

GUIDE TO GREEN CHARCOAL PRODUCTION

INITIATIVES CLIMAT



GUIDE TO GREEN CHARCOAL PRODUCTION

INITIATIVES CLIMAT



Writers:

Benoît THÉAU et Ruphin KINANGA (Congo) with the collaboration of Roméo AZONHOUMON (Benin), Hassan EL HEMER (Morocco), Fadimatou HASSIMI (Cameroon), Meriem HOUZIR (Morocco), Muller NANDOU TENKEU (Cameroon), Vincent NIKIEMA (Burkina Faso), Fulgence N'RDI (Ivory coast), Guido MURHULA ZIGABE (Democratic Republic of Congo).

Reading committee:

Hind NACIRI
Chifae MRKIM
Khadija AIMARA

Graphic design and printing:

Napalm

This publication was made possible thanks to the contribution of the Micro-Financing Programme of the Global Environment Fund - SGP/GEF - Office of Morocco.

For more information on Initiatives Climat activities:

www.initiativesclimat.org
www.jeunes-entrepreneurs-verts.org
www.facebook.com/InitiativesClimat/

To find out more about our partners:

www.4c.ma
www.ma.undp.org

PREFACE

In Africa, access to firewood for cooking and heating is becoming increasingly difficult. Some regions have diminishing forest cover and desertification.

In rural areas, collecting firewood is a difficult task, often for women and girls. The increase in logging bans in some areas is forcing firewood collectors to find new sources of supply, which are increasingly far from their living areas. In addition, charcoal production is highly regulated and even banned in some regions or countries.

In urban areas, prices of firewood and charcoal have risen sharply in recent decades due to its scarcity, increased demand, and remoteness of production areas to areas of consumption.

Efforts are certainly being made to **find alternative** energy-efficient fire stoves, which reduce the consumption of firewood or charcoal by 30-60%. However, if these households are not subsidized or produced by the populations themselves, the cost will be high for low-income households. In any case, the demand for wood-energy remains very high. Some countries subsidize gas to promote this type of energy, which is not accessible to all. And some food preparations (grills, tagines...) require the use of charcoal.

Green charcoal is an alternative to firewood and charcoal. It can be produced locally, with simple materials, in areas that are not reached by electricity distribution (or areas with no electricity) from locally available organic wastes. However, to be acceptable by housewives and restaurant owners, the green charcoal must be of very good quality.

Many associations, cooperatives, and young green entrepreneurs interested in alternative fuel for cooking have embarked on this green charcoal production. However, most of these new producers failed in their projects due to a lack of technical knowledge and entrepreneurship spirit.

The "green charcoal" chain is very promising in terms of recycling organic waste, the production of renewable energy or even in the creation of jobs. On the other hand, it is unstructured and therefore cannot support civil society organizations and other young green entrepreneurs to create production units and ensure their sustainability.

The association Initiatives Climat decided to create the "African Green Charcoal Cluster", which brings together experienced producers from a dozen French-speaking African countries. They can advise and provide technical support and management assistance to any actor wishing to start the green charcoal project.

The technical support is reflected in the provision of this manual. The information provided here is certainly not enough to set up a craft or intermediate production unit, but it is essential to appreciate the main aspects.

The Association Initiatives Climat is grateful to the people, especially the producers of green charcoal, who contributed to the realization of this manual.



INTRODUCING THE ASSOCIATION INITIATIVES CLIMAT

The *Initiatives Climat* association aims to “contribute to the awareness of environmental issues, sustainable development and the effects of climate change and to build the capacity of project leaders in developing countries” (particularly French-speaking African countries).

The association has initiated and runs a South-South cooperation programme “Climate Initiatives Francophone Africa / ICAF”. The aim of the programme is to identify and enhance projects to adapt to and mitigate climate change, which are now inspiring, replicable and transferable solutions, thus enabling any African actor to contribute to the regionalisation of the commitments of African states and in particular to the national commitment to contribute in the realization of CDN/NDC.

Its activities are of various natures: carrying out databases on good practices and project owners (www.initiativesclimat.org); conducting collaborative training; animation of a network of development actors in French-speaking Africa; organising side events at international conferences and forums; production of capitalization documents or feasibility studies and popularization of good practices and reporting.

The association wants to develop a “green charcoal” chain. It was behind the creation of the “African Green Charcoal Cluster”.

— PUBLISHING PARTNERS —



THE UNITED NATIONS DEVELOPMENT PROGRAMME UNDP MOROCCO

In accordance with Morocco’s national development priorities and UNDP’s strategic plan at the global level, the adoption of sustainable development methods, the strengthening of democratic governance systems, and the reinforcement of resilience constitute the three priority axes of UNDP’s intervention in Morocco.

In the area of climate change, UNDP helps countries reduce their greenhouse gas emissions and set a long-term goal of zero carbon emissions. Alongside with that, UNDP works with partners to improve the potential of adaptation to the impacts of climate change expand access to clean energy, minimize disaster risks and, where necessary, build capacity for post-disaster recovery.

Through the 4C Morocco Operational Strengthening Project, UNDP Morocco provides technical assistance and supports the country’s efforts to adapt to new international challenges through three key areas of support:

- Morocco’s programmatic framework for the implementation of the NDC;
- Morocco’s transparency framework for monitoring the implementation of the NDC;
- Support framework for South-South cooperation through the Congo Basin Blue Fund.



THE CLIMATE CHANGE COMPETENCE CENTRE 4C MOROCCO

The Climate Change Competencies Center of Morocco is a platform for capacity building of relevant actors from different sectors (public, economic, research & training, civil society, local authorities...) and a hub for the development and dissemination of skills in the field of climate change (CC) open to its national and African environment.

The main contributions 4C Morocco are as follows:

1. Contributing to the capacity building of national actors on climate change
2. Capitalizing on information/knowledge/know-hows on climate change vulnerability, adaptation, mitigation and finance
3. Developing tools to assist decision-making on climate change issues
4. Contributing to the global effort by sharing experience, monitoring and networking in relation to climate change at the international level

These four missions are deployed according to specific programmes responding to the different needs of the beneficiaries in terms of capacity building in GHG mitigation and building resilience, to the adverse the impacts of climate change.

The 4C Morocco benefits from the support of the Department of the Environment and all its members who make up its 4 platforms, namely:

1. Ministries, Public Administrations and Territorial Collectivities
2. Private Sector
3. Research, Expertise and Training
4. Civil Society



THE SMALL GRANTS PROGRAMME OF THE GLOBAL ENVIRONMENT FACILITY SGF/GEF

Established in 1992, the year of the Rio Earth Summit, the GEF Small Grants Programme embodies the very essence of sustainable development by "thinking globally acting locally". By providing financial and technical support to projects that conserve and restore the environment while enhancing people's well-being and livelihoods, SGP demonstrates that community action can maintain the fine balance between human needs and environmental imperatives.

SGP recognizes that environmental degradation such as the destruction of ecosystems and the species that depend upon them, increasing levels of carbon dioxide and other greenhouse gases in our atmosphere, pollution of international waters, land degradation and the spread of persistent organic pollutants are life-threatening challenges that endanger us all. However, poor and vulnerable communities -SGP's primary stakeholders- are most at risk because they depend on access to natural resources for their livelihoods and often live in fragile ecosystems.

The programme provides grants of up to \$50,000 directly to local communities including indigenous people, community-based organizations and other non-governmental groups for projects in Biodiversity, Climate Change Mitigation and Adaptation, Land Degradation and Sustainable Forest Management, International Waters and Chemicals.

TABLE OF CONTENT

Preface	5
1 Green Charcoal	12
1.1. Access to Energy	12
1.2. Definition of green charcoal	13
1.3. Physical properties	15
1.3.1. Humidity rate	15
1.3.2. Density	15
1.3.3. Fire/Calorific value	15
1.3.4. The impact resistance index	15
1.3.5. The rate of flammability	15
1.4. Chemical propertiess	16
1.4.1. Carbon rate	16
1.4.2. Ash rate	16
1.4.3. Organic matter rate	16
1.4.4. Total lipid content	16
2 Green charcoal production	17
2.1. General Principles	17
2.2. Raw materials	18
2.2.1. Sources of supply	19
2.2.2. Collection and sorting of waste	20

2.3. Production techniques	22
2.3.1. Method 1: compacting and carbonizing.....	22
2.3.2. Method 2: carbonization and pressing.....	23
3 The materials	34
3.1. The carbonizers.....	34
3.2. The Compacting press	35
3.3. The measuring device	36
4 The use of green charcoal	37
4.1. The marketing.....	37
4.1.1. The different trading channels.....	37
4.1.2. Advertising.....	38
4.1.3. Contacts and partners	38
4.2. The users' awareness	39
4.3. The lighters	39
5 The economic data.....	40
5.1. Investment costs	40
5.2. Cost price.....	40

TABLE OF CONTENT

6 The green charcoal benefits	41
6.1. Social benefits	41
6.2. Health benefits	41
6.3. Economic benefits.....	41
6.4. Ecological benefits	41
6.5. Political benefits	42
7 The conditions for the success of the creation of a green charcoal production unit	43
7.1. Prior study in relation to energy needse.....	43
7.2. Choosing organic waste and agricultural waste	43
7.3. Choosing the legal structure.....	44
7.4. Choosing the size of the production unit	44
7.4.1. Craft unit.....	44
7.4.2. Intermediate unit	45
7.4.3. Semi-industrial unit.....	46
7.5. Choosing the location of the unit	47
7.5.1. Workspace	47
7.5.2. Location of the unit.....	47

7.6. Choosing the material.....	48
7.6.1. Locally made materials.....	48
7.6.2. Imported materials	48
7.7. Training and support.....	49
7.7.1. Self-taught	49
7.7.2. With the support of producers	49
7.7.3. With the support of trainers.....	49
7.8. Marketing	50
8 Training.....	51
8.1. Targeted goals.....	51
8.2. A typical training module	51
9 The online directory of French-speaking African producers	53
10 The African Green Charcoal Cluster	54
10.1. Rationale for its creation.....	54
10.2. Its structure and services offered	54
Ressources	56



Trade of firewood and charcoal along the road.
Burkina Faso.

