possess this simple home-manufactured oven and a mogogo stove made of clay used for cooking the cereal dish injera. The cultural attachments of the people with the mogogo and its product of baking, injera, is so strong that people are not expected to get rid of it in the short term. Thus, dependence on biomass is expected to exist for the foreseeable future. One serious disadvantage is that the mogogo consumes considerable quantities of firewood, estimated to be at least 50% of the biomass energy consumption per household per year. Due to the dense smoke in the kitchen and low level construction, the population is often suffering from respiratory and eye diseases. This is more severe on women and children.

The traditional clay oven has many design faults which make it an extremely energy inefficient cooker, thus leading to wastage of wood fuel, is inconvenient and unhealthy and has the following characteristic design problems:

8. The heat from the burning fuel is not enclosed in a firebox, so much heat escapes;
9. The mogogo geometry is not optimised to transfer heat well to the baking surface;
10. Much smoke is produced leading to health problems for those baking with the stove;
11. Due to poor air supply, it is often difficult to get the fire started. Blowing, and kerosene are often used;
12. With the exposed flame and floor-level construction, the burning stove is dangerous to children.

For these reasons, the Energy Research and Training Centre of the Ministry of Energy and Mines established at Asmara in 1996, developed an improved version, which combines some of the advantages of the traditional mogogo design with advanced thermodynamic concepts. The initial research involved taking tests and measurements of various types of mogogos as part of evaluating which design solutions are most effective in increasing efficiency. The design characteristics and innovations of the improved stoves include:- a two-layer insulated walls, a ceramic fire- holder that has openings in its body to allow improved air- flow and the release of ashes, optimally positioned fire-holder from the stove with door for biomass inlet, a chimney structure with control valve, etc.

Technical Description

The improved household biomass stove project facilitates a village by village transformation from the traditional inefficient stoves to the new more efficient designs. The project is carried out by the Energy Research and Training Center

(ERTC) of the Department of Energy of the State of Eritrea. Project activities by the ERTC include:

13. Community education and mobilization regarding stove, health and home economics issues.
14. Negotiation of project terms, including local contributions and assurance that all village members obtain access to improved stoves.
15. Training of local artisans in the design and construction of the new stoves.
16. Provision of non-local supplies including:
    - Fire Grate
    - Chimney and Rain Cap
    - Air Control Flap
    - Ceramic Firebox Blocks
    - Ash Trap Form
17. Project Implementation Oversight
18. Testing and Monitoring of Stove Performance

This project satisfies the eligibility criteria of the Clean Development Mechanism of the Kyoto agreement by virtue of satisfying the three major eligibility criteria:

19. Contribution to Sustainable Development
20. Environmental Additionality
21. Financial Additionality

We discuss in general terms how the project satisfies these criteria as follows.

Contribution to Sustainable Development

The project contributes to Eritrea's efforts at sustainable development by improving the standard of living of rural Eritrean households, improving health, improving the environment, and enhancing social equity. In summary, the benefits of the improved stoves are as follows:

22. Improved stove use will decrease deforestation pressures, and aid environmental restoration through decreased biomass harvesting;
23. The standard of living will increase at the household level due to decreased energy expenses and improved health;
24. Wood or dung collection labour will now be reduced by 50% or more;
25. Due to decrease in wood collection duties, students will be able to spend more time studying;
26. Cooking time is reduced, and so is cooking labour;
27. Household cash expenditures are reduced from reduced wood, dung and kerosene purchases;
28. The health of people in the household will improve due to nearly eliminating the inhalation of smoke, respirable particulates, and other toxic emissions during cooking;
29. There is also a social benefit, as cooks will no longer have clothes that smell of smoke, and the household interior will be cleaner due to reduced soot;

30. Social equity is improved as the project benefits the poorest sectors of Eritrean society the most.

Environmental Additionality

In the absence of an improved stove program, there would be a continuing depletion of Eritrean biomass stocks due to continuing unsustainable biomass harvesting for fuelwood.

