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Greenhouse gas Emission Produced By Diesel Multifunctional Platforms of The Program Pn_ptfm / Lcp 2000-2014 in Burkina Faso

Environmental Science

KEYWORDS : Multifunctional Platform (MPF) - Greenhouse gas (GHG).

Deli Goron	Environmental Energy Technologies Laboratory (EETL)/ Faculty of Sciences/ University of Yaounde 1/ P.O. Box 812 Yaounde/ Cameroon
Donatien Njomo	Environmental Energy Technologies Laboratory (EETL)/ Faculty of Sciences/ University of Yaounde 1/ P.O. Box 812 Yaounde/ Cameroon
Zacharie Koalaga	Laboratory of Materials and Environment (LAME)/ Faculty of Sciences/ University of Ouagadougou/P.O. Box 7021 Ouagadougou/ Burkina-Faso

ABSTRACT

In order to improve the living conditions of rural African populations, the concept of multifunctional platform was initiated by the United Nations Development Program. The success of these multifunctional platforms in West Africa is proof that the concept is an effective solution to the problems of poverty and access to modern energy faced by people, particularly the women, in sub-Saharan rural areas. However, although the platforms are an appropriate solution to ease the painful labour of the village women as part of an integrated social and economic approach, they use heat engines pollution source. These heat engines are the cause of many problems such as: the damage to human health, global warming and environmental pollution. In this paper, Burkina Faso's National Fleet multifunctional platforms and the assessment of the amount of greenhouse gases it emits at its various stages of evolution that bleed from 2000 to 2012, is being presented.

1. INTRODUCTION

The awareness of the fact that, the working day of the African rural women is extremely difficult and her time schedule does not permit her to take care of: herself, her children and some income generating activities. We sadly notice that lack of time is an important but unrecognized cause of poverty. Poverty which particularly affects women and children, explains their greater vulnerability due to the load which are allocated to them compared to that of men. It is in this context that UNDP, in its objectives in the fight against poverty, shared to some African countries, particularly in West Africa, the diesel multifunctional devices commonly known as multifunctional platforms (MFP).

A multifunctional platform is a source of mechanical and electrical energy supplied by a diesel engine 8 to 12 horse power mounted on a platform to which many different devices can be connected, such as: grinding mills, battery chargers, electric water pumps, oil or vegetables presser, welding machines, carpentry tools, and even micro-grids for lighting (Brew-Hammond et al, 2004). It is mainly intended to relieve the hard work of the women which can then dedicate themselves to generative activities of income which allow them to have a more independent status and a greater social and economic responsibility.

However, if MFP has a positive impact on social and economic aspects, they nevertheless have a negative impact on the environment. In fact, MPF uses pollution sources heat engines. These heat engines are the cause of many phenomena such as: the damage to human health, global warming and environmental pollution. On the other hand, the stationary combustion of these engines is responsible for about 70% of greenhouse gas (GHG) emissions from the energy sector (Gomez et al, 2006). Knowing that in the year 2002, CO2 emissions from Burkina Faso was estimated at 1090000 tCO2Eq [W1], thus representing less than 1% of global emissions [W1], the objective of this paper is to evaluate the amount of GHG emitted by the Burkina Faso's national Fleet MFP from the 1st June 2000 to 31st December. Specifically, it will be to assess the quantity of GHG emissions by the MFP per day, week, month, and in the various major phases I and II (in progress) of the program. Due to the fact that in the combustion process, most of the carbon is immediately released as CO2 (Gomez et al, 2006), we will try to assess the impact of the latter on the warming of our planet. It should be noted that part of this carbon is released as carbon monoxide (CO), methane (CH4) and made of non-metallic volatile organic compounds (NMVOCs).

2. METHOD

Generally, the emissions for each greenhouse gas resulting from stationary sources are calculated by multiplying the fuel consumption by the corresponding emission factor (Gomez et al, 2006). Fuel consumption is estimated on the basis of statistics and documentation on the use of energy. Data on fuel consumption in units of volume or mass must be converted based on the energy content of the fuels. As for the shape factor (SF) it is a value, specific to Burkina Faso. This value is obtained based on a well-documented data.