1 | Green Charcoal

1.1. Access to Energy

Access to energy is an essential factor in development. This is mentioned in the Sustainable Development Goals (2030 Agenda for Sustainable Development), SDG 7, which aims to “ensure access for all to reliable, sustainable and modern energy services at an affordable cost”.

However, in many developing countries, despite efforts through a range of sectoral programmes, universal access to energy is not assured. Vulnerable populations, particularly in rural areas, face energy crisis/insufficiency as a result of unfair (or unequal) access to energy resources and services.

In recent years, international advocacy/awareness on the issue of sustainable energy and gender equality has been raised. Gender inequalities in the energy sector have been found a barrier to economic and social development.

A few data that illustrates energy crisis:

- Around 1.3 billion people worldwide do not have access to energy services, including electricity. 80% of them live in rural areas; they are mainly found in 20 countries in sub-Saharan Africa and Asia (UN 2015);
- 2.8 billion people still must use forest wood or other biomass products to prepare meals and provide warmth during cold season. These firewood are a major source of indoor pollution and pose health hazards; the effects of this pollution cause the premature death of about four million people a year, mostly women;
- In North Africa, for example, a household consumes an average of 17 kg per day of wood in arid areas and 52 kg per day in mountainous areas; this wood is often carried by women. The distance to be covered for timber harvesting may be less than 5 km when the forests are close to the villages through walking, and more than 15 km when the forest is far from the village;
- Only 20% of the workforce in the present renewable energy sector are women. Documented examples of women energy entrepreneurs remain largely limited to small-scale initiatives (IRENA 2014).

According to a 2017 report by the International Energy Agency, titled "Africa Energy Outlook: A Focus On Energy Prospects in Sub-Saharan Africa", biomass consumption in sub-Saharan Africa is expected to increase by 40% over the next two decades. As a result, the market value of biomass energy will be close to \$70 billion by 2040.

Charcoal is widely used by African households for cooking meals/food. This practice contributed to the proliferation of illegal logging activities, making charcoal-making one of the major causes of deforestation. The reduction in the use of charcoal contributes to the fight against excessive logging and the preservation of forests. In addition, pollution from coal has significant human, environmental and economic costs. Most of these are of a professional and health nature. The charcoal industry involves landowners, coal miners, transporters, wholesalers and retail resellers. All these actors often work without coordination and have no sense of consultation because law enforcement has been long neglected. The share of wood in Africa's energy balance is not known accurately due to the lack of reliable energy surveys. However, according to past statistics, it is estimated that more than 80% of households use wood and its by-products as the main source of energy for cooking.

Access to sustainable energy is one of the major challenges for Africa, which can be addressed through a policy on energy efficiency and the production of more clean fuels.

1.2. Definition of green charcoal

The production of "green" or "renewable" energy can partly solve the problem of energy problem/crisis. Green charcoal is one of those green energies that can be accessed in both urban and rural areas. Green charcoal is also referred to as "organic coal" or "vegetal coal". It is made with plant waste or agricultural residues such as rice husks, peanut shells, millet stalks, cotton seed shells, banana peels or peelings, corncobs, coconut shells, cocoa pods, etc. This product is unknown to the majority of the population. Green charcoal surveys conducted by producers in African markets show a low rate of use of this product. However, if this product is of good quality, it is an alternative to charcoal, which requires large quantities of wood to produce. In addition, its highly decentralized production provides income-generating activities for grassroots community organizations and young green entrepreneurs.



Raw materials (stems and rosemary leaves), carbonization product (dust), powder obtained after grinding and compressed and dried briquettes. Morocco.



OTHER DEFINITIONS OF GREEN CHARCOAL

"Green charcoal is coal that is produced without wood, from any vegetable waste. Indeed, there are many releases and residues that are neither consumed nor used: various straws, crop remains such as cotton, millet, reed stems, etc. The product comes in the form of easy-to-use briquettes with no methane release".

Source: Encyclopédie de L'Agora pour un monde durable (The Encyclopedia of the Agora for a sustainable world).

"Green charcoal is coal produced from carbon-rich biodegradable residues, mainly from agricultural residues and household waste. It comes in the form of briquettes or balls the size of traditional charcoal pieces and could be used in most traditional ovens used in the South. Green charcoal can be used as a substitute for coal, firewood for domestic cooking and even heat production in industries".

Source: Dictionnaire de l'Environnement et du Développement Durable, 2017, P180-182 (the Environment and Sustainable Development Dictionary).

"Ecological coal is a stable carbon product made from by-products of plant biomass or organic waste for domestic use. In theory, it is therefore a product similar to charcoal in its appearance as well as in its use but prevents the cutting of trees".

Source: Roméo AZONHOUMON, Almighty Services Plus, Benin, in Eric BOCOVOU, *Production of green charcoal briquettes in the district of Abomey-Calavi*, Professional Licence dissertation, 2018.



1.3. Physical properties

The physical properties are the physical components of a substance that cannot change without implying a change in chemical composition. The non-characteristic physical properties include mass, length, volume, and temperature. Characteristics of physical properties include solubility, density, and boiling point. The physical properties of green charcoal are closely related to those of the organic materials used in its production.

1.3.1. Humidity rate

This rate determines the percentage of water contained in a material, in this case green charcoal. This is a determining factor for combustion use. The less moist the green charcoal, the more efficient it is as a fuel.

1.3.2. Density

Density is the ratio of the mass of a body's volume to that of the same volume of water.

The density (Q) of green charcoal is the quotient of its mass on its volume. It is expressed in kg/m^3 .

The density makes it possible to appreciate the resistance of a green charcoal.

1.3.3. Fire/Calorific value

The power is the thermal energy released by the combustion of one kilogram of fuel. It is usually expressed in kJ/kg (kilojoules per kilogram).

This is the energy released when burning green charcoal per kg. The higher the mass, the greater the amount of energy.

There are two types of calorific value:

- The higher calorific value is obtained when all green charcoal has been converted into energy, including free water vapour and fumes;
- The lower calorific value (LCP) is the thermal energy released by the combustion of one kilogram of green charcoal in the form of sensitive heat, excluding the vaporization energy of the water present at the end of the reaction.

The calorific value is inversely proportional to the humidity level, i.e. the wetter a material is, the lower its calorific value, and vice versa.

The calorific value of green charcoal varies depending on the raw materials used.

Producers must ensure that green charcoal has an LCP at least equivalent to that of charcoal. To do this, it is necessary to have your product tested by an approved laboratory.

1.3.4. The impact resistance index

The impact resistance index is an important physical data which allows to verify the compactness and solidity of coal for transport over long distances, without crumbling.

1.3.5. The rate of flammability

The flammability rating is the ability of charcoal to catch fire, even in a humid environment. This data depends on the compaction rate and the drying quality of the finished coal.



1.4. Chemical properties

Chemical properties represent the behaviours of a substance that gets in contact with another substance.

For green charcoal, carbon content, ash content and mineral composition are assessed.

1.4.1. Carbon rate

This rate determines the percentage of mineral elements contained in a dry mass of coal powder. This value is important because it is related to the ability of the powder to produce heat; to do this, laboratory tests are carried out. It is estimated that the average rate is 50% for green charcoal. The value of this rate is important because it determines the ability of the powder to produce heat.

1.4.2. Ash rate

The ash rate is the solid residue content that remains after complete combustion of green charcoal. It contains activated elements such as potassium (K), calcium (Ca^{2+}), magnesium (Mg^{2+}).

1.4.3. Organic matter rate

This is the share of organic matter, composed of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), sulphur (S), contained in a dry mass of fine green charcoal powders. They may also be combinations between these different elements to form more complex molecules.

Burning heat degrades some of these elements such as oxygen. Also, for the production of green charcoal, it is necessary to identify among these organic materials, those with low humidity and a high carbon content.

1.4.4. Total lipid content

Total fat content is the amount of oil contained in a biodegradable raw material. It determines the rate of pyrolysis oil that will be obtained at the end of carbonization. These pyrolysis oils determine the energy renewal of a raw material.