In the traditional way of cooking, the heat utilization efficiency of biomass stoves is very low averaging around 10% or less for the semi-enclosed stoves common in the highlands and around 5% for the open hearths common in the lowlands. The combination of high demand, aggravated by low use efficiency has contributed to deforestation, rural poverty and the rural energy shortage in Eritrea. The scarcity of biomass supply comes from a combination of factors including a semi-arid climate, the destruction brought by the 30-year war of independence, frequent droughts and the growing land use and population pressures. This means that as biomass energy supplies get shorter, more and more labour and effort is used to obtain them. This has resulted in deforestation pressures, and a diminished standard of living. This is forcing a shift to dung, an energy fuel with low energy content. Finally the dung that was traditionally used for enriching agricultural farm-lands is being burnt for energy instead. These set of circumstances, i. e., deforestation pressures and decreased agricultural productivity, is simply not sustainable in rural Eritrea. In Eritrea, many places are now severely denuded. Forest cover, which may have covered as high as 30% of the land surface in 1880, fell to 20% in 1930 and 5% in 1960; today it stands at 2.3%. About 34 tree species are threatened of extinction (Ministry of Agriculture reports). The total biomass potential in 1995 was estimated at 73-76 million tons (Lahmeyer, 1997). From these resources, the forest take-off for energy was estimated to be 2.4-2.8% in the 1995 national energy survey whereas the critical take- off for sustainability should have been 1.25%.

In contrast to the traditional stove efficiency of 10%, the improved stoves have measured efficiencies of 20-25% or more. This translates directly into reduced fuel wood, agricultural residue, and dung burning at the household level. The unburned fuel wood is left in the environment for longer, and the unburned dung is either left uncollected (to fertilize the ground) or is used to add extra fertilizer to the agricultural fields. This increases the biomass stocks through both increased soil fertility and increased residence time of biomass in the ecosystem.

Financial Additionality

The Dissemination of Improved Stoves Program will enable the rapid increase in efficiency use of energy by rural households in Eritrea by resolving a market imperfection in improved efficiency investments. The revenues from the sale of the Verified Emissions Reductions (VER) make it is possible to finance the non-local cash costs of improved household efficiency which is the main barrier to the purchase of materials and equipment necessary for the improved stove construction. Rural households have extreme shortages of cash resources (due to a shortage of cash labour opportunities in rural areas) but a have ready availability of labour and local materials resources. The financing of cash costs combined with local labour and materials contributions make the conversion to high efficiency stoves economically feasible and highly desirable for rural Eritrean households.

Field tests in Eritrea have shown that in many areas, improved stoves are enthusiastically accepted and desired by rural Eritrean households. Village by village market transformation experiments have attained 100% conversion rates and unanimous acclaim from rural households in areas with fuel shortages (primarily the highland portions of Eritrea but fuel shortages exist throughout the country). The savings obtained with improved stoves, while large, consist of savings in non-cash household expenditures and costs (i.e. firewood and dung collection and preparation time, and women's respiratory health and comfort). Because of the extreme shortage of cash in the rural economy, it is not economically feasible for rural households to finance cash expenditures with non-cash cost savings.

The materials necessary for the improved stoves can be classified into local material and labour, and non- local materials and training. The local labour and materials can be financed with non-cash contributions that are within the economic capacity of rural households to make. The non- local materials expenditures which is estimated to be less than $ USD 15 needs to be financed in ways that give cash credit to rural household for the national and international environmental benefits they are producing. Thus the money obtained from the sale of the VERs finances that portion of improved stove expenses that cannot be financed by rural households on their own. In the absence of the VER revenues, the Government of Eritrea is unable to cover the non-local material costs because of the many urgent development needs being provided by limited government funds. Since the shortage of capital for investment on non-local materials and training is a critical barrier to the market feasibility of the project in the cash-poor rural economy, traditional inefficient stoves will remain dominant unless an alternative form of financing is found to compensate rural households for the contribution that their emissions reductions make to an improved global environment.

Project Boundary

The project boundary defines the physical and conceptual area that is to be monitored with regards to green house gas emissions. For the Eritrea Dissemination of Improved Stoves Program the project boundary consists of the individual villages that participate and their surrounding environs. Each village will be its own monitoring domain. The justification of this particular project boundary is that the vast majority of rural households, biomass fuel for stoves is collected locally, or purchased from local markets. The exception to this are major towns and cities which may import wood fuel from around the country. One could alternatively select a household level project boundary, but by selecting a village-level project boundary, we increase the ease of monitoring since village-level rather than household level data may be collected. This allows the project to measure average village project impacts using statistical sampling of individual household impacts.

b. *A proposed baseline methodology in accordance with the annex on modalities and procedures for a CDM including in the case of the:*

