Natural Resource Conservation and Development-III

Based on March 2018, Version3 Occupational standards

Module Title: - Promoting Sustainable Utilization of Forest-based Energy Sources

LG Code: AGR NRC3 M 06 LO (1-3) LG (39- 41)

TTLM Code: AGR NRC3 TTLM 0621v1

June, 2021

Adama, Oromia, Ethiopia

East Africa Skills for Transformation and Regional Integration Project (EASTRIP)

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LG #39	**LO1: Identify and introduce fuel wood & charcoal trees and shrub species**

Instruction sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Accessing and utilizing relevant information • Selecting and introducing fuel wood trees and shrubs • Selecting trees and shrubs for charcoal production • Carrying out trees and shrubs replacement planting This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Access and utilize relevant information • Select and introduce fuel wood trees and shrubs species in accordance with relevant regulation. • Select and introduce trees and shrubs species that used for charcoal production in accordance with relevant regulation and organizational policy • Carry out trees and shrubs replacement planting in accordance with relevant regulation and organizational guideline

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets”
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Accessing and utilizing relevant information

Introduction

Fuel wood (firewood and charcoal) are the most important energy source and the leading forest product in most developing countries, where they may contribute 50 to 90 percent of all energy used and 60 to 80 percent of total wood consumption. Around 1.8 billion cubic meters of round-wood (roughly half of the global supply) is currently used as fuel each year.

As the global demand for energy is soaring, high fossil fuel prices, increasing greenhouse gas emissions and concerns over energy import dependence are prompting a major shift in the sources from which energy is derived. Alternative forms of energy are receiving considerable interest as a means to reduce fossil fuel consumption and limit greenhouse gas emissions. For instance, biomass such as wood, crops and agricultural by-products can be used as a renewable source of energy, known as bioenergy. This bioenergy could help reduce dependence on fossil fuel imports and lower energy price while emitting less greenhouse gases than fossil fuels.

As in most sub-Saharan countries, a marked feature of Ethiopia's energy sector is the high dependence on biomass (firewood, charcoal, crop residues and animal dung). The bulk of the national energy consumption is met from biomass sources. It has one of the lowest rates of access to modern energy services, whereby the energy supply is primarily based on biomass. With a share of 92.4% of Ethiopia's energy supply, waste and biomass are the country's primary energy sources, followed by oil (5.7%) and hydropower (1.6%)

It is estimated that biomass energy accounted for 89 percent of total national energy consumption in 2010. Nearly 60 million tons of biomass is consumed for energy purposes with about 81% of the estimated 16 million households using firewood and 11.5% of them cooking with leaves and dung cakes. It has one of the lowest rates of access to modern energy services, whereby the energy supply is primarily based on biomass. With a share of 92.4% of Ethiopia's energy supply, waste and biomass are the country's primary energy sources, followed by oil (5.7%) and hydropower (1.6%)

1.1. Accessing and utilizing relevant information

Relevant information may be including

- Organizational rules, regulation and guidelines
- Internet, related books and related materials
- Technical manuals
- Virtual library
- Workplace guidelines
- Recorded documents/logo/history

Self-check 1	Written test

Name………………………………… ID……….. Date………………

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Give short answer (6 point)

1. Write at least the three ways to get relevant information?
2. What is the importance of fuel wood?

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Information Sheet 2- Selecting and Introducing Fuel wood trees and shrubs

2.1. Selecting and introducing fuel wood trees and shrubs

Plant identification is a skill that takes time and patience to develop. The reward for developing this skill is confidence when communicating with clients, improved access to plant diagnostics materials (most based on plant identification) and the personal satisfaction of knowing the names of plants in the community. The steps to plant identification involve observation, questioning, and research, similar to the process learned in diagnosing tree disorders.

The most important skill used in successful plant identification is the ability to observe and define the characteristics of an individual plant. examine the plant and note the structure and texture of stems, leaves, flowers and fruit, as well as any available roots.