2 | Green charcoal production

2.1. General Principles

Green charcoal is an energy resource derived from biomass. It has many advantages over traditional fuels such as wood and charcoal in Africa (80% of cooking and heating needs). The energy potential of these two fuels is only partially exploited. The wood, which is still fresh and therefore moist and has a low energy value, is still too often used. As for charcoal, traditional techniques do not optimize its production and many manufacturing residues are unused. Consumption is increasing due in part to Africa's strong population growth. Moreover, in urban areas, the prices of these fuels are rising at a rapid rate as they become increasingly scarce.

It should also be noted that the smoke produced during combustion contains fine particles and carbon monoxide; this causes respiratory diseases, especially among women, who are the main users.

On the other hand, other biomass, such as organic matter from plants, agro-industrial residues and waste, are under-exploited. Recently, a relationship between the energy issue and that of waste management has begun to be established (until now this topic has only been addressed in terms of public health) by exploring the economic opportunities associated with their recovery. Biomass and organic waste can be fairly easily converted into energy through a carbonization process. The advantage of green charcoal, if it is of good quality, is its greater energy efficiency. In addition, it contributes to the protection of health and the environment; its cost is affordable. Its appearance and use differ little from those of charcoal, traditionally used by households and restaurant owners. This ensures an acceptability for innovation.

The use of green charcoal, combined with energy efficient techniques, such as improved fireplaces, can result in an overall fuel savings of more than 80%. The energy saved reduces women's workload and saves households' financial resources.

To produce green charcoal manually, all it takes is an oven and a press and some small tools (home, pot, bags, gloves...). The carbonization product is kneaded with a starch paste (e.g. cassava flour residue) and pressed into a mould to make briquettes.





2.2. Raw materials

The amount of solid waste produced daily in African cities is high. Lack of treatment poses hygiene and health challenges.

Indeed, in most African countries there is no sorting system, so organic waste is mixed with other types of garbage and often dumped in open landfills. Waste can be spotted in the streets of many African cities, as well as in rainwater drainage systems (natural and artificial collectors). In addition, existing landfills are sources of pollution of surface water and groundwater from the decomposition of waste. Solid waste management, often left to the personal initiative of residents, results in uncontrolled disposal systems: households manage waste by burying or burning on their plots or on the streets.

In addition, anaerobic decomposition (in the absence of oxygen) of household waste has adverse effects on climate change because it causes emissions of methane, a greenhouse gas 25 times more potent than CO₂.

Solid waste produced in urban areas has a large stock of organic residues or biomass. In addition, low-value agro-industrial residues are also included. Some of these organic residues could be turned into green charcoal briquettes. Another part could be valued in other forms: compost and biogas for example.

While many trees are cut down each year to produce charcoal (5 to 6 kg of wood is needed to make 1 kg of charcoal), millions of tons of organic waste are an unvalued resource and cause serious nuisance. The production of green charcoal briquettes is a contribution to the preservation of forest cover and to the improvement of sanitation.

There is no standard that defines from which type of organic residue green charcoal can be produced. Different raw materials, a large quantity of which is not valued, can be used:

- Organic agricultural or biomass residues: straw, leaves, stem residues (mil, sorghum, cotton, corn, tomatoes, peppers...), corncobs palm nut residues, coconut shells, sugar cane bagasse, banana peels, cocoa pods...
- Agro-industrial residues: cotton seed shells, peanut shells, olive nuts, argan nut shells, sawdust and wood chips...
- Harmful aquatic plants with high proliferation, such as Typha Australis or water hyacinth;
- Organic household waste.

All these organic residues, the list of which is not exhaustive above, can be converted into green charcoal briquettes. Even a fuel produced from waste or neglected charcoal dust can be considered green charcoal. Thus, there is a wide variety of biodegradable waste, which can be carbonized to make green charcoal, but not all give the same quality coal.

The most interesting waste for the manufacture of green charcoal is the organic residues that have a lot of mass, such as banana peels, cassava, corncobs, different hulls, etc. The very choice of raw materials from which green charcoal will be produced is an essential point for the success of the project. The other important aspect is the availability of the resource over time and its accessibility.

The quality of the raw material is an aspect to be taken into account. Any organic residue can be carbonized and moulded into green charcoal briquettes, but not all organic residues give a green charcoal with the same fire/calorific value. Thus, the charcoal produced from banana peels and cassava gives a green charcoal with longer cooking, while the charcoal produced from grain stems has a lower calorific value than charcoal.

2.2.1. Sources of supply

Organic and biomass residues are available in large quantities everywhere on our planet, but waste management is a major concern especially for African cities. Indeed, there is currently a proliferation of waste of any kind in cities. Africa's growing capitals are experiencing enormous challenges in collecting and treating wastes. An ambitious policy should aim not only to limit the production of harmful waste, but also to value waste as a source of energy or reusable materials through recycling. In addition, agri-food industries generate large amounts of organic waste, which can lead to serious environmental problems: negative impacts on soil and water (surface and groundwater), methane emissions, foul odours and sanitation problems. The processing plants/factories of sugar cane, fruit and vegetables are a good example of this.

The amount of waste generated is increasing steadily and gradually from year to year due to the rapidly expanding industrial development. This is a source of supply for green charcoal producers, not to mention other sources (household waste and biomass waste collected in the wild).



Coconut shells that, when crushed, can be compacted. Benin.

2.2.2. Collection and sorting of waste

Before starting a project to produce briquettes, it is essential to evaluate the quantity of raw materials that can be actually mobilized, its regularity and availability. Too often the quantity is overestimated, and the cost of collection and transport is underestimated.

Just because waste is free doesn't mean it doesn't cost anything. It is very important not to underestimate its laborious collection. In addition, waste collection involves costs for handling and transportation. Just because green charcoal is produced from waste does not mean that the cost of the raw material is zero. Sometimes collection costs can be high in areas where there is little raw material. Underestimating collection costs or overestimating the amount of raw material actually available are common mistakes. Making a mistake on this point can compromise the financial balance of the project. The cost of collection and transportation is to be accurately assessed.

To reduce the cost of transport, it is necessary to look for organic residues that preferably have a fairly high mass. To produce 1 kg of green charcoal, you need 3 to 6 kg of organic residue. However, 10 kg of coconut shells represent a small volume to carry compared to 10 kg of straw for example. The transport of large organic residues requires the use of a rickshaw, a motorcycle tricycle or other-like vehicles.

If the raw material is not available all year round, it is necessary to have a large space for storage. This can be cost-effective and require the construction of a storage store. It is therefore preferable that the raw material be available throughout the year, that the waste deposit is close enough to the production site and that the cost price is quite low (this price includes the eventual purchase if the waste is not free and its collection and transport costs). These aspects are essential because the cost of the raw material can vary significantly.

The manufacture of briquettes requires a large amount of waste. To allow a regular supply of waste, a "win-win" household waste collection strategy or incentive for free collaboration for the success of the operation should be adopted. The aim is to encourage as many partners as possible to participate in the collection.

In urban areas, a first type of collection can be done by the producer of green coal from households identified in advance by the sole criterion of their willingness to sort organic waste using garbage bags made available to them: a first bag for organic waste or organic waste (peeling, peeling, cut grass, dead leaves, etc., and another bag for other waste, which will be directed to landfills controlled by the locality where the project is being implemented. In return, households dispose of their waste free of charge and, if necessary, buy green coal at a preferential price. However, it is necessary that the collected waste is not decomposing.

Another type of collection can be carried out in markets where organic waste is generally found. In Africa's major cities, the deposit can be hundreds of tons per month. Often, because of a lack of political will or resources, municipalities do not collect this waste or is poorly carried out. Green charcoal producers will find a variety of waste in the markets; however, they will have to collect and transport it.

In rural areas, farmers may be involved in collecting agricultural residues that are not turned into compost or animal feed. Farmers may consider to hand it over for green charcoal production. In addition, village groups can organize themselves for collection in the fields or in the bush. This is particularly the case for women's groups producing green charcoal in Burkina Faso, Cameroon and Senegal.



Waste collected in markets (corn leaves and corncobs, banana peels, sugar cane stalks). Cameroon.

Focus on: Waste sorting

- In most cases, dry waste on land contains dust, small stones, pieces of metal, etc.;
- All inorganic material must therefore be removed before the carbonization stage to ensure safe and smooth combustion;
- It is important to put only the same type of organic waste in the carbonizer to obtain a consistent and quality product.

NB: Soil residues slow down combustion and increase carbonization time.

2.3. Production techniques

2.3.1. Method 1: compacting and carbonizing

This first method produces compacted biomass briquettes that can be used directly as fuels. The residue used must be powdered beforehand. Sawdust, coconut shells or rice hulls are particularly suitable. To do this, a press should be available. The raw material, which has a humidity of 8-12%, is poured into a hopper. An endless screw drives the residues into a chain surrounded by electrical resistances whose function is to agglomerate the material (lignin facilitates this transformation) in order to obtain compacted and tough briquettes. The product, ejected from the press continuously and in a shape corresponding to that of the chain, is cut to the desired length. It requires high pressure; done with high-powered electrical machines. As a result, the endless screw and chain wear and tear. It is a question of taking these elements into account in order to avoid any problems that would lead to the shutdown of production.