For the Eritrea Dissemination of Improved Stoves Program we use a baseline methodology customized to Eritrean national conditions in order to maximize the accuracy of both the baseline estimates and the greenhouse gas emissions reductions estimates.

i. *Application of an approved methodology:*
[Not Applicable]
   - *- Statement of which approved methodology has been selected.*
     [Not Applicable]
   - *- Description of how the approved methodology will be applied in the context of the projects*
     [Not Applicable]

ii. *Application of a new methodology:*
   - *- Description of the baseline methodology and justification of choice, including an assessment of strengths and weaknesses of the methodology;*
   - *- Description of key parameters, data sources and assumptions used in the baseline estimate, assessment of uncertainties;*
   - *- Projections of baseline emissions;*

Emissions Estimate Methodology

The basic methodology for estimating CO_2 emissions arising from cook-stove use estimates emissions on a per-capita basis. This is because per-capita consumption is likely to be more consistent than per-household consumption due to variations in household size. For the project, emissions are estimated at the village level by multiplying the per-capita emissions by the village population that is participating in the stove improvement program.

There is a substantial amount of uncertainty in the estimation of CO_2 emissions from cook-stove use. Because of this, the project will use two methods for emissions estimates, based on two independent pieces of data that will be collected from village interviews. The first method estimates emissions from the starting point of per-capita food consumption. Then the factors that convert per-capita food consumption to energy, then to biomass, and then to CO_2 emissions. The second method estimates CO_2 emissions from the starting point of biomass fuel consumption. The advantage of the first method is that per-capita food consumption can be measured to greater accuracy than per-capita biomass consumption. The advantage of the second method is that fewer conversion factors are needed in order to estimate CO_2 emissions from the measured data.

Method #1: CO_2 Emissions Estimate from Food Consumption Measurement

The first method for estimating CO_2 emissions is described by the following equation:

$C0_2$/capita/FuelType = FracPerm * FuelFrac * InjC * EInj * 1/Eff * 1/EBio * BLife * 1/WetEff * (1+BGBio) * CCont

where:

- ***FracPerm*** = The fraction of the population that permanently convert to the new mogogo once they have converted their traditional stove to an improved stove.
- ***FuelFrac*** = The fraction of cooking energy obtained from a particular fuel type. The fuel energy is related to the fractional fuel mass by *FuelMass * EBio = FuelEnergy*.
- ***InjC*** = The average injera consumption per year per person in units of kilograms/year.
- ***EInj*** = The energy intensity of injera production with a 100% efficient stove in units of megajoules/kilograms.
- ***Eff*** = The efficiency of the injera stove in dimensionless units.
- ***EBio*** = The energy content of the dry biomass fuel in units of megajoules per kilogram.
- ***BLife*** = The average lifetime of biomass in the ecosystem in years defined in terms of biomass stocks that result from a change in harvest rate. It is the stock of biomass in the ecosystem that results from a unit decrease in the annual harvest rate.
- ***WetEff*** = The efficiency of burning wet biomass compared to burning dry biomass. This quantity is dimensionless.
- ***BGBio*** = The fraction of biomass that is below ground. It is assumed that as above ground wood biomass is removed that a corresponding amount of below ground biomass is indirectly removed from stocks through decay of roots and loss of soil carbon. This quantity is dimensionless.
- ***CCont*** = The CO_2 content of biomass fuel in units of kg CO_2/kg Biomass.

In this equation, the injera consumption per capita, *InjC*, and the fuel fraction, *FuelFrac*, are estimated from surveys in the project area. The energy intensity of injera production, *EInj*, is obtained from laboratory experiments and studies, that estimate energy intensity as a function of the final injera thickness or density. The Eritrean Department of Energy may use an average injera energy intensity, if this is not seen to vary substantially between households and villages.

The efficiency of the cook-stove is a function of cook-stove type and features. With regards to firebox construction there are four types of cook-stoves:

11. A traditional unimproved mogogo
12. An improved mogogo made with stones and sand
13. An improved mogogo made with ceramic blocks and sand
14. An improved mogogo made with ceramic blocks, and ash insulation

In addition, improved stoves may include only the mogogo, or they may include an integrated design of three stoves that includes a mogogo (for cooking *taita* or *injera*), a moqolo (for cooking *qiCa*), and a smaller in-build stove for cooking sauces.

