# MOBILISING RURAL HOUSEHOLDS TO STORE CARBON, REDUCE HARMFUL EMISSIONS AND IMPROVE SOIL FERTILITY;INTRODUCTION OF THIRD GENERATION STOVES

**By Robert Flanagan & Dr. Stephen Joseph**

## ABSTRACT

**Commercialization of a high-efficiency household stove, which burns crop and forest waste as part of a clean, carbon capturing & storing household energy programme, to be implemented with local reforestation initiative**.

This paper introduces the concept of mobilising rural households in developing countries to help alleviate the impacts of climate change through a reduction of emissions from inefficient biomass burning stoves, and halting of soil degradation through the incorporation of charcoal/biochar, produced in high-efficiency stoves into the soil (biochar is the name given to charcoal when used in agriculture).

To achieve these outcomes a new biomass stove has been developed (figure 1). This stove can use biomass (wood, dung, agricultural residues) as fuel, it's portable, and works via natural draft (no external power required). This stove uses the principal of gasification. In the first stage, a small amount of air is forced through the biomass to produce charcoal and a combustible gas (the wood is pyrolysed). Extra air is then added above the fuel to burn the combustible gas. This allows more complete combustion of the wood and increases the temperature of the flame so that more heat is transferred to the cooking pot. Thus there are three advantages over an open fire or simple mud or ceramic stove:

1. Reduction in the amount of harmful smoke that is inhaled by the household (in particular by women and children)
2. Increase in the amount of heat transfer from the biomass energy to the food/water
3. Production of charcoal that can be used by the household or sold as a fuel and/or a soil enhancer.

The proposed stove can be filled with approximately 0.5kg of biomass to provide up to 30minutes of cooking time (depending on the fuel used and air flow through the reaction zone). Approximately 15% of carbonized waste (charcoal) is produced from the original amount of biomass. The stove can also run continuously as fuel can be added below the flaming pyrolysis zone, avoiding the reintroduction of smoke when fresh biomass is added.

This stove allows households to become active participants in improving the local environment and soil, and assisting in the removal of $CO_2$ from the atmosphere by reducing the amount of biomass required for domestic cooking and also by fixing organic carbon in the form of charcoal. With international support and funding for forest management and a push to stop deforestation and soil degradation (REDD) due to concerns over climate change, this programme could provide foreign revenue for developing countries. The social, economic and environmental benefits of the development and implementation of this unique system are considerable.

# LOW COST CARBON CAPTURE & STORAGE, ENERGY

## Stoves, Health, Greenhouse Emissions and Income Generation

An estimated 2.4 billion people rely on traditional biomass for cooking and heating (wood, dung, and agricultural residues), mostly burnt using inefficient and dirty cooking devices or open fires. Cooking and heating with solid fuels on open fires or traditional stoves results in high levels of indoor air pollution. This is a major contributor to respiratory health problems, particularly for women and children, resulting in 1.6 million premature deaths each year (W.H.O. http://www.who.int/indoorair/impacts/en/).

A 2001 IEA study (*Towards a Sustainable Energy Future*; IEA, Paris 2001) states that low efficiency biomass stoves can have a global warming potential ten times that of an LPG or kerosene stove. In contrast, Wang and Smith (1999) note that the total green house gas (GHG) emissions from a high efficiency biomass fueled stove were similar to that of an efficient natural gas stove. An evaluation of a stove programme in Uganda by Feldman states that the introduction of 200,000 improved stoves resulted in:

1. Reduction of firewood by 220,000 tones/year which negated the need for reforestation costing 1.4 million Euros
2. Avoidance of $CO_2$ and $CH_4$ emissions amounting to 1.7 million Euros at CER price of 5 Euros per tonne of $CO_2$eq.

The introduction of first generation improved stoves commenced in earnest in the late 1970s and 1980s. Over 10 million stoves that save between 10 and 50 per cent of biomass and coal as compared to traditional stoves have been introduced either via a market or an extension mechanism (Prasad et al, 1986). Many of these improved stove programmes were carried out in collaboration with community and social forestry programmes. In the 1990s, a second generation stove was introduced which utilized advanced combustion techniques (Tom Reed).The second generation stoves had much lower emission levels than the first generation stoves as they utilized a two-stage combustion process.

It is estimated that every improved cooking stove, with its more efficient combustion, can reduce GHG emissions by up to two tonns of $CO_2$ per year via the reduction of fuel needed for the same heat transfer. The potential carbon market from this reduction in carbon alone could offer a significant funding potential for the deployment of improved cooking stoves. If we add the potential of fixing part of the carbon stored in the biomass (biochar) and incorporate the biochar back into local soil we further increase the overall carbon equation.

The benefits of this "Third generation stove" promoting carbon capture and storage are fivefold:

1. Reduction in both the amount of fuel used and in cooking times
2. Reduction of health problems related to the inhalation of smoke and indoor air pollution
3. Reduction in GHG and black carbon emissions through more efficient combustion
4. Improvement in yields of plants and trees grown by the household using biochar as soil enhancer, or increased household income via sale of biochar to other growers
5. Reduction of $CO_2$ in the atmosphere through incorporation of biochar into the soil

**The Concept of Co- Production of Clean Heat and Biochar**

Production from land is the basis for the livelihood of many households in developing countries. The lives of the poorest section of society could be significantly improved if technology and supporting education programmes that can improve soil health (boosting crop yields), increase tree cover (preventing soil erosion) and improve the household environment (reduction of indoor air pollution) are implemented.