The briquettes thus produced can also be carbonized. This will give them a higher market value than non-carbonized briquettes.

This manufacturing method is not very common because it requires a fairly substantial investment and an electricity connection (with a three-phase-powered meter). However, it allows to produce substantial yields.



A Chinese-made press. Benin.

2.3.2. Method 2: carbonization and pressing

a. Drying of waste

The next step following sorting waste is drying. This is an important phase of production because while all solid organic waste can produce briquettes, only dense, dry waste will produce quality coal dust. The drying time varies from two to seven days. In some areas, such as tropical wetlands, it is sometimes necessary to dry waste in an oven.



A two-ton oven to carbonize the already compressed briquettes. Benin.



Arranging waste on trays to dry in an oven. Cameroon.

Focus on: The optimal drying of waste

- The main beneficial factors for drying are exposure to heat and air circulation;
- Different types of waste have an equivalent drying time. This can range from two days to more than a week;
- Drying can be improved by pre-cutting of waste;
- Different drying techniques are possible: Table-Reed, wire mesh, plastic sheeting, etc.;
- In the rainy season, the waste should be disposed of under a well-ventilated shade/canopy.



A carbonizer made with a simple barrel. Burkina Faso.

b. The carbonization

The most delicate step in the production of green charcoal briquettes is the carbonization phase. This consists in allowing the chemical decomposition of the raw material, agricultural residues or plants, through the action of heat. This process takes place within a carbonizer made with a 200-litre metal barrel. Very dry biomass (plant or agricultural residue) is introduced into the boiler (carbonizer) that includes a lid (sometimes topped with a chimney), a door, openings on the sides that regulate the flow of air supply, as well as welded feet's and handles that allow the carbonizer to be manipulated. Before the carbonization process begins, all the necessary equipment must be available: a carbon oven, a shovel, leather gloves, a protective mask, a watering can with water and a tarpaulin or sheet metal.

It is necessary to operate as follows:

- Introduce the residues to be carbonized in the oven gradually to the top, while pressing them slightly to fill the space as best as possible;
- Avoid, however, too much watering off the residue to facilitate the passage of hot air. In fact, by pressing biomass, we create isolated spaces that do not facilitate the passage of heat;
- Turn on the fire and wait for it to enter the entire surface of the oven and then close the lid;
- Remove the topped lid from the chimney at the end of carbonization and let re-cool;
- Dump the resulting dust (carbon product) on a tarpaulin or on a sheet (if the temperature is still high);
- Repeat operations as desired.

It is necessary to choose a production site away from the houses in order to avoid complaints from the inhabitants because of the fumes released and possible accidents due to the heat.

Focus on: The good carbonization

Organic residue inside the boiler should not burn completely; they only have to carbonize.

The control consists of observing the smoke. If it is yellow, it means that moisture is still escaping. If it's white, the carbonization is perfect. On the other hand, if the smoke is blue, it means that the temperature is too high, then it is necessary to reduce the air inflows to slow the combustion, by obstructing, at least partially, the openings provided for this purpose.

Organic residues should not be burned, only carbonized, i.e. turned into coal. The difficulty of carbonization is therefore to control the entrants of air (oxygen) in order to obtain the largest quantity of a quality coal.

Focus on: The dust quality

- The quality of the briquettes produced depends on the quality of the coal dust (called ash) obtained during carbonization;
- Quality is determined by: residue selection, proper drying time and careful carbonization;
- Carbonization time is important:
 - If the time is too short, some of the material is not carbonized;
 - If the time is too long, you get too much ash.

Focus on: The protection, health and security

- It is imperative to perform the carbonization in the open air and to wear a protective facemask to protect against the smoke;
- The temperature of the carbonation furnace can be very high; caution is therefore required around it, especially for children. It is advisable to use protective gloves and keep anyone who is not involved in the production away from the ovens;
- Coal dust is highly volatile and dangerous to inhale when spread on the air. It is necessary to wear a breathing facemask.

Carbonization can occur near the area where residues are available if they are away from the compaction unit. This reduces the volume of materials to be transported. To this end, the green charcoal producer will train a group of people to perform carbonization. An agreement will be reached between the two parties to determine the purchase price of the dust.



SCIENTIFIC EXPLANATIONS

Carbonization is a technique that involves placing organic residues in defined heat conditions (from 400 to 600 degrees Celsius) and in a low-oxygen environment, to produce coal.

The proper course of the carbonization process depends on the proper management of the oxygen supply to the system. Too much oxygen can burn the raw material instead of producing the desired carbon material.

After the oven container is ignited, the temperature gradually rises to 100°C. Therefore, the humidity (about 10%) biomass evaporates.

The temperature then rises to 280°C. This phase, called endothermic, requires energy. This is provided by the complete combustion of a small part of the biomass contained in the carbonizer. If this biomass is dry, combustion will require less energy.

Starting at 280°C, the pyrolysis phase begins. Biomass breaks down into coal, tar and other elements. This reaction is called exothermic, it releases energy. Oxygen supply should therefore be limited by clogging the openings to avoid the total combustion of the oven contents. The heat from the pyrolysis causes the temperature to rise to 400°C, until all the material is turned into coal.

c. The grinding

After carbonization, the coal is still partially chopped. However, for the manufacturing of briquettes, it is necessary to dispose of coal dust. The next operation is to grind the dust from the carbonization. A regular grain coal powder is obtained when grinding is done with mechanical material. If done manually, the grind product will be sifted.

It is recommended that you have a storage site for coal powder and a certain amount of coal powder before compacting.

Focus on: The grinding and sieving

- It is difficult to compress the briquettes with large dust particles. Grinding enable to crush these particles to obtain a fairly fine coal dust;
- There are different ways to grind dust: simple tools such as mortar and pestle, manual grinders or mechanical shredders;
- For a small production, sieving can be done with a strainer made with wire mesh.



Mill for grinding cassava flour which is used as a dust mill to obtain green charcoal dust. Uganda.

d. The binders and kneading

To make a perfect compaction, add a binder to the coal dust. There are several binders: starch, cassava flour, arab gum, molasses, clay... Cassava flour is considered the best binder.

The mixture is done by hand or in a mixer. Cassava flour is often used because it contains starch that has a glue consistency. The proportions of the mix are approximately 1 kg of cassava flour, 10 litres of water, 20 kg of charred powder of organic residues. The binder is first prepared before coldly incorporated into the powder to obtain a mixture that is homogeneous and compact.

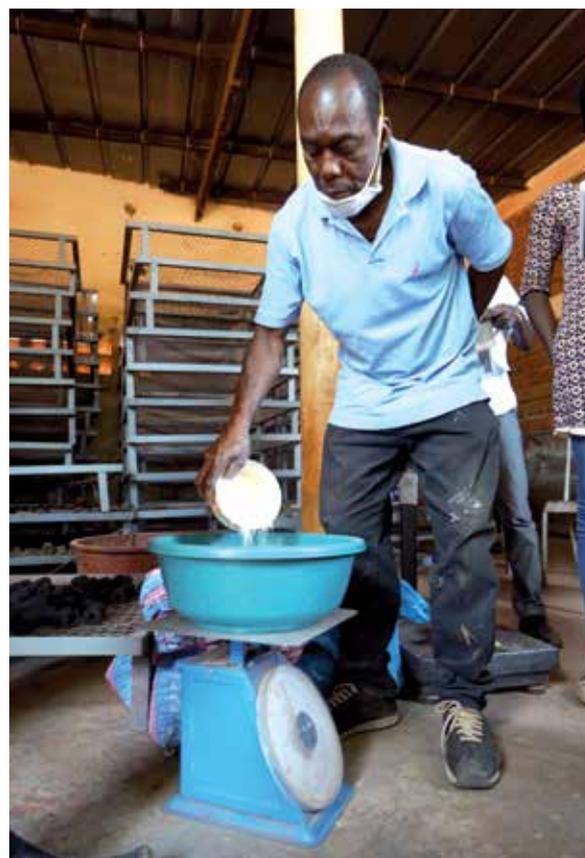
The choice of binder is important: depending on the binder chosen, the duration and intensity of the green charcoal combustion may vary.

Clay is another interesting binder. It is a component that helps to increase the burning time of the briquettes. But the ignition of briquettes made with clay is very difficult. The main binder used in large green charcoal production units is cassava flour.

Focus on: The binders' preparation: example with cassava flour

- Boil the water. The proportions are about as follows: 10 litres of water per 1 kg of cassava flour;
- Pour the flour into a small amount of cold water;
- Pour the dough into boiling water and stir until a change in texture appears, the mixture turns yellow and thickens;
- Let it cool.

To perform a test of a good proportion of the mixture: make a ball with the hands and then release it a meter high. The ball has to stand. If it breaks, there is not enough water. If it crashes significantly, there is too much water.



Weighing cassava flour as a binder. Burkina Faso.



Preparation of the binder using cassava flour. Burkina Faso.