Charcoal plays an important role in both the energy sectors and the economies of most African countries. However, the inefficiencies inherent to the production and use of charcoal, rapid urbanization, and the preference of urban dwellers for charcoal place a heavy strain on local wood resources. This in turn has severe environmental consequences. The use of charcoal cannot be stopped; but, experience has shown, it can be reduced through implementing a variety of measures that promote the sustainable production of wood and efficient use of charcoal through incentives at the local level. Players in the charcoal market need to be guided so that they can make efficient use of the resources. This should have a high priority in the development plans for most African countries. The World Bank can help by allocating more funds for the realization of these plans.

Plant identification is a process that begins with observing the plant as a whole, followed by evaluating the details of the plant parts. Gathering data and making notes of details before looking at references often saves time and frustration during the actual identification process. The details may seem trivial, but can play a major role in determining the species being identified.

Step 1: Collect information regarding the Plant

A. Determine if the Tree / Shrub is a Conifer or a Broadleaf flowering Plant

- Conifers are woody trees and shrubs generally with needle-like or scale-like foliage, and usually evergreen.
- Broadleaf flowering plants (members of the Angiosperms) are a highly diverse group of plants that produce seed via flowers. This group includes woody trees, shrubs, and vines and is often referred to as broadleaf plants due to the flattened leaf blade.

B. Determine if the Plant is Deciduous or Evergreen.

- Deciduous plants shed leaves in the fall.
- Semi-evergreen plants may retain some leaves, depending on winter temperatures and moisture.
- Evergreen plants retain leaves for multiple seasons. Leaves (needles) will be present throughout the year. Most conifers are evergreen, along with some broadleaf plants

C. Determine the Growth Habit of the Plant.

Growth habit refers to the genetic tendency of a plant to grow in a certain shape and to attain a certain mature height and spread.

- Trees typically have a single trunk and mature height over 12 feet.
- Shrubs typically have multiple-branches from the ground and a mature height less than 12 feet.
- Vines have a climbing, clasping, or self-clinging growth habit.

Note: The term "tree" or "shrub" would be applied based on the general appearance of the plant.

Step 2- Consult a Key person

Most biomass energy in Ethiopia is derived from owned sources like farm trees or cattle, or is collected by households from common property lands. The biomass energy consumption is primarily limited to meet cooking needs of households and traditional industries and services in rural areas. In absence of a developed energy market in rural areas, most biomass fuels are not traded nor do they compete with commercial energy resources. In developing countries, due to excess labor, biomass acquires no resource value so long as it is not scarce. In the absence of an energy market, the traditional biomass fails to acquire exchange value in substitution. Absence of market thus acts as a barrier to the penetration of efficient and clean energy resources and technologies.

Self-check 2	Written test

Name_______ ______________________ ID_____________Date______________

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test II: Short Answer Questions

1. how do you identify plant for fuel wood? (3pts)
2. What types of information would be gathered during selection of fuel wood trees? (4pts)
3. What is the difference b/n tree and shrubs? (3pts)

You can ask you teacher for the copy of the correct answers

Note: Satisfactory rating – 6 points Unsatisfactory - below6 points

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Information Sheet 3. Selecting trees and shrubs for charcoal production

3.1. Selecting trees and shrubs for charcoal production

Many people who want to obtain firewood from their own woodlots are concerned about the practicality and sustainability of this practice.

- Which trees species
- Time to cut the trees
- Drying, then split or split it first

This information provides the basics of choosing and cutting trees out of a woodlot for fuel use. Since it is possible to ruin the value of a woodlot and reduce the efficiency of your wood stove by cutting the wrong trees for firewood, these guidelines will help you improve the condition of your forest and get the most fuel heat from your labor. Firewood derived from one's own woodlot might pass the test of economics, but make sure you are considering all the associated costs

1. Selecting trees appropriate for charcoal production

Fortunately, given the problems of fuelwood and charcoal supply in many developing countries where natural forests have been cleared, or otherwise devastated, forest science has developed systems for cultivating man-made plantations of quick growing forest trees. The eucalypts native to Australia have been widely adopted and modified by selection for this purpose throughout the world. There are many species of eucalypts used in plantations, allowing adaptation to particular local conditions, and, fortunately all make excellent fuelwood and charcoal. Where plantations are established and managed correctly on suitable sites, growth can be rapid. Mean Annual Increments (MAI) of 15-20 m^3 per ha over 12-20-year rotations are not uncommon.