Description of MFP

A platform is said to be multifunctional, if it is made of a heat engine capable of operating at least two modules simultaneously.

sA Multifunctional Platform enables the provision of mechanical and electrical energy in a decentralized way; it is designed with readily available material and spare parts. In the philosophy of the national program of MFP, a platform enables to provide energy services for productive, social, individual and collective uses. Energy services can save both human energy and time, and raise the possibility of income generation, poverty reduction and human development (Blin et al, 2008). The basic modules of a multifunctional platform are: an engine of 8, 10 or 12 hp, a frame or pedestal on which are placed the various equipment, rails for motion and to adjust the good functioning of the apparatus; a grain mill, multi-grain mill, a cooling and exhaust system, a generator that is used to generate electricity and a shed with tin roof to shed the aforementioned devices.

To these basic modules can be add optional modules such as: oil pressers, a welding machine, a saw machine, a battery charger,

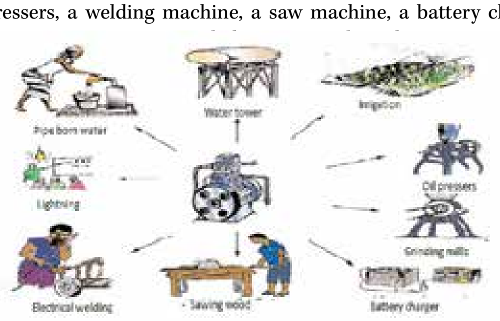

Figure 1 : Data sheet of a multiplatform.

Pattern of organizational boundaries: Presentation of the National Fleet MFP of Burkina Faso

Burkina Faso is a West African country located between parallels of 9° and 15° North of the Latitude and 3 ° East of the longitude and 6 ° West of the longitude [W2]. The country has Sudano-Sahelian type of tropical climate with two (02) unequal seasons: a rainy season for three (03) to four (04) months and a long dry season of eight (08) to nine months [W3]. The history of MPF in Burkina Faso can be divided into three (03) phases:

- The pilot phase which covered the period from June 2000 to November 2004. This pilot initiative introduced and tested platforms as a source of decentralized energy services in five (05) villages in the Eastern Region;

- Phase I ranged from December 2004 to 2008. This program became national execution is intended to analyze the effects and impacts of access to MFP on beneficiary communities. This phase covered 9 of the 13 regions in Burkina Faso with 400 MFP installed.

- Phase II ranging from 2008 and will end in 2015. The overall objective of the program is to consolidate and expand access to basic energy services decentralized and affordable provided by the MFP (MEF, 2009). The establishment of a national fleet (covering 13 regions of Burkina) of at least 1700 functional units by the end of the program, is therefore envisaged (MEF1, 2009) (see Table 1).

Tableau 1 : Evaluation of Burkina Faso's MFP national Fleet

Program Phases	Pilot Phase 2000/2004	Phase 1 2004/2008	Phase 2 2010/2015
MFP installed within the phase	5	395	1300
Total (Cumulative)	5	400	1700

Operational scope

The operations that generate emissions within an organizational scope are of two (02) categories (Scopes):

- Direct emissions from stationary and mobile sources necessary for the activities of the moral person (scope 1);

- Indirect emissions associated with electricity consumption, heat or steam necessary for the activities of the moral person (scope 2);

A third category of emission is distinguished, namely other emissions produced indirectly by the activities of the moral person (Scope 3) (Michaud et al, 2013); (MEDDTL, 2012).

The operational scope used for this study is that of direct emissions from stationary combustion sources.

Diesel engine and origin of pollutants of a diesel MFP

The diesel engine is a heat engine in which heat energy is converted into mechanical energy (Sidibé, 2011). It operates on the four-stroke cycle comprising the following phases: intake, compression, combustion, expansion and exhaust.

The motor is an Indian type of 8 to 12 hp. The 10 hp is generally used in Burkina Faso (Blin et al, 2008).

The exhaust gases are the main source of pollution. They are due to the combustion reaction of fuel (diesel) with air (assuming that air is composed of 21% oxygen and 79% nitrogen), the initial and final states of equilibrium are described by the following reaction:

$$C_xH_y+\left(x+\frac{y}{4}\right)O_2+\frac{79}{21}\left(x+\frac{y}{4}\right)N_2\rightarrow xCO_2+\frac{y}{2}H_2O+\frac{79}{21}\left(x+\frac{y}{4}\right)N_2 \quad (1)$$

The combustion equation not assumed complete (Giansetti, 2005) can also be written:

$$C_xH_y+\upsilon_{air}(O_2+3,77N_2)\rightarrow \upsilon_{CO_2}CO_2+\upsilon_{CO}CO+ \upsilon_{CH_4}CH_4+\upsilon_{H_2O}H_2O+\upsilon_{NO_2}NO_2+\upsilon_{O_2}O_2 \quad (2)$$

With υ_i the stoichiometric coefficient of the *i* component.