Focus on: Mixing and kneading

- Weigh the fine dust, add the appropriate amount of binder and mix until the mixture is even;
- The binder should represent about 5% of the dry weight of the briquettes. It is therefore recommend to incorporate 1 kg of cassava flour to 20 kg of dry dust. For other binders, tests must be carried out;
- Sometimes it is necessary to add a little water to make it easier to knead;
- Mixing can be done on a tarp or in bowls. It can also be done manually or with a motorized mixer;
- Fine dust is dangerous for the respiratory system, it is important to take the necessary precautions when wearing a facemask. It is also advisable to use gloves.

NB: In excess of 7% cassava flour binder (dry weight), briquettes will emit smoke. Below 4%, they will break when drying.



Electric mixer made in Benin



Added binder to powder after carbonization and grinding. Burkina Faso.

e. The Compacting / pressing

This step is intended to compress the mixture obtained to acquire the green charcoal briquettes. This is done using a press whose capacity depends on the expected production volume.

The quality of green charcoal briquettes depends on the nature of the binder, the speed of compacting and the granulometry of the coal dust.

An important aspect of this step is the choice of the shape of the briquettes and the level of compaction. Indeed, the combustion will not be carried out in the same way if the coal is in the form of pellets or briquettes. The level of compaction that affects the speed of combustion will be less homogeneous in the case of manual compaction than in the case of mechanical compaction.



Machine, made in Uganda, which produces more than one tonne of green charcoal per hour.



A manual compacting press. Cameroon.



Green charcoal in the form of pellets, Uganda.



Compacting operation with a manual press. Democratic Republic of Congo.

f. The drying

The last operation in the production chain, just before marketing, is the drying of the briquettes.

The compressed briquettes are placed on dryers, which can be exposed to the sun or in a greenhouse, in order to dry gradually.

The aim is to reduce the humidity level in order to improve the combustion of the briquettes. Drying can be done in the open air in case the rain fall is low. The drying time of a briquette is one or several days depending on the rate of humidity and the season. This is the last step before marketing the product.

NB: If exposed to water, the binder will decompose. Regular testing is required on the briquettes produced to ensure consistency in quality.

Focus on: Quality control

- Quality control must be carried out at every step;
- A quality briquette burns well and does not crumble. In addition, it does not break until it is delivered to the customer.

NB : The briquettes do not fire-up well if they are not completely dry.



Sun-drying green charcoal rolls/slices on slats. Burkina Faso and Cameroon.



Drying briquettes on slats and under cover. Ivory Coast.

g. Le contrôle qualité

Quality control is all the operations carried out by the producers of green charcoal from the raw materials to the finished product. As far as the raw material is concerned, the operator will be interested in several elements:

- The fermentation rate of the raw material;
- The rate of decay (apart from fermentation decay) of the raw material;
- A possible infection with mildew (a fungus that colonises the raw material left in the environment);
- The general appearance of the raw material.

As far as the finished product is concerned, the operator will check:

- The moisture content of the finished product's output (generally of the order of 8 to 10 %). If the rate is higher than 10%, the briquettes will have to be dried again;
- A possible colonisation of the product by fungi that may come from the binder;
- The grammage and regularity of shape of the green charcoal;
- The calorific value, which will have to be tested;

Controls can be carried out in the laboratory or by the producers themselves using measuring kits.

Producers must ensure that their production is of consistent quality and that their green charcoal has a quality comparable to the charcoal.

Here are a few steps to follow for the quality control of the raw material:

- Weigh the mass;
- Measure the moisture content using a hygrometer ;
- Measure the amount of heat in the raw material, using a thermoflash (non-contact laser thermometer);
- Analyze by sight whether there are black spots on the peel or a whitish coating (a fungus).

Here are some steps to follow for the control of green charcoal briquettes:

- Weighing the samples;
- Using a hygrometer, measure the amount of water in the finished product (the moisture content should not exceed 10%);
- Check by sight whether the shapes are regular;
- Check that there is no whitish development on the outer surface.

h. The packaging

Packaging practices vary according to state policies. For example, in Congo Brazzaville, plastic packaging is prohibited, while in Uganda it is allowed. Several types of packaging can then be used: flour bags or feed bags for quantities of 25 or 50 kg, cartons for 5 to 7 kg of coal and resistant paper bags for lots of 1 kg, 2 kg, 3 kg or 5 kg.

If producers have enough financial resources, they can make print overs on their packaging in order for visibility of their product.

To create an advertising message, it is possible to draw inspiration from the ideas below. For example, it is possible to focus on the beneficial side of green charcoal.

Characteristics	Benefits
No smoke and soot	Green charcoal keeps your family healthy
Long-term combustion	Green charcoal saves you money
Low greenhouse gas emissions	Green charcoal respects the environment
Standardized quality	Good quality green charcoal is a trusted product
Similar use to charcoal	Green charcoal is as efficient for cooking as coal

See also "Advertising" paragraph in Chapter 4.1 The Marketing.

Plastic bag packaging in Uganda. In many French-speaking African countries plastic bags are not allowed.



Green charcoal storage shed in 50 kg bags. Uganda.

Packaging for retail. Cameroon.

Packing for deliveries of 1 or 2 kg. Congo.

3 | The materials

3.1. The carbonizers

Carbonization is the thermal decomposition of organic matter in the absence of oxygen or in a low-oxygen atmosphere. There is a wide variety of hardware to do this. Small producers use simple ovens made from old 200-litre metal barrel. Various adaptations are made to allow the adjustment of the air flow : openings on the sides, lid with hinge and chimney, holes around the barrel, handles welded to facilitate the movement of the oven, feet at the base of the oven to ensure its stability and regulate the air flow, etc. A door can be installed in the lower part of the oven to facilitate the recovery of dust.

Plans are available on request:

initativesclimat@gmail.com

More sophisticated ovens allow pyrolysis to be used to recover combustion gases during carbonization: the yield is better (45% for pyrolysis versus 25% for simple carbonization) and the dust is of high quality. Pyrolysis takes longer than a simple carbonization.

Another type of oven, of greater capacity, includes an insulated steel sheet structure with sand and refractory bricks. The carbonization is slower but of very good quality (no ash in particular) and the size of the oven in relation to the ovens made with barrels. This oven was designed during a research workshop organized by Initiatives Climat.

Information about this oven is available:

initativesclimat@gmail.com



Locally manufactured carbonizers. Cameroon.



Carbonization furnace with a volume of 1 m³. Ivory Coast.



3.2. The Compacting press

A press is used to compact the carbonized powder from the organic residue mixed with the binder to make briquettes.

Production per hour varies greatly depending on the driving force used (manual, engineless, motorized), the capacity and power of the press (number of moulds, ejection speed...), the mode of power (manual or automatic), the number of operators. Production can range from a few kilos to several hundred kilos per hour.

Depending on the press models, the briquettes come out in cylindrical pieces, cubes or in the form of pellets.

Information on this press, designed by Initiatives Climat (ICAF) in Burkina Faso in April 2019, is available: initativesclimat@gmail.com

Making a press prototype. Burkina Faso.



36 moulds compacting press. Ivory Coast.



Material that performs two operations: grinding and compacting. Morocco.



Press of 60 moulds made in Benin.

Production of briquettes with the ICAF press. Burkina Faso.

3.3. The measuring devices

It is necessary to have a moisture tester and a digital infrared thermometer with a measurement range of 32 to 400 degrees Celsius.

The moisture tester allows to know the moist of the residues to be carbonized and also that of the green charcoal briquettes. The thermometer tracks the rise in temperature during carbonization, especially for ovens insulated with refractory bricks.

4 | The use of green charcoal

4.1. The marketing

Part of the production of green charcoal, especially when done by women's groups, helps to cover the cooking needs of the producers themselves. However, the portion they consume themselves only takes a small part of the total volume produced. The marketing aspect is therefore important to cover production costs and generate income for producers.

The selling (or marketing) of green charcoal may be done near the production site because of the existence of an important market and a reduction on the cost of delivery.

The inception of a production unit must incorporate a market study, even if it is not carried out in the proper way by an expert: see "Chapter 7.1. Prior study in relation to energy needs".

4.1.1. The different trading channels

As an indication, here are examples of trading channels used by different producers.

The direct selling:

- Selling at the production site: a space can be set up in a room or under a canopy/ shade to welcome customers and sell green charcoal by weight. Customers are advised to bring their own containers;
- Selling to restaurant owners given their high fuel requirements, selling of 25 kgs per bag is possible. However, it is necessary to ensure delivery and to set up a system of orders over the phone;
- Selling to canteens: these can be corporate canteens, public authorities, schools, etc.

The distribution via resellers:

- Selling to charcoal distributors they already have a loyal customer base. It's about convincing them to offer a new product to this one. A competitive price compared to charcoal can be a good selling point;
- "Ambulant selling" selling in cities, where small vendors can offer green charcoal in a neighbourhood, on the corner of a street. Green charcoal can also be sold at strategic locations along traffic lanes and vehicle stop areas. These vendors can also target street food grillers sells on the streets, often from late afternoon;
- Market sales: a network of small resellers can ensure the flow of green charcoal to consumers;
- Food carts using scooters, rickshaws;
- Trade fairs at special national or regional trade shows or events.