The consumption of fuel wood is very high in Ethiopia, but the production of fuel wood has not been able to keep pace with requirements, the prices of fuel wood during last 40 years have shown an abnormally high increase. Because of the escalating prices of petroleum products and the rising demands, a stage has reached where fuel woods can be economically farmed with inputs of selected species and varieties of plants and biofertilizers.

Useful criteria for selecting species for fuel-wood in developing countries are that they should be:

- Preferably coppicing hardwoods
- Adapt well to the site conditions
- Easy to establish and require minimum care, especially where the establishment is by farmers in agroforestry situations.
- Readily available as seed or plants
- Grow rapidly with early culmination of current annual increment
- Have nitrogen-fixing ability
- Produce high-calorific wood, which burns without sparks or toxic smoke, splits easily and dries quickly. Usually they are moderate to high-density species.
- Have resistance to goat and wildlife damage, unless grown also for fodder
- Multiple-use species.

Fuel wood (charcoal and/or firewood) species used by the Afar and Oromo (Kereyu and Ittu) Nations in and around the semi-arid Awash National Park (ANP), Ethiopia was conducted ethnobotanically. From 27 species used for charcoal and firewood production, 11 species (40.7%) belonged to the genus Acacia.

Table 1. Species selected for charcoal production in Ethiopia

No	Scientific Name	Family Name
1	Acacia abssyinica	Fabaceae
2	Acacia nilotica	Fabaceae
3	Acacia seyal	Fabaceae
4	Acacia tortilis	Fabaceae
5	Allophylus abyssinicus	Sapindaceae
6	Cardia Africana	Boraginaceae
7	Combretum mole	Cuperssaceae
8	Croton macrostachyus	Euphorbiaceae
9	Dichrostachus cinereal	Fabaceae
10	Eucalyptus camaldulensis	Myrtaceae
11	Eucalyptus glubules	Myrtaceae
12	Junipeus procera	Cuperssaceae
13	Nuxia congesta	Loganiaceae
14	Olea welwitshii	Oleaceae
15	Osyris quadripartite	Santalaceae
16	Terminalia browin	Combretaceae
17	Ziziphus spina	Rhammaceae

Self-Check –3	Written test

Name…………………………………………… ID……………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions. (10 point)

1. List down at four tree species used for charcoal production in Ethiopia. (4pts)
2. What are the criteria for selection of species for fuel-wood? (4pts)
3. How many tree species are identified for fuel wood production in Ethiopia? (2pts)

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 5 points Unsatisfactory - below 5 points**

Operation Sheet 3 - **Selecting trees and shrubs for charcoal production**

Objective to Selecting trees and shrubs for charcoal production

Materials needed:

1. Note book
2. Pen
3. Hut
4. PPE

Procedures:

1. Observe plant species around your environment
2. Apply fuel wood selection criteria
3. Identify and select fuel wood tree species
4. Collect the equipment's you used and store in appropriate place.
5. Prepare a report to supervisor

Information Sheet 4- Carrying out trees and shrubs replacement planting

4.1. Carrying out trees and shrubs replacement planting

Cover plantations which may range in size from woodlots, grown by individuals or communities, to larger forests usually under government or industry management. At the smaller scale they can be appropriate for supplying local needs of urban people. Larger scale plantations are more appropriate for supplying wood for charcoal or small-scale industries (e.g. bakeries, brick, potteries) or for use in wood fuel-based power stations or perhaps conversion to liquid fuels.

Site evaluation is the assessment of suitability or potential of the site for one or more specified land use type. In this context, it involves the determination of the suitability of an area for production plantation establishment.

4.1.1. Important attributes of a site for plantation purpose

Three important aspects of an area are worthy of consideration in site evaluation for forestry.

- Biophysical attributes of the area
- Socio-economic factors
- Environmental factors

1. Biophysical attributes of the site

Biophysical attributes of the site: denotes the totality of biotic and abiotic factors that can affect the survival, development and growth of a given tree species.

The three major physical/abiotic environmental factors are climate, soil and topography. Site assessment in forestry involves the characterization of a given site in terms of these important environmental factors. The site will be described through a quantitative and qualitative assessment of these factors to enable making decision on its capacity for tree growth and the appropriate species for planting.