In fact, in contact with air, the fuel burns and the energy released by combustion starts up the engine which in turn takes care of the functioning of the various devices which are grafted to it by means of a belt. The products of the reaction are expelled in the form of gas through the exhaust pipe. Thus, the combustion of diesel fuel in engines generates two types of gas emissions: greenhouse gas emissions and harmful gases:

- The harmful gases

These gases have an impact on health. In diesel exhaust exit, they contain fine particles (FP); nitrogen oxides (NOx) and unburned hydrocarbons (C_xH_y); carbon monoxide (CO); sulfur dioxide (SO2). In exhaust gases we also find products that are not generally regulated but are subject to special attention because of their toxicity or environmental impact. These products are aldehydes, Polycyclic Aromatic Hydrocarbons (PAHs) and specific hydrocarbons such as benzene, 1,3-diene (Sidibé, 2011).

- Greenhouse gas emissions (GHG)

Greenhouse gas emissions are gaseous constituents of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at wavelengths of the data of infrared radiation spectrum emitted from the surface of the Earth, the atmosphere and clouds. It is this property which is responsible for the greenhouse effect.

These gases have an impact on the environment. They are composed of carbon dioxide (CO^2) those emissions is a natural consequence of good combustion: it is the main gas emitted during the combustion of hydrocarbons: methane (CH^4); nitrous oxide (N_2O); ozone (O_3).

Evaluation of GHGs

The fuel consumption of MFP varies with respect to the equipment that is linked to the engine at a given operating time. The technical data of the PN-MFP / LCP program of Burkina Faso gives a consumption of 1.5 to 2 liters per hour (Blin, 2008). On average, a standard MFP consumes 7 liters of diesel per day. Also, the running time is an average of 5 hours per day as adopted by the UNDP (Blin et al, 2008).

The mass consumption rate *Cm* (g / hr) of diesel is given by the following equation:

$$C_m(g/h)=C_v(l/h).d(g/l) \quad (3)$$

Where *Cv (l/h)* is the volume consump tion rate and *d(g/l)* the density of the fuel. The specific consumption rate Cs is the weight in grams of fuel consumed per hour (1 hour) for one kilowatt (1kW) of effective power:

$$C_s(g/kWh)=\frac{C_v(l/h).d(g/l)}{P_e(kW)}=\frac{C_m(g/h)}{P_e(kW)} \quad (4)$$

The heat energy released during the combustion is given by the relation

$$Q_{comb}(kWh)=m_f(m^3).PCI(kWh/m^3) \quad (5)$$

Where *mf* is the amount of fuel inject ed and PCI is the calorific value of the fuel. The amount of GHG emitted is given by the following equation:

$$GHG(tCO_2Eq) = \begin{bmatrix} Activity \\ quantity \end{bmatrix} \times \begin{bmatrix} Emission\ factor \\ (tCO_2Eq\,/\,quantity) \end{bmatrix} \quad (6)$$

According to the assessment carbon report of 2IE (International Engineering Institute for Water and Environment), the emission factor of the combustion of clean diesel in Burkina Faso is EF = 2.77 tCO2Eq / m3 (Thionbiano et al, 2011). This factor takes into consideration the emissions from transportion of imported fuel, since the Burkina Faso imports fossil fuels.

Simulation

The physical properties of diesel fuel are shown in Table 2:

Table 2: Physical properties of diesel

Fuel	Density à 15° (g/l)	PCI (kWh/m3)	FE (tCO2Eq/m3)
Diesel	844	1,07	2,77

The engine used is the Indian type whose specifications are given in Table 3:

Table 3: Specifications of the engine used

Type of Equipment	Indian Engine
Model	LISTER
Manufacturer	Rhino
Power (HP)	10
Rotation speed (tr/min)	1000
Cooling agent	Eau
Fuel	Gasoil
Fuel consumption (l / h) at 80% load	1,5

From the model proposed above, the principle of measuring GHG emissions is described by the following steps:

- Delineation of the organizational perimeter;
- Choice of operational perimeter;
- Evaluation of the frequency of use of a MFP;
- Evaluation of fuel consumption;
- Assessment of greenhouse gas emissions a MFP;
- Assessment of GHG emissions from the National Fleet of MFP in its various phases.