Retail in a market. Cameroon.

Promotional actions

These actions both inform potential users about the existence of green charcoal, publicize its benefits and make sales. The choice of a form of action will vary depending on the location and the target people. These may include:

- Commercial animations on a stand in public places;
- Animations through groups: women's groups, village groups, neighbourhood associations, schools...

During these actions, it is possible to give out samples and inform potential consumers the different places where they can source their supplies later.

4.1.2. Advertising

For producers who can allocate a budget to advertise, it is possible to make a tarpaulin for commercial animations, posters or even flyers.

Radio is a good media to promote green charcoal. Producers can be invited into programs and also to broadcast commercials (paying). It is also possible to suggest that local television stations or bloggers make reports.

Social networks allow information to be disseminated quickly and free of charge, illustrated by photos and videos. This can include information on the production, uses of green charcoal or on the various points of selling.

Retaining one or more slogans can make sales more efficient. It would be advantage to use slogans to attract target audience. Examples:

- *"Protect your family, save money and protect forests";*
- *"Green products for a healthy future/world";*
- *"The New Generation of Charcoal";*
- *"Organic charcoal is the best";*
- *"Rejoice in a new cooking experience";*
- *"Clean and cheaper, briquettes are a bargain".*

4.1.3. Contacts and partners

It is essential to contact different stakeholders who are interested in renewable energy. This is the case of public institutions, private companies, international organisations, associations and NGOs that are involved in the dissemination of energy-efficient improved homes.

At a time when climate change issues are of concern to many stakeholders, it is interesting to present the benefits of green charcoal in terms of adaptation and mitigation at meetings or events on these issues.

4.2. The users' awareness

Most housewives and other biofuel users are unaware of green charcoal; its production is limited, sometimes even non-existent, in some countries. Priority has been given in recent decades to the dissemination of energy-efficient homes; these save wood and charcoal. However, these energy resources are depleted, and their purchase can represent a significant part of the families' budget.

As a challenge for producers, they must promote a new kind of fuel to the householders. Users are often reluctant because they are still uninformed about the characteristics of green charcoal. It is necessary to conduct activities with both users and distributors.

Perhaps the most effective way is to conduct demonstrations (in markets, at specific events) and to give away free samples for each to conduct their own tests. A more ambitious communication campaign, with the support of the media, is possible, but subject to having a budget.



Animation in a high school in Douala to introduce green charcoal. Cameroon.

4.3. The lighters



Ecological firelight produced by Eco Bio Africa (Simone MBOULE AKOMO), Cameroon.

A survey of a few markets and neighbourhoods close to the University of Douala revealed what the population uses to light the traditional fireplace: latex, oil and its plastic derivatives, old slippers, old clothes, etc. These commonly used fuels emit foul odours and toxic gases. They change the taste of foods cooked with embers and harm the health of humans and animals as well as the environment.

An eco-friendly firelighter has been designed; it is made using household waste, citrus waste and wood waste. It is water resistant and is available in all seasons because the raw material is abundant. It does not give off a toxic smell, but rather a pleasant natural fragrance, that of citrus. For its production, once the waste is collected, it must be rid of any plastic or iron chip, and then compacted with moulds. The resulting product is economical: a fire-light disk can be used for ten ignitions; a piece burns for ten minutes, giving the wood or charcoal time to ignite.

5 | The economic data

5.1. Investment costs

In estimating the cost, a set of expenditure items must be taken into account.

Direct costs

Organic waste supply	Training and monitoring	Making green charcoal	Marketing
<ul style="list-style-type: none"> • Purchase of organic residues; • Cost of transport; • Staff costs for collection and transport. 	<ul style="list-style-type: none"> • Training participation cost; • Purchase of an in-situ training service; • Purchase of an supplements or back-up (over one year). 	<ul style="list-style-type: none"> • Purchase of protective equipment; • Purchase of consumables (binders...); • Water and electricity costs; • Depreciation of equipment (for example, over three years); • Equipment depreciation cost; • Rental of premises; “ • Staff costs for production. 	<ul style="list-style-type: none"> • Packaging; • Communication and advertising costs; • Cost of samples; • Delivery costs; • Staff costs for marketing.

Indirect costs

Financial expenses	Managing expenses	Profit margin
Repayment of interest on loans taken out.	As a percentage of direct costs, for example 5%.	To be determined according to the price of fuels on the market in order to be competitive.

NOTE: Some of these expenses may be zero (if, for example, organic wastes are free) or very small.

5.2. Cost price

They vary greatly depending on the size of the production unit: craft unit, intermediate unit, semi-industrial unit and industrial unit (these are often “turn-key” delivered plants that are not studied in this guide).

Encrypted elements are given in the “Chapter 7.4. Choosing the Size of the Production Unit.”

6 | The green charcoal benefits

Green charcoal, as a substitute for charcoal, has advantages in several areas.

6.1. Social benefits

- The hardwork of collecting wood for women and girls is lightened; so, they can do other activities;
- Women's social status improves as a result of the training they receive and the income they receive from a green charcoal production activity. With this income, children can go to school and receive better care;
- People are better informed about the risks associated with climate change.

6.2. Health benefits

- Women and their children are less exposed to respiratory diseases due to inhaling burning fumes from wood and charcoal. Indeed, the combustion of a good quality green charcoal emits little smoke;
- The collection of organic waste in markets and in the streets helps to clean up cities.

6.3. Economic benefits

- Households and catering professionals save on the purchase of fuels because, most of the time, green charcoal is sold cheaper than charcoal;
- Capital gains are generated through the processing of agricultural residues;
- Local jobs are created;
- Income is generated, especially for women and young people;
- The local economy is energized;
- When green charcoal is exported; it brings foreign currency back to the country.

6.4. Ecological benefits

Green charcoal is a substitute for charcoal, which requires a large amount of wood to be produced. In Africa, forests and mangrove areas are overexploited:

- Greenhouse gas emissions (CO₂/carbon dioxide, CH₄/methane and N₂O/nitrous oxide) are reduced because green charcoal production emits less GHG than charcoal;
- The forest cover is preserved and restores naturally;
- Carbon sinks made up by trees are preserved because the pressure on wooded areas is less;
- Mangrove areas are better preserved;
- Maintaining forest cover promotes biodiversity.



THE POTENTIAL TO FIGHT CLIMATE CHANGE

- Deforestation avoided per tonne of charcoal: 5.5 tonnes of dry wood;
- Avoided CH₄ emissions per tonne of charcoal produced: 3.5 tonnes CO₂-equivalent;
- Calculations estimating the carbon credits generated by a Piro-7 machine yield 11.6 tonnes of CO₂-equivalent per tonne of green charcoal.

Source: *L'encyclopédie de la Francophonie*.

6.5. Political benefits

- States can take more strict measures to preserve forest cover (e.g. logging restrictions) because green charcoal offers an alternative for cooking food.
- The use of green charcoal supports in the achievement of nationally determined contributions (NDCs).



7 | The conditions for the success of the creation of a green charcoal production unit

7.1. Prior study in relation to energy needs

Any study in the creation of a green charcoal production unit must be accompanied in advance by an analysis of the energy situation of the region. This analysis allows to:

- Identify existing laws and regulations for firewood and charcoal production;
- Know the energy sources used by different users: households, collective establishments (restaurants, hotels, schools, SMEs, etc.);
- Assess the different uses and needs of users for charcoal and firewood, such as the monthly consumption of an average household or restaurant;
- Know the production, supply and sale of charcoal: coal miners, street vendors, distributors, shops...;
- Learn about the selling prices of charcoal to end-users and wholesalers (to find out their margin);
- Identify, if any, green charcoal producers in the region or country.

The collected information is used to:

- Assess the feasibility of creating a green charcoal production unit;
- Develop a business plan (for projects of a certain size that require investor research or loans);
- Size up the production unit to meet the needs of the market;
- Determine the price structure of green charcoal: costs of purchasing or collecting organic wastes, transporting them, damping equipment, binders and other consumables, electricity, personnel, packaging and marketing (advertising, delivery, margin for wholesalers).

7.2. Choosing organic waste and agricultural waste

As mentioned above, a wide variety of waste and residues can be used to make green charcoal. It should be to:

- Identify available local waste to use, preferably near the future green charcoal production unit;
- Classify the nature of this waste. Note that the humidity is one of the factors to be considered in the choice of waste to be processed: it is better to process the waste that has the lowest humidity;
- Assess the amount of usable waste (weight and volume);
- Assess the distances to be covered for the transport of waste and the means of transport that are necessary (vehicles and communication routes);
- Assess: purchase costs (if waste is sold, which is sometimes the case by agricultural processors), collection costs (e.g. if waste is collected in markets or in the fields), costs of transporting to the place where carbonization occurs.

7.3. Choosing the legal structure

Any group that has already been formed can engage in the production of green charcoal. However, it must first comply with the laws of its country that govern the marketing of biofuels.

The producer or producers who do not have a legal structure can organize themselves by:

- Grassroots community organization;
- Association, ONG;
- Cooperative;
- Young green entrepreneur (self-entrepreneur, individual company, LLC, etc.).