Other features of the stoves may include whether or not the stove has a chimney (almost all improved stoves do), and whether the chimney has a control valve.

The efficiency of the different types of stoves (Eff) are performed using a combination of laboratory and field tests. Average values of efficiency are used that correspond to an average length of cooking session that produces between 15 to 20 injera.

The variables *EBio*, *WetEff*, *BGBio*, and *CCont* are derived from references in the international literature, as is the value of *BLife* for wood. An estimate of the value of *EBio* for dung is provided in an appendix of this report.

The total CO_2 emissions are estimated as the sum of the per-capita CO_2 emissions for each fuel type times the population.

Table 1: Emissions Estimation Parameters for Method #1

Parameter	**Low**	**Medium**	**High**	**Selected**	**Source**
FracPerm	80%	90%	100%	90%	Estimated
FuelFrac Dung Wood	 100% 0%	 60% 40%	 0% 100%	 60% 40%	2001 Study
InjC	70 kg/year	130 kg/year	180 kg/year	130 kg/year	2001 Study
EInj	0.8 MJ/kg	1.4 MJ/kg	2.0 MJ/kg	1.4 MJ/kg	1996 Study
Eff Old Field Old Lab New A	 	 7% 10% 18%		 10% Base 	 Field Measurement 1998 Study

New B New C		23% 26%		20% Project	1998 Measurement Estimated 2000 Measurement
EBio Dung Wood		12.0 MJ/kg 16.6 MJ/kg		12.0 MJ/kg 16.6 MJ/kg	IPCC 1996 IPCC 1996
BLife Dung Wood	5.0 years	1.0 years 9.4 years	13.7 years	1.0 years 9.4 years	Estimated IPCC 1996
WetEff	70%	90%	100%	100%	Estmated
BGBio	0.23	0.47	0.85	0.47	IPCC 1996
CCont	1.6	1.8	2.1	1.8	IPCC 1996[2]

[2]Page 5.31 of *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*. Carbon content of biomass is stated as 0.43 - 0.58 kg C/kg Biomass while CO_2 equivalent of carbon is 3.67 kg CO_2/kg C

Method #2: CO_2 Emissions Estimate from Biomass Consumption Measurement

The second method for estimating CO_2 emissions is described by the following equation:

$$C0_2/capita/FuelType = FracPerm * Biomass * (1-WCont) * BLife * (1+BGBio) * CCont$$

where:

- ***FracPerm*** = The fraction of the population that permanently convert to the new mogogo once they have converted their traditional stove to an improved stove.
- ***Biomass*** = The annual biomass consumption of a particular fuel type per capita measured by village survey in kilograms per year.
- ***WCont*** = The fractional water content of biomass fuel. This quantity is dimensionless.
- ***BLife*** = The average lifetime of biomass in the ecosystem in years defined in terms of biomass stocks that result in a change in harvest rate. It is the stock of biomass in the ecosystem that results from a unit decrease in the annual harvest rate.

- ***BGBio*** = The fraction of biomass that is below ground. It is assumed that as above ground wood biomass is removed that a corresponding amount of below ground biomass is indirectly removed from stocks through decay of roots and loss of soil carbon. This quantity is dimensionless.
- ***CCont*** = The CO_2 content of biomass fuel in units of kg CO_2/kg Biomass.

In this equation, the biomass consumption per capita, *Biomass*, for a particular fuel type are estimated from surveys in the project area. Ideally such surveys would be conducted both before and after the improved stove project is implemented. If this is not possible then the biomass consumption for one case will be estimated from the biomass consumption from the other case with the following formula:

$$Biomass_1 = Biomass_2 * Eff_2/Eff_1$$

The efficiency of the cook-stove is a function of cook-stove type and stove features as described above in the first emissions estimation method.

The variables *WCont*, *BGBio*, and *CCont* are derived from references in the international literature, as is the value of *BLife* for wood. An estimate of the value of *BLife* for dung is provided in an appendix of this report.

The total CO_2 emissions are estimated as the sum of the per-capita CO_2 emissions for each fuel type times the population.