3. RESULTS

As of December 31, 2012 and based on the Burkina Faso's database on the PN_MFP / LCP program, the number of MFP installed are 1,073 [W4]. Figure 2 shows the number of MFP installed during each year and total number of MFP established in this period.

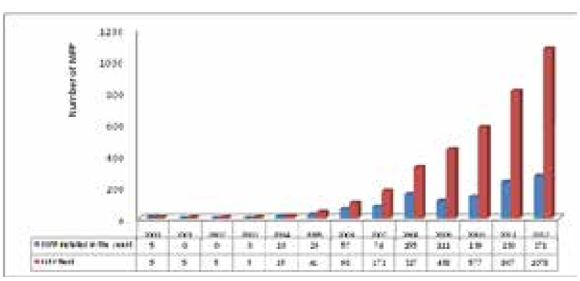

Figure 2: Evolution of implantation of MFP in Burkina Faso.

In Figure 2, the evolution of installed MFP in each year can be divided into three parts:

- A decreasing part that goes from the year 2000 to November 2004 with 05 MFP installed in the years 2000 2001,2002 and 2003, no installations were recorded: This is the pilot phase of the MFP national program.

- Another part that goes from December 2004 to 2008 was characterized by a growing trend of implementations MFP in an order of 10, 26, 57, 74 and 155 for the years of 2004, 2005, 2006, 2007 and 2008 respectively. This is Phase I of MFP national program;

- Finally, a part that goes from 2009 to 2012 characterized by an increased number MFP installation in the following order: 111, 139, 230 and 271: This is Phase II of the MFP national program, in progress.

As for the total number of MFP installed on the Burkinabe national territory, it had an increasing rate each year. Therefore, at the end of the pilot phase there were 5 MFP while in December 31, 2008 which marks the end of Phase I, there were 327 MFP installed. In December 31, 2012 (ongoing Phase II), the MFP National Fleet amounted to 1073.

Knowing that the MFP are typically installed at the beginning, end or middle of the year, to assess the operating time of these MFP, we will consider all the MFP were installed in the middle of each year (1st June). Thus, the number of days of operation of the pilot Phase, phase I and phase II are respectively 1643, 1492 and 1461.

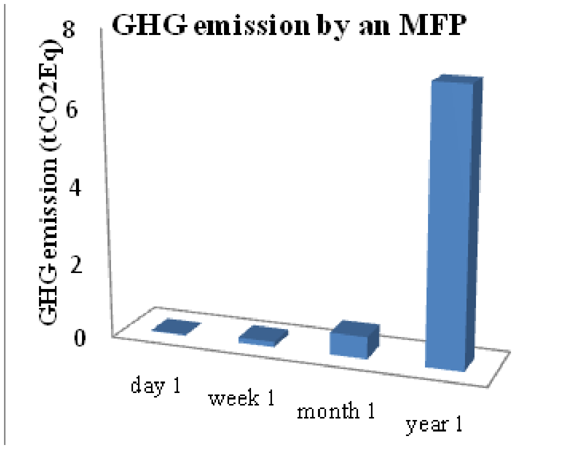

Figure 3: Estimation of GHG emissions from a diesel MFP in different temporal sequences

In Burkina Faso, a diesel MFP working at an average of 5 hours per day with a daily consumption of 7 liters, emits 0.01939 tCO2Eq of GHGs daily. For a Week, it emits 0.13573 tCO2Eq; thus, emits 0.5817 t CO2Eq of GHG monthly. The annual report shows that the quantity of GHGs emitted by a MFP is in the range of 7.07735 tCO2Eq (see Figure 3).

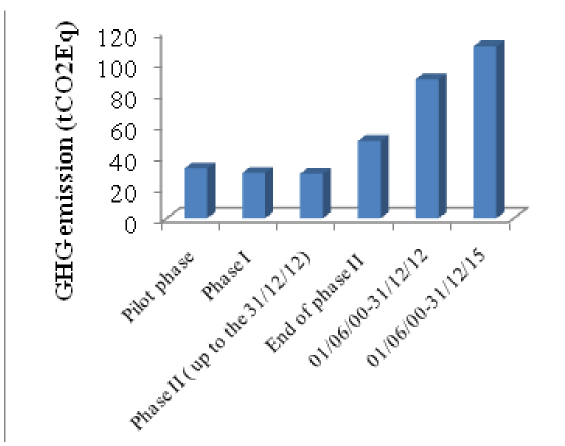

Figure 4: GHG emissions from a MFP in different phases of the program platform Burkina Faso.