A. Climate

Climate is the most dominant factor determining the potential of the site for tree growth. The main descriptors of the climate of an area with respect to plantation establishment requirement are:

B. Rainfall

- ✓ Total amount of rainfall
- ✓ Distribution of rainfall – the number of months with a certain amount of rainfall

C. Temperature

Most tropical species have optimum growth between 20^0 C and 35^0 C. Below 10^0C chilling injury may occur while temperature below 0^0C could kill trees.

Diurnal temperature variation can affect the germination and growth of shoots. It will be important to measure the following variables of temperature on the site.

- ✓ Mean annual temperature
- ✓ Mean temperature of the hottest months
- ✓ Mean temperature of the coldest months
- ✓ The coldest or hottest temperature ever recorded

D. Potential evapo-transpiration

Help to determine the water balance of the site. Determination of the water balance of an area will be very important, if possible, to assess the suitability of an area in terms of moisture availability.

E. Soil

The soil serves three basic functions for tree growth

- ✓ Supply of moisture
- ✓ Supply of nutrients
- ✓ Provision of mechanical support

The following properties of the soil determine its capacity to fulfil its three basic functions and needs to be assessed

- ✓ Depth
- ✓ Soil structure and texture
- ✓ Fertility
- ✓ PH

2. Socio -economic considerations

I. Economic transport distance of the product

Firewood and charcoal: In many cases, plantations are managed for the purpose of producing both fuel wood and poles. In Ethiopia these plantations are largely established by villagers themselves, and small units by the government, which means that the plantations are in relatively small units, usually close to villages.

In some countries, also in Ethiopia to some extent, the government has started plantations near towns, to provide town people with fuel and poles.

To minimize the transport distance, firewood plantations for domestic use should be located as close to villages as possible. It is more economical to transport charcoal than firewood over long distances. Charcoal is commonly transported over 200-300 km in many African countries.

II. Management of plantations

Establishment and management of fuelwood plantations is a specialized branch of forestry and should only be attempted when specialist advice has been obtained. To be successful it is necessary that land of suitable fertility be set aside for the plantations, that a suitable tree species be selected and that a proper system of dedicated management be set up. The first crop will not be produced until 12 - 15 years have passed which makes the development of man-made forests a job for government, well organized cooperatives, or a large private corporation.

Producing wood for charcoal from plantations demands that the cost of producing the fuelwood on the stump be carefully calculated to ensure that such a long-term investment is, in fact, worthwhile. On the other hand, the cost or stumpage of wood from natural forests is arbitrary and is set, in effect, by ordinary market forces, somewhere between zero cost where a small-scale charcoal producer gathers wood without payment from vacant forested land, and the cost of producing equivalent fuelwood from plantations. State forest service's sometimes attempt to set fuelwood stumpage by calculating the management cost of the natural forest from which the wood is taken. Sometimes private natural forest owners set a stumpage rate as a percentage of the value of the charcoal produced.

Management option such as coppicing, thinning, weeding, pruning, and pollarding is very important based on the tree species.

III. Unit processes of charcoal-making

Charcoal-making can be divided into several stages or unit operation. They are:

- Growing the fuelwood or plantation
- Management
- Wood harvesting
- Drying and preparation of wood for carbonization
- Carbonizing the wood to charcoal
- Screening, storage and transport to warehouse or distribution point.

Self-Check –4	Written test

Name…………………………………………… ID……………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions. (10 point)

1. Write down the three important aspects considered in site evaluation (3pts)
2. List some management option for fuel wood tree species. (3pts)
3. What are the two most important climatic factors during site evaluation? (4pts)

You can ask you teacher for the copy of the correct answers.

***Note:* Satisfactory rating – 5 points** **Unsatisfactory - below 5 points**

LAP Test	Practical Demonstration

Name. ___________________________ID _______________ Date: ________________

Time started: __________________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 2 hours.