Table 2: Emissions Estimation Parameters for Method #2

Parameter	Low	Medium	High	Selected	Source
FracPerm	80%	90%	100%	90%	Estimated
Biomass Dung Wood		To Be Measured			
WCont	20%	10%	0%	15%	Estimated
BLife Dung Wood	5.0 years	1.0 years 9.4 years	13.7 years	1.0 years 9.4 years	Estimated IPCC 1996
BGBio	0.23	0.47	0.85	0.47	IPCC 1996
CCont	1.6	1.8	2.1	1.8	IPCC 1996

Preliminary Estimate of Baseline Emissions

A preliminary estimate of baseline emissions is provided here using data from the above tables and data received from a recent project test survey Adi Nefas. The first estimate is obtained using the first method based on per-capita injera consumption:

*$C0_2$/capita/Dung = 90% * 60% * 130 kg Inj/year/cap * 1.4 MJ/kg Ing * 1/10% * 1/(12.0 MJ/kg Biomass) * 1 year * 1/100% * (1+0.47) * 1.8 kg CO_2/kg Biomass*
= 217 kg CO_2/capita/Dung

*$C0_2$/capita/Wood = 90% * 40% * 130 kg Inj/year/cap * 1.4 MJ/kg Ing * 1/10% * 1/(16.6 MJ/kg Biomass) * 9.4 years * 1/100% * (1+0.47) * 1.8 kg CO_2/kg Biomass*
= 982 kg CO_2/capita/Wood

This calculation yeilds a baseline estimate of per-capita CO_2 emissions from injera cooking as 1199 kg/capita.

Using the second method which is based on surveys of fuel use, we obtain the following estimate of per-capita CO_2 emissions:

*$C0_2$/capita/Dung = 90% * 132 kg Dung/year/cap * (1-15%) 1 year * 1/100% * (1+0.47) * 1.8 kg CO_2/kg Biomass*
= 267 kg CO_2/capita/Dung

*$C0_2$/capita/Wood = 90% * 58 kg Wood/year/cap * (1-15%) 9.4 years * 1/100% * (1+0.47) * 1.8 kg CO_2/kg Biomass*
= 1103 kg CO_2/capita/Wood

This calculation using the second method yeilds a baseline estimate of per-capita CO_2 emissions from injera cooking as 1370 kg/capita.

The two methods yield quite similar results with the second method providing a slightly higher estimate than the first. This could be due to a variety of reasons. The first method has more factors in it. Each factor may have some error in its estimation and if each is estimated slight conservatively (i.e. biased towards a low emissions estimate) then there may be a cumulative underestimate of baseline emissions. The conservative bias of each factor can accumulate to produce a lower estimate of emissions reductions compared to a method with fewer multiplicative factors.

- *- Description of how the baseline methodology addresses potential leakage;*

Leakage is a measureable change in emissions that is caused by the project but which is outside of the project boundary or time frame. Leakage can be positive (leading to decreased emissions elswhere) or negative (leading to increased emissions elsewhere). There are several potential sources of leakage for the stove project including:

0. Reversion to the use of unimproved stoves after some time.
1. Rebound effects where people use more energy because the energy use is more efficient and cheaper.
2. Spillover effects where other households outside the project area adopt improved stoves.
3. Reduced emissions due to increased soil fertility from greater dung fertilizer availabilitiy.

The baseline methodology is conservative in that it does not include estimates of positive leakage when this is difficult to measure. To account for reversion to old stoves a factor is included in the emissions estimation equation which is the proportion of improved stove conversions that are considered permanent. Given the high satisfaction level with the new stoves, the 90% permanent conversion is considered reasonable.

As for leakage due to rebound effects, the method of direct measurement of biomass consumption should be able to measure such rebound if it is large. Though long-term rebound effects would be difficult to measure.

iii. *Other considerations such as a description of how national and/or sectoral policies and circumstances have been taken into account and an explanation of how the baseline was established in a transparent and conservative manner;*

In many countries, charcoal is a very important biomass fuel. In Eritrea commercial charcoal production is prohibited. Therefore it is assumed that emissions are due to the use of non-charcoal biomass fuels, which results in lower emissions estimates than if significant charcoal use is assumed.

c. *Statement of the estimated operational lifetime of the project and which crediting period was selected;*

The operational lifetime of the project is 20 years, while the crediting period is a single period of 10 years from 2003 to 2013. Consistent with project experience to date, it is assumed that more than 90% of the households that convert to the improved stoves never convert back to the unimproved stoves.

d. *Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occured in the absence of the registered CDM project activity.*