During the pilot phase, the estimation of GHG emissions from a diesel MFP is approximately 31.85777 tCO2Eq. As for Phase 1 of the program, the MFP issued approximately 28.92988 tCO2Eq of GHG. A MFP operating in the period of ongoing Phase II (until 31 December 2012) would have approximately emitted 28.32879 tCO2Eq. Similarly, a MFP which will operate for the entire phase 2 (2008/2015) will emit 49.56084 tCO2Eq of GHG. Finally, MFP installed during the pilot phase and having functioned until December 2012 would emit a quantity of GHG of about 89.11644 tCO2Eq. In the same conditions, this MFP will emit 110.34849 tCO2Eq at the end of Phase II (see Figure 4).

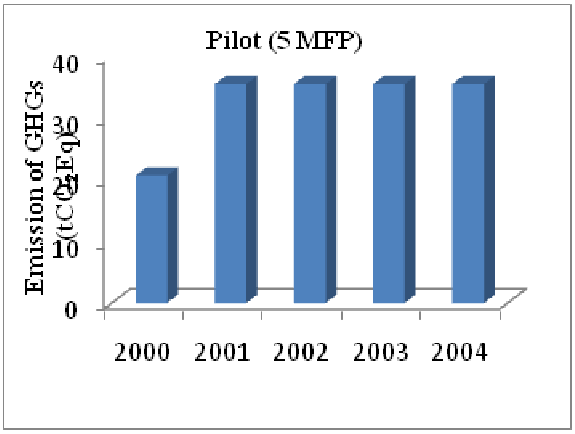

Figure 5: GHG emissions from the Burkina Faso's MFP National Fleet of during the pilot phase.

The number of MFP National Fleet being totaled at five (05) (MEF, 2009) and assuming that 05 MFP have been running fromthe 1st June 2000 to 30th November 2004 for this pilot phase, GHG emissions are averagely estimated at 35.4837 tCO2Eq per year for the years 2001, 2002, 2003 and 2004, while in the year 2000 they are estimated at 20.65035 tCO2Eq (see Figure 5).

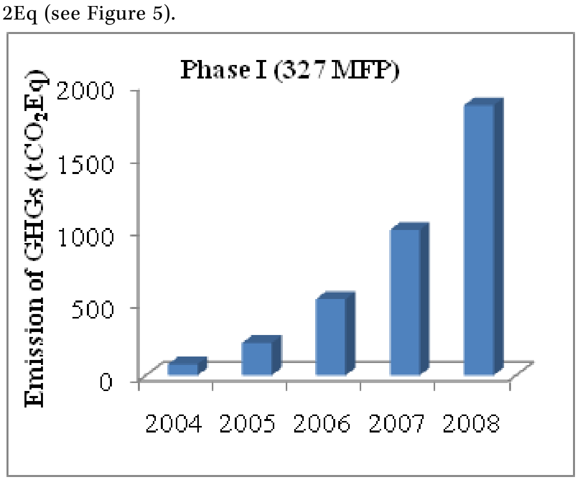

Figure 6: GHG emissions from the National Fleet MFP of Burkina Faso in Phase 1 to December 31, 2008

Phase 1 of the platform program in Burkina Faso whose duration was for four (04) years (during the period of 1st December 2004 to the 31st December 2008 is considered in our calculations), saw the installation of 322 MFP going to 327 the cumulative number of MFP (W4). GHGs emissions are increasing as the years increase. Thus, the GHG emissions in the years 2004, 2005, 2006, 2007 and 2008 are respectively 76.68745; 222.90744; 525.58534; 1001.1057; 1857.46505 tCO2Eq (see Figure 6).

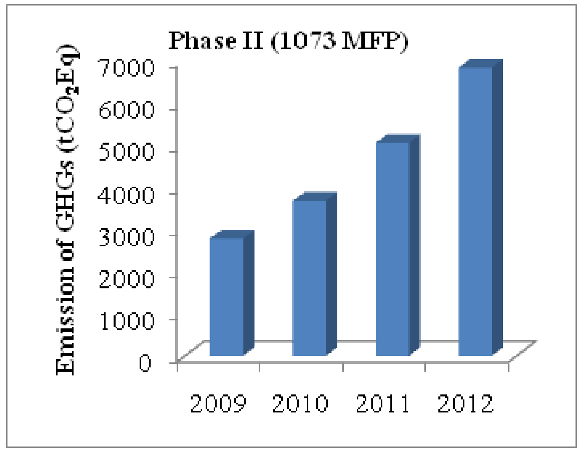

Figure 7: GHG emissions from the MFP National Fleet of Burkina Faso during phase 2.