Task 1. Select trees and shrubs for charcoal production

LG #40	LO2- Improve the existing Traditional Charcoal Making Technologies

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Observing and applying OHS procedures
- Constraints and limitations of traditional charcoal making technologies
- Introducing modern kilns

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, **you will be able to**:

- Identify constraints and limitations of existing traditional charcoal making technologies based on their efficiency
- Introduce modern kilns based on interest of the community
- Observe and apply OHS procedures to prevent their further expansion according to working documents

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the "Self-checks" which are placed following all information sheets.
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Information Sheet 1- Observing and Applying OHS procedures

Introduction

Charcoal is a residue of solid organic matter that results from incomplete carbonization by heat in the absence of air at temperatures above 300°C. The essential requirement for wood carbonization is a source of heat to raise the temperature to the necessary level and exclusion of oxygen. Various methods have been used in wood carbonization (commonly referred as charcoal burning). Some of these methods are crude with low yield and very limited control of the quality of the charcoal produced while others are highly automated (e.g. retorts). The efficiency of traditional charcoal production methods is about 10%–22%. Higher charcoal conversion efficiency and quality can be achieved through proper control of the carbonization process. The carbonization process for oil drum kiln takes 6-12 hours giving a charcoal recovery of 28- 30%.

Charcoal ready for use by the consumer implies a certain sequence of steps in a production chain, all of which are important and all of which must be carried out in the correct order. They have varying incidence on production cost. Noting these differences enables the importance of each step or unit process to be assessed so that attention may be concentrated on the most costly links of the production chain.

1.1. Observing and applying OHS procedures

Occupational Health is a multi-disciplinary activity that aims at

- Protection and promotion of health workers by preventing and controlling occupational disease and accident and eliminate occupational factors and condition hazards.
- The enhancement of physical, mental and social well-being of workers

The Occupational Safety and Health requires employers to implement fire protection and prevention programs in the workplace.

OHS requirements are to be in line with applicable Commonwealth, State or Territory legislation and regulations, and organizational safety policies and procedures, and may include:

- personal protective equipment and clothing
- safety equipment
- first aid equipment
- firefighting equipment
- hazard and risk control
- elimination of hazardous materials and substances
- safe forest practices including required actions relating to forest fire
- protective shields for welding and grinding activities
- Protect from fire flames
- Care while using tools and equipment like axes and cross-cut saw
- Use appropriate manuals before operation of introduced charcoal making machines

Self-Check –1	Written test

Name………………………………………… ID……………… Date……

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Part I. Give short answer (6pts)

1. What is charcoal? (2pts)
2. What is the main objectives of OHS? (2pts)
3. List down materials needed for charcoal making. (2pts)

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 3 points Unsatisfactory - below 3 points**

Information Sheet 2- Constraints and limitations of traditional charcoal making technologies

2.1. Constraints and limitations of traditional charcoal making technologies

In the traditional charcoal kiln or pit some of the wood loaded into the kiln is burned to dry the wood and raise the temperature of the whole of the wood charge, so that pyrolysis starts and continues to completion by itself. The wood burned in this way is lost. By contrast, the success of sophisticated continuous retorts in producing high yields of quality charcoal is due to the ingenious way in which they make use of the heat of pyrolysis, normally wasted, to raise the temperature of the incoming wood so that pyrolysis is accomplished without burning additional wood, although some heat impact is needed to make up for heat losses through the walls and other parts of the equipment. The combustible wood gas given off by the carbonizing wood can be burned to provide this heat and to dry the wood. All carbonizing systems give higher efficiency when fed with dry wood, since removal of water from wood needs large inputs of heat energy.

The pyrolysis process produces charcoal which consists mainly of carbon, together with a small amount of tarry residues, the ash contained in the original wood, combustible gases, tars, a number of chemicals mainly acetic acid and methanol - and a large amount of water which is given off as vapor from the drying and pyrolytic decomposition of the wood.

When pyrolysis is completed the charcoal, having arrived at a temperature of about 500° Celsius, is allowed to cool down without access of air; it is then safe to unload and it is ready for use.

The overwhelming bulk of the world's charcoal is still produced by the simple process briefly described above. It wastefully burns part of the wood charge to produce initial heat and does not recover any of the by-products or the heat given off by the pyrolysis process.