The anthropogenic emissions reduction occurs because the higher efficiency biomass stove results in decreased biomass fuel burning and harvesting. The decreased harvesting of biomass results in this biomass being retained in the ecosystem and results in increased biomass stocks. The estimated change in biomass stocks is as described in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual* section 5.1.2: "the flux of C02 to or from the atmosphere is assumed to be equal to the changes in carbon stocks in existing biomass and soil." For dung and agricultural residues, the changes in biomass stocks are estimated from estimates of decay rates and the average residence time of such biomass in the ecosystem is assumed to be one year. For wood fuel, the change in biomass stocks due to decreased biomass harvesting is estimated from the ratio of stocks to regeneration rates for African dry forests provided in the Revised 1996 IPCC Guidelines as 9.4 years.

e. *Environmental impacts:*

   . *Documentation on the analysis of environmental impacts including transboundary impacts.*

   i. *If impacts are considered significant by the project participants or the host Party; conclusions and all references to support documentation of an environmental impact assessment that has been undertaken in accordance with procedures as required by the host Party;*

   Currently virtually all environmental impacts from the project are estimated to be beneficial including:

   1. Improvements in indoor air quality due to improved combustion and the removal of smoke from the household interior via a chimney. This is expected to reduce acute respiratory infections.
   2. Improvements in outdoor air quality due to improved combustion efficiency and decreased production of incomplete combustion products.
   3. Enhanced environmental rehabilitation due to decreased biomass harvesting.
   4. Increase soil and agricultural productivity due to decreased dung burning and increased soil fertilization.

f. *Information on sources of public funding for the project activity from Parties included in Annex I which shall provide an affirmation that such funding does not result in diversion of official development assistance and is separate from and is not counted towards the financial obligations of those Parties.*

   No development assistance funding from Annex I parties is used for project implementation.

g. *Stakeholder comments, including a brief description of the process, a summary of the comments received, and a report on how due account was taken of any comments received;*

The primary stakeholders for the project are the households that convert to the improved stoves, the artisans that build both the old and improved stoves, and the local governments of the villages that engage in the improved stove program. Comments on the improved stove program are solicited during interviews that are undertaken during the course of monitoring surveys. The comments received to recently on the improved stoves and the improved stove program include:

0. A major advantage of the improved stove is the elimination of smoke from the household.
1. Another major advantage of the stove is that it is very economic.
2. When one cooks with the new stove, one can still wear nice clothes without getting them dirty or smokey.
3. Sometimes the ceramic firegrate of the improved stove breaks
4. The improved stove cooks injera even better than an electric stove.

h. *Monitoring Plan:*

. *Identification of data needs and data quality with regard to accuracy, comparability, completeness and validity;*

Monitoring of the impacts of the improved stove program requires the collection of data regarding the number of stoves installed, the number of people using such stoves, the type of stove installed, and the fuel consumption for both the improved stoves and unimproved stoves. The necessary data on per-capital energy will be collected through village interviews and through stove efficiency tests. Meanwhile information on the number of stoves, and the population served by improved stoves will be gathered from village visits and interviews village and local government administrators and confirmatory questioning of individual households. An accounting of the project villages and the number of installed stoves per village will be maintained by the Energy Research and Training Center.

i. *Methodologies to be used for data collection and monitoring including quality assurance and quality control provisions for monitoring, collecting, and reporting;*

The primary monitoring data is obtained through village interviews of households with both improved and unimproved mogogos. The collected data undergoes quality control checks, and all orginal interview forms are filed and archived in the Energy Research and Training Center in Asmara, Eritrea. An English version of the village interview form is provided in appendix B.

ii. *In the case of a new monitoring methodology, provide a description of the methodology, including an assessment of strengths and weaknesses of the methodology and whether or not it has been applied successfully elsewhere;*

The description of the monitoring methodology is provided above.

i. *Calculations*

. *Description of formulae used to calculate and estimate anthropogenic emissions by sources of greenhouse gasses of the CDM project activity within the project boundary.*

The methodology for estimating emissions from the project activity is the same as for the baseline case. Differences between project and baseline emissions arise from differences in measured stove efficiencies and differences in measured fuel consumption.

i. *Description of formulae used to calculate and to project leakage, defined as: the net change of anthropogenic emissions by sources of greenhouse gasses which occurs outside the CDM project activity boundary, and that is measureable and attributable to the CDM project activity.*

Negative leakage due to reversion to unimproved stoves at a later date is factored in by the *FracPerm* parameter.