Artisanal production can be done informally with the support of family members or friends. As for the search for financing (subsidies or loans) and the commercialization of production, they often require legal status.

7.4. Choosing the size of the production unit

7.4.1. Craft unit

The production of green charcoal can be done manually with materials manufactured on site for a few hundred euros that can produce a few hundred kilos per month. The work surface can be about 50 square meters.



EXAMPLE OF A PRODUCTION UNIT OF A WOMEN'S GROUP IN BURKINA FASO

Field

The group already had land and constructed buildings/workshop. All it took was to do some construction work for a total of 600 euros.

Materials

- Three carbonizers at a unit price of 115 euros;
- A manual press of 20 moulds, priced at 500 euros;
- Mobile metal drying trays for a total of 450 euros;
- Small equipment for 340 euros;
- And the installation of the workshop for 600 euros.

That's a total of 2,235 euros.

This price can be reduced if the trays are made locally of wood. It should be noted, however, that they will be less durable. This price does not consider the possible acquisition of a means of transporting organic residues.



Women's group of the NGO SOS Energy, Burkina Faso.

7.4.2. Intermediate unit

For a larger production, of several tons per month, it is necessary to:

- Have a grant or seed capital to purchase the production equipment (it can be manual, but it is preferable to be electrified);
- Partly covered workspace: 100 to 200 square metres;
- Electricity supply if necessary;
- A skilled workforce.



EXAMPLE OF A TYPICAL PRODUCTION UNIT FOR A WOMEN'S GROUP IN CAMEROON

Plot

The purchase of land and the construction of premises are sometimes necessary. Here's a cost estimate:

- Purchase of the land: 1,500 euros;
- Store construction: 2,600 euros;
- Construction of a hangar: 460 euros.

That's a total of 4,560 euros.

Make sure the land has a water source. Otherwise, digging a well or supply work is necessary.

Materials

- Five carbonizers at a unit price of 60 euros;
- A motorized grinder priced at 600 euros;
- An electrified compacting press priced at 1,275 euros;
- A manual mixer priced at 250 euros;
- Drying trays for a total of 150 euros;
- Small equipment* for a total price of 600 euros;
- Five "rickshaws", which allow the residues to be transported from the fields to the production unit at 130 euros.

That's a total of 3,825 euros.

Transportation

Price of a motorcycle tricycle for transporting green charcoal to the places of sale: 4,500 euros.

* Scales, basins, wheelbarrows, buckets, shovels, scales, rakes, watering cans, drying tarpaulin, work gowns, boots, leather gloves, dust masks, empty 50 kg bags.



Women's group of the NGO Info Horizon, Cameroon.

7.4.3. Semi-industrial unit

For semi-industrial production, which produces tens of tons per month, it is necessary to have a production line that allows the completion of all the production stages. The investment can be estimated between 50,000 and 100,000 euros.

This list is given as an indication; they may vary depending on the country and the choices made for the acquisition of materials (locally manufactured or imported).



EXAMPLE OF KEMIT ECOLOGY'S SEMI-INDUSTRIAL PRODUCTION UNIT DOUALA, CAMEROON

The semi-industrial unit of KEMIT ECOLOGY SARL in Cameroon processes 120 tonnes of raw material each month into 22 tonnes of green charcoal and related products (scrub, charcoal, black soap, etc.).

Production site

It is necessary to have:

- An open site of at least 600 m² paved for the reception and pre-treatment of raw materials;
- A building with a minimum surface area of 400m² for the transformation of raw materials into green charcoal.

Materials

- A 6-wheel truck or a large model pickup for the collection of residues;
- Two or three motorcycles to collect it in hard-to-reach areas;
- A rotating drum carbonizer with a drying and carbonization capacity of one ton per hour (approximately 15,000 euros including accessories: air compressor, piping, control panel);
- A dry grinder with a 10-horsepower steam engine and a two-ton-an-hour capacity (1,500 euros);
- A conveyor belt with unlimited drop capacity (approximately 8,000 euros);
- A large-capacity mixer (about 7,000 euros);
- A multi-parameter compactor with a capacity of one ton per hour with radiator system at the exit and several moulds (about 12,000 euros);
- A coal-fired drying chamber with a drying finishing capacity of two tons every four hours with a giant vacuum cleaner and spare carts (about 15,000 euros);
- A fresh grinder for raw materials with high humidity (approximately 1,500 euros);
- Production utensils and inputs for an amount of around 8,000 euros.

That's a total of 68,000 euros, excluding transport vehicles and manpower.

A unit with such equipment can produce 32 to 70 tons per month, or 380 to 840 tons per year.



Kemit Ecology's production team consists of 15 people.

7.5. Choosing the location of the unit

7.5.1. Workspace

The workspace should have several areas:

- A *storage* area for collected waste: it can be in the open, which allows you to take advantage of the heat of the sun to accelerate the drop in the moisture level of the residues; it can also be under shelter to prevent the residues from being exposed to water during the rainy seasons. In areas where humidity is very high for much of the year (especially in tropical forest areas), residues may need to be dried in ovens;
- A *carbonization* area: it must be located a little away from buildings and workspaces so that staff and the neighbourhood are not inconvenienced by the fumes from carbonization. The necessary permits should be given to the relevant authorities to carry out the carbonization;
- An area for the *manufacture of briquettes*, where grinding, kneading and compacting operations are carried out;
- An area for *drying briquettes*: it can be in the open air to benefit from the direct heat of the sun or under a shade during the rainy seasons;
- A *storage* area, where the packaging and storage operations of the final production are carried out. A closed room can also be used for the storage of materials and consumables (e.g. binders and bags).

NOTE: Some rural producers (particularly village groups) produce less green charcoal during the rainy season because they are busy with fieldwork. In this case, the production of green charcoal is considered a dry season activity.

7.5.2. Location of the unit

Each producer invests primarily a place that he or she owns or has the communal space (for example the premises of a village group or cooperative). However, it is necessary to ensure that the raw materials that will be collected are not too far from the place of production. Transportation costs can be high in time and money.





ICAF press of 25 moulds.

7.6. Choosing the material

7.6.1. Locally made materials

For artisanal or intermediate units, it is recommended that the materials needed to produce green charcoal be produced locally. This manual provides information that allows local craftsmen to produce the materials mentioned. It is advisable to use good quality steel to have a sustainable/lasting equipment. Craftsmen and other welding workshops that are used to making metal huts or post-harvesting equipment are in principle qualified to produce green charcoal production materials. Competition is always possible in order to get the best value for money.

Locally manufactured materials will always be cheaper than imported materials. In addition, it will be easier to maintain and repair.

In the opinion of several African producers of green charcoal, the purchase of Chinese equipment carries a set of risks: sometimes high import taxes, wear parts not available locally, power of electric motors (sometimes tripled) not always compatible with the power capacity by electricity networks, substantial operating costs. It is necessary to have a solid experience before using this type of equipment.

7.6.2. Imported materials

There are manufacturers in several countries, including Brazil, China and France. The acquisition of these materials can only be envisaged in the case of a substantial production. The price of the first press model was estimated to 5,000 euros.

Some companies also offer turnkey plants, which produce several hundred tons of green charcoal monthly.

Production lines are also designed and manufactured in Africa. This is particularly the case with the Kemit Ecology facility in Cameroon.

7.7. Training and support

7.7.1. Self-taught

Many groups or individuals have embarked without outside support in the manufacture of green charcoal. They were collected, here or there, especially on the Internet, information often delivered sparingly and without scientific and technical validation. Most of these initiators have failed in their venture because they have not assembled all the necessary conditions to produce quality coal.

Many collective green charcoal projects have been found in Africa for the benefit of cooperatives and groups. But some of these projects have not survived at the end of the subsidies they have received. Is it necessary to remember that a production unit is only sustainable if it is economically profitable? And that this data must be considered from the design of the project?

However, a few pioneers managed to establish their unit because they had a good technical background, a favourable environment (incubator, university laboratory, etc.) or a solid experience as a charcoal producer (traditional charcoal producer). And of course, also motivation and perseverance to overcome the many obstacles that can arise.

Some of these producers are now gathered in the “African Green Charcoal Cluster”, whose goal is to *“contribute to the development of the green charcoal sector in French-speaking Africa”*. See Chapter 10: “The African Green Charcoal Cluster.”

7.7.2. With the support of producers

Green charcoal producers with a functional production unit are in high demand by associations and individuals to discover production techniques. They often agree to do this work on a voluntary basis. For lack of training structure, this is the main path open to anyone who wants to discover things first-hand, in addition to learning about the literature that exists on the subject.

7.7.3. With the support of trainers

Training for groups set up is beginning to be organized in different countries to meet the high demand. A first training, from a few days to a week, helps to raise awareness of the interest of green charcoal and to discover the stages of production. However, this is not enough to start creating a production unit on its own. In order not to fail, it is strongly recommended to be accompanied by an experienced person for a set of tasks: sizing the unit, choosing the equipment, setting up the equipment, starting the production chain, training on-site of the team, evaluation of the quality of production, support for management and marketing. This requires regular support over a period of several months to a year. This is one of the conditions for the success of the project.