Environmentally, the reliance on biomass as fuel can put considerable pressure on forests, particularly in areas where wood fuel is scarce and its demand outweighs natural re-growth. Ensuring that the fuel used in the stove is primarily from agricultural and forestry waste combined with the introduction of an education and awareness programme can alleviate this issue. In an environment of global warming and climate change, particularly when all governments are turning their attention to potential abrupt climate change and ways to mitigate greenhouse gas emissions, reforestation has already been recognized as of the most efficient way to restore the planet's imbalance of carbon in the atmosphere. Additionally, the novel use of charcoal as a soil enhancer further stores carbon which would otherwise be released back into the atmosphere.

This concept is a complete cycle solution which will have a positive impact on a number of issues including: household energy; indoor air pollution; the reduction of dependence on fossil fuels for domestic cooking; the disposal of agricultural and forestry waste; the generation of micro businesses and incomes for subsistence farmers and pressing environmental concerns regarding global warming, greenhouse gas emissions, and deforestation from the cutting of forests to supply fuel or to make way for biofuel crops. It also aims to restore soil fertility and increase plant/forest health and vigor and to store carbon in the soils for thousands of years to come. Last year's publications and presentations regarding biochar and biomass gasification at the United Nations Climate Change Conference, Bali, 2007 were well received.
http://www.biochar.org/joomla/images/stories/Pechoelbrennen/SteinerUNCCD.pdf
http://www.biochar.org/joomla/images/stories/Pechoelbrennen/ZechUNCCD.pdf

**The Technology**

The concept of this project revolves around the development of a natural draft gasifier. The stove uses biomass feedstock's that are often disposed of via open burning or allowed to decompose resulting in the re-release of $CO_2$ back into the atmosphere. The technology enables households to be energy independent for domestic cooking and provides an alternative to the use of fossil fuels like kerosene and LPG while producing a valuable bi-product (charcoal).

**Use and Efficiency of the Stove**

The stove can be filled with approximately 0.5kg of biomass and then provides up to 30minutes of cooking time depending on the fuel used and the air flowing through the reaction zone. The user of the stove has the option to keep the charcoal produced (approximately 15% of the original amount of biomass) or to burn the charcoal to ash. The stove can run continuously as it can be reloaded even during burning or cooking. The biggest difference with this stove is that all the gas passes through a hot carbon layer where the gas and moisture are cracked (where the minimum temperature is 600C), producing clean syngas (water and high temp carbon, H2O + C = H2 + CO).

The specific shape of this stove also ensures that the pots sit down into the potholder transferring maximum heat from the hot gas before it exits up the chimney. The stove offers two pot positions, one for direct cooking over flames and the second, a simmering position as the gas is redirected via a baffle from the main chamber around the pot before it exits via the chimney.

**Costs and Economics of the Stove**

Due to the simple design, the construction costs of the stove are low and the additional benefits may open the potential for the stove to be subsidized by local government, NGOs or by carbon offsetting agencies. If the biochar is utilized for soil amendment it may be integrated as part of a local reforestation programme. Users would repay the cost of the stove through the sale of the biochar. The biochar produced by the household can be used in potting mix to grow seedlings that can be sold to local reforestation projects to generate an income for the household. It would therefore not only provide an income for the households (allowing them to recover the initial cost of the stoves), but also increase the success of forest seedling growth and of the reforestation programme.

One of the contentious issues concerning household energy, and often touted by other stove programmes, is the restriction of economic development by reducing the ability to switch to 'clean' fuel. This model allows for the development of a micro business and also for the provision of a passive income from the support of a reforestation programme.

A programme that supports the use of biochar to enhance the germination, growth and survival of trees should garner international support (REDD), particularly if the forests were to remain a carbon sink as opposed to being harvested. Any such programme would also inspire rural development via micro business and attract foreign funding through carbon offsets.

**Potential for the use of biochar**

If the user of the stove decides to keep the charcoal it can be used back in agriculture (biochar). Biochar has been proved to increase growth and vigor of plants via the ability to retain moisture and nutrients in soil and also provide a secure environment for beneficial microbes and fungi. Soil microbial communities are also stimulated by charcoal (Rondon et al. 2007, Steiner et al. 2007). This results in a marked increase in the growth rate, health and strength of seedlings and plants making them more resistant to disease and pests.

**International Research into Biochar**

The use of biochar to assist in the development of forest seedlings is a pioneering agricultural development, based on the ancient Amazonian dark earths (otherwise known as Terra Preta). Current ongoing international research is aimed at recreating and rediscovering the values of this remarkable soil, created by indigenous peoples of the Amazon over 4000 years ago. Though these aims have yet to be fully realized, research has already led to a much deeper understanding of the soils and in particular an awareness of the importance of carbon in restoring soil fertility and quality. Trials have proved beyond doubt that the use of biochar combined with the application of beneficial microbes and fungi, results in markedly improved plant survival rates (Rondon et al. 2007, Steiner et al. 2007).

**Linked International Associations and upcoming events**

For several years, agricultural trials using charcoal have been conducted all around the world resulting in numerous publications (please see below reference) Following the 2006 meeting in Philadelphia of the International Soil Science Congress, the International Biochar Initiative was established http://www.biochar-international.org/ and its inaugural conference was held in Australia in May 2007 and this year's meeting was held in Newcastle upon Tyne, England in September 2008 with new publications and findings presented.

**Photos:** Figure1.

Lower fuel feed resulting in no reintroduction of smoke

**Top**: Good Combustion, **Bottom**: Charcoal/Biochar Bi-product.

**Above:** Biochar "V" Control on Jatropha seedlings in Indonesia **Below:** Corn trial China 2007

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