Positive leakage from the project is not counted in the emissions estimates.

ii. *The sum of i and ii above repesenting the CDM project activity emissions.*

See section on baseline emissions estimate.

iii. *Description of formulae used to calculate and to project the anthropogenic emissions by sources of greenhouse gases of the baseline.*

See section on baseline emissions estimate.

iv. *Description of formulae used to calculate and to project leakage;*

See section on baseline emissions estimate.

v. *The sum of iv and v above representing baseline emissions;*

See section on baseline emissions estimate.

vi. *Difference between vi and iii above representing the emission reductions of the CDM project activity;*

The emissions reduction from the project activity is as follows:

$CO_2/baseline = Population * (CO_2/capita/dung + CO_2/capita/wood)$

$CO_2/project = Population * (CO_2/capita/dung + CO_2/capita/wood)$

EmissionsReduction = CO_2/baseline - CO_2/project

To provide a preliminary estimate the emissions reduction per stove we use the average size of the population using each stove (assumed to be 5 persons because the average size of an Eritrean household is 5). In addition we can assume (consistent with measurements to date) that the efficiency of the unimproved stove is 10%, while the efficiency of the improved stove is 20%. The yields the following estimates of emissions reductions per stove:

- **Method #1:** EmissionsReduction = 5 persons * (1199 kg/person - 600 kg/person) = 3.0 tonnes/stove
- **Method #2:** EmissionsReduction = 5 persons * (1370 kg/person - 685 kg/person) = 3.4 tonnes/stove

The preliminary estimate is therefore approximately 3 tonnes CO_2/stove which will be calculated more precisely during project monitoring and verification.

j. *References to support the above if any.*

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Appendix A: Estimation of *BLife* Parameter

Estimation of *BLife* Parameter for Wood

A key parameter in the estimate of CO_2 emissions impacts from reduced biomass fuel consumption is BLife, the ratio of the annual consumption rate to the biomass stocks. The unit of this parameter is years. In this appendix, we estimate this parameter using data from Volume 3 of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: the Greenhouse Gas Inventory Reference Manual.

In section 5 of the Greenhouse Gas Inventory Reference Manual on Land-Use Change & Forestry, estimates of annual average aboveground biomass update by natural regeneration are provided in table 5-2. We select for Eritrea, the dry forest regeneration rate for Africa for the first 20 years of regeneration as the figure that is most relevant to Eritrea biomass harvesting. The dry-forest regeneration rate is 4.0 tonnes/ha.

In table 5-4, total aboveground biomass is provided for different forest types for different African countries. We select as most relevant to Eritrea, the dry forest type which is estimated to have average aboveground biomass of 20-55 tonnes/ha. We select the median value of 37.5 tonnes/ha for Eritrea. This provides an estimate for BLife of 37.5/4.0 = 9.4 years.

Appendix B: Carbon Credit Verification Data Collection, Village Interview Form:

How many people reside in the household that uses the mogogo?

____Adult Males ____Adule Females ____Children under 16

How many taita and qiCa are cooked per cooking session and how often are the cooking sessions?

_____taita ____qiCa every ____ days (or ____ times per week)

How often is qiCa cooked without taita and how often are these cooking sessions?

____qiCa every ____ days (or ____ times per week)

What is the weight and diameter of the taita that are cooked? (Here the interviewer asks for a sample of taita, measures the diameter [perhaps from the plate] and weighs a group of taita)

Diameter = ___cm and ____taita weigh ____ kilograms

Does the household have an improved mogogo? And when was it obtained?

Improved mogogo? ___ Yes ___No   Date built: _____

What type of improved mogogo does the household have?

Type of Walls: ___ Rock and Sand
___ Ceramic Block and Sand
___ Ceramic Block and Ash

Chimney: ___ Yes ___ No Control Flap: ___ Yes ___ No

Improved moqolo: ___ Yes ____ No

How much fuel is used in a cooking session? (Here the interviewer asks for a sample of the fuel used in one session and weighs it by fuel type)

Unimproved Mogogo:

___ kg Dung   ___ kg Residue   ___ kg Sticks   ___ kg Wood

(Note: sticks are pieces of wood with a diameter less than
2 centimeters, and wood is any wood with a diameter less than this)

Improved Mogogo

___ kg Dung   ___ kg Residue   ___ kg Sticks   ___ kg Wood

End of interview.