The “African Green Charcoal Cluster” has a pool of trainers and experienced people, able to accompany such steps.



ONE REQUIREMENT: THE QUALITY OF PRODUCTION

A major condition to be fulfilled in order to sustain a production activity is that of the quality of the charcoal produced. Charcoal that is too brittle, charcoal that smokes or has a lower calorific value than regular charcoal will not be adopted by the end user. The latter will be inclined to use it if the charcoal has undeniable advantages during cooking and if it is sold at a lower price than charcoal. Quality is the essential criterion for acceptance. Therefore, a new producer must do everything possible to meet this requirement.

7.8. Marketing

- **Marketing elements:** invent a brand, and if necessary, deposit it (and make sure an anteriority search is carried out), design a logo, imagine a slogan, develop a poster, flyers, business cards, photos, video;
- **Packaging:** have bags of different sizes, preferably paper (1 kg, 2 kg, 3 kg and 5 kg) as well as large reusable bags for delivery to distributors who sell by weight;
- **Distribution of test samples** to end-users to gather their opinions. A small survey can be conducted using a simple MCQ (Multiple Choice Quiz) that has different elements: ease of use (especially ignition), supply possibility (proximity), efficiency (calorific value), purchase price (compared to other fuels), ease of use (smoke);
- **Modes of sale:** direct sales at the place of production, networks of small resellers, stores, selling or trading to communities, wholesalers;
- **Stock level** (to meet the demands of loyal customers and avoid disruptions).

8 | Training

8.1. Targeted goals

The training of future green charcoal producers is of great importance. In fact, few people or organizations provide training that covers all areas of expertise to be acquired to create and manage a production unit.

There are two types of training needs:

- Basic training: group animation techniques, human resources management, administrative and financial management, market research, budget forecasting (or even a business plan for projects of a certain size), project assembly, marketing and communication and marketing strategies...
- More specific training on green charcoal production techniques.

Basic training is usually provided by civil society support organizations, international cooperation organizations or incubators. Project owners should identify existing offers and contact training organizations.

The more specific training courses on green charcoal aim at a set of objectives for project owners:

- Acquire basics about the physical and chemical properties of green charcoal and understand the transformations that were made during its production;
- Find out which organic waste or agricultural waste is most interesting from a technical, financial and logistical point of view (transportation) for optimal production;
- Choose the right equipment based on the volume of production envisaged;
- Carry out a rational installation of the production unit;
- Master the different stages of green charcoal production;
- Supervise production when it is carried out by a group of people;
- Ensure regular maintenance of production equipment;
- Control the quality of green charcoal before it is put on the market;
- Basics for the marketing of fuels.

It is highly recommended to surround yourself with the collaboration of a trainer who has a great deal of experience in this field. This person will also have to accompany the project owner, on a regular basis, during the first year of operation of the unit.

8.2. A typical training module

It is suggested to conduct the training in two stages:

- Over a three-day period (discovery phase) to discover green charcoal, production technique, the benefits it presents and the conditions for creating a production unit;
- (deepening phase) with a producer to further the production technique.

It is essential that these initial trainings be supplemented by an experienced person, for example over a period of one year.

The discovery phases

It breaks down into four phases:

- Time 1: discovery of green charcoal;
- Time 2: manufacturing technique;
- Time 3: putting it into practice;
- Time 4: assessment and problematic points.

Day 1: Discovery of green charcoal - 0.5 days

This sequence, which takes place in the audio-visual room allows us to address the following questions:

- Definition and use of green charcoal;
- The physical and chemical properties of green charcoal;
- Green charcoal interests.

These presentations are followed by the presenting video reports on the experiences of three producers in Benin, Cameroon and Morocco. This then links to the production technique.

Day 2: Manufacturing technique - 1 day

The different steps, which take place in the field and in the production unit, allow us to discover the different stages of production:

- Raw materials: different useful waste, collection and preparation of these (drying, calibration...);
- Carbonization: explanation of the principle, discovery of carbonizers, carbonization test, collection of charred material;
- Grinding: getting carbon dust;
- Kneading: preparing binders, adding a binder and water to the carbon material, kneaded;
- Compaction: explanation of principle, invention of equipment, compaction tests;
- Drying;
- Testing the product obtained to verify its quality. Prospective producers are advised to do a laboratory test to calculate the ICH of their green charcoal.

All these operations are carried out by the trainer. Trainees observe and take notes.

Day 3: Practice - 1 day

In groups of four or five, the trainees put their acquired skills into practice. Each group produces green charcoal samples under the supervision of the trainer.

Day 4: Assessment and reflections - 0.5 days

This step, which takes place in the classroom, will now proceed/ connect to the production process from the tests conducted the previous day by the trainees.

In addition, it addresses the following issues:

- The conditions for a successful creation of a green charcoal production unit;
- Economic data: amount of investment, cost price, selling price;
- Professional fees/honorarium provided by the African Green Charcoal Cluster.



Participants in a training led by Initiatives Climat in Bobo-Dioulasso, Burkina Faso.

9 | The online directory of French-speaking African producers

A directory of green charcoal producers in French-speaking Africa is available online. It provides several types of data, such as the type of organization (village associations, cooperatives, young entrepreneurs...), the volume of production, some of the characteristics/specification of the products offered and sometimes the mode of production. The producers' files are illustrated with photos of their activities.

The first edition of the directory includes fifteen producers from ten French-speaking African countries. Additional new producers will be included later.

The directory is a valuable tool to facilitate exchanges of practices between producers, to share recommendations, difficulties encountered. It therefore includes the contact information of the producers in order to facilitate exchanges.

<http://www.initiativesclimat.org/Cluster-Charbon-Vert/Missions-et-activites>



10| The African Green Charcoal Cluster

10.1. Rationale for its creation

Since 2016, the *Initiatives Climat* association has produced a collection of advocacy and information materials on climate initiatives that can be accessed online (www.initiativesclimat.org), which includes 230 initiatives led by 220 project owners. These include green charcoal producers.

In order to encourage exchanges of practices, a collaborative training session was held in Morocco in March 2018. It brought together both green charcoal producers from eight African countries and interested members of Moroccan cooperatives to discover the green charcoal manufacturing process. During this meeting, the producers exchanged experiences on the manner of their operations, gave advice/recommendations and thought about ways to improve their activities. Co-op representatives benefited from the producers' experiences.

In addition, participants expressed a desire to strengthen their collaboration by creating a “green charcoal” cluster in French-speaking Africa that could provide a range of services.



Participants in the collaborative training organized by Initiatives Climat, held in Morocco, in March 2018.

10.2. Its structure and services offered

The overall objective of the cluster is to contribute to the development of the “green charcoal” sector in French-speaking Africa.

Operational objectives (Oo) include:

- Oo1: animating a regional cluster of producers;
- Oo2: building capacity;
- Oo3: producing reference publications;
- Oo4: communicating about the cluster's activities and encouraging exchanges.



AFRICAN GREEN CHARCOAL CLUSTER: SERVICES

GENERAL OBJECTIF

Contributing to the development of the green charcoal sector in French-speaking

PORTING

Initiatives Climat Association

OPERATING STRUCTURE

Membres, a steering committee and coordinators

THE SERVICES

1

Capitalisation and diffusion
of best practices

2

Exchanges between producers
(self-fertilization)

3

Research
et development

4

Training
(pool of trainers)

5

Advice and
support of producers

6

Monitoring

7

Financial support

8

Communication

RESSOURCES

Directory

A directory of producers is available online:

- <http://www.initiativesclimat.org/Cluster-Charbon-Vert/Missions-et-activites>

Video report in English

Report on activities carried out under the “African Green Charcoal Cluster”:

- <http://www.initiativesclimat.org/Mediatheque/Reportages/The-African-Green-Charcoal-Cluster>

Video reports in French

Reports on the production of green charcoal and the manufacture of production equipment:

- Presse de compactage manuelle à vérin : <https://vimeo.com/460589501>
- Presse de compactage électrique : <https://vimeo.com/460587020>
- Préparation de la matière à compacter : <https://vimeo.com/460584579>
- La carbonisation dans des fûts métalliques : <https://vimeo.com/460580733>
- Fabrication d’un carbonisateur métallique : <https://vimeo.com/460577101>
- La carbonisation avec un four en briques réfractaires : <https://vimeo.com/460579030>

Reports on green charcoal producers by Initiatives Climat:

- Kemit Ecology, Cameroon: <http://www.initiativesclimat.org/Mediatheque/Reportages/Production-de-charbon-vert-au-Cameroun>
- Biochar, in Morocco: <http://www.jeunes-entrepreneurs-verts.org/Mediatheque/Reportages/Hassan-EL-HEMER-producteur-de-biochar-et-de-briquettesde-charbon-vert>
- Almighty Services Plus, in Benin: <http://www.jeunes-entrepreneurs-verts.org/Mediatheque/Reportages/Romeo-AZONHOUMON-le-specialiste-des-energiesrenouvelables>

Publishers' websites:

www.initiativesclimat.org

www.4c.ma

www.ma.undp.org