For a fleet of 1073 MFP installed in Burkina Faso (W4) as part of Phase 2 of the PN-MFP / LCP program as of December 31, 2012, the GHG emissions for the years 2009, 2010, 2011 and 2012 are respectively around 2779.07; 3673.95; 5044.73 and 6830.67 tCO2Eq (see Figure 7).

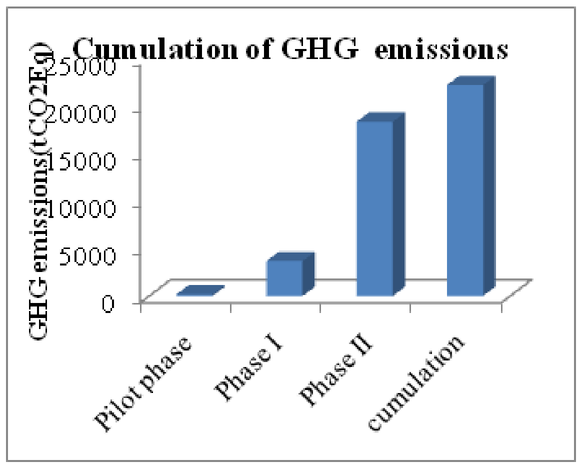

Figure 8: GHG Emission MFP National Fleet in the different phases of the program.

In assessing GHG emissions in the different phases of the program, it appears that 162.58515 t CO2Eq are emitted during the pilot phase, 3683.75098 t CO2Eq in Phase I and 18328.43628 tCO2Eq during the ongoing Phase II from the 31 December 2012. Lastly, we can estimate the GHG emissions due to diesel MFP installed in Burkina Faso at about 22174.70241 tCO2Eq for the period from the year 2000 to 2012, by combining the emissions of phases 1, 2 and the pilot phase.

4. DISCUSSIONS

From the results listed above, it appears that if the number of MFP during the pilot phase is identical to the one we encounter in literature, it will not be the same for phase I. In fact, at the deadline for Phase I that is to say, at December 31, 2008, we count 327 MFP installed against 400 MFP as envisaged by the program. This difference is due to the late completion and late MFP delivery. The 73 lacking MFP will be installed during the year 2009.

Estimating greenhouse gas emissions across the MFP National Fleet reveals a significant proportion of CO2 in the atmosphere. Our calculations show that a diesel MFP with an output of 10 hp and which consumes an average of 7 liters of diesel per day emits about 7.07735 t CO2Eq / year; that is 7593.99655 t CO2Eq/ year emitted and estimated at 1,073 MFP against 12031.495 tCO2Eq per year for a fleet of 1,700 MFP at the end of Phase II. Knowing that CO2 emissions in Burkina Faso are estimated at 1,091,000 t CO2Eq / year [W1], the proportion of the national emissions from a MFP is 0.00065%; or 0.70% of national emissions attributed to a National fleet of 1073 MFP against 1.1% for a fleet of 1700 MFP in the year 2015. Being aware of part of the load rate, the frequency of consumption and aging of these diesel engines, and also the growing installation of MFPs to meet the demand of the needs in rural areas, we expect a significant increase in CO2 emissions in the coming years if the PN_MFP program / LCP is renewed at the end of phase II in the year 2015. It is in this context that policy makers are now encouraging the development of alternatives sustainable technology (Sow et al, 2009) and protection of the environment for any activity related to the concept of MFP (MEF, 2009). Thus, the use of solar energy and Jatropha oil plant is highly demanded to make a green MFP sector.

5. CONCLUSION

The MFP, although being effective solution to the fight against poverty, has a negative impact on our health and our environment: they emit harmful pollutants that affect our health and gases that affects environment. They also contribute to global warming by emitting significant amounts of greenhouse gases as shown by the results obtained. Given the success and the growing expansion of MFP in Africa (especially West Africa and East), GHG emissions by these companies will become very important in the coming years depending on the operating frequency and density implantation MFP. To limit these emissions from concept MFP the program now encourages the use of sustainable renewable energy, and clean energy such as solar, biomass (plant jatropha oil).

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