Other woody materials such as nut shells and bark are sometimes used to produce charcoal. Wood is, however, the preferred and most widely available material for charcoal production. Many agricultural residues can also produce charcoal by pyrolysis but such charcoal is produced as a fine powder which usually must be briquetted at extra cost for most charcoal uses. In any case, encouraging the wider use of crop residues for charcoal-making or even as fuel is generally an unwise agricultural practice, although the burning of sugar cane bagasse to provide heat in sugar production and the burning of cornstalks and coarse grasses as domestic fuel in some regions do provide an overall benefit where carried out as part of a rational agricultural policy.

On the grounds of availability, properties of the finished charcoal, and sound ecological principles, wood remains the preferred and most widely used raw material and there appears to be no reason why this should change in the future.

There are two broad categories of energy resources and delivery systems: The traditional energy systems and the modern/conventional energy systems.

2.1.1. Traditional charcoal making technologies

Until the beginning of the twentieth century virtually all charcoal was produced by traditional methods. Wood was put in dug-out earth pits, lit and covered with earth. The combustion of part of the wood produced enough heat to carbonize the remainder. For conversion of wood into charcoal people use "kilns".

The most common types of traditional kilns are earth pit or mound kilns with efficiencies ranging between 8% and 12 %

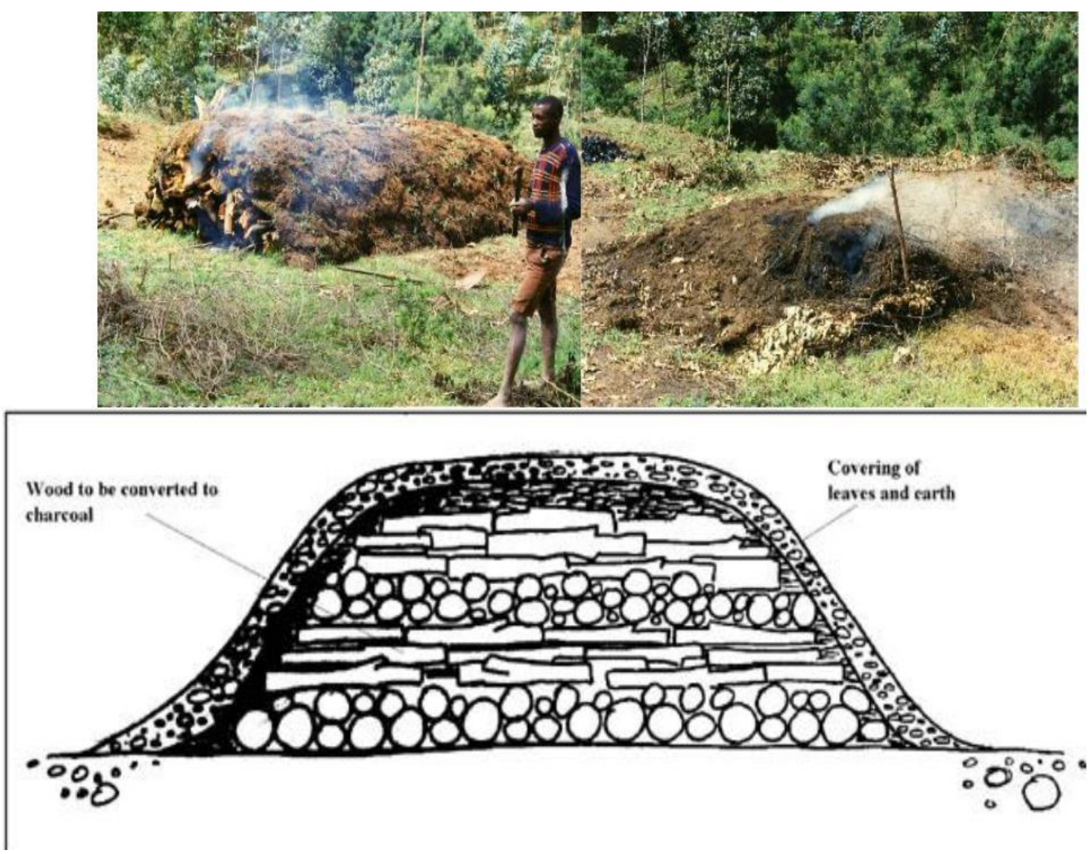
1. Earth Pit Kilns

Earth pit kilns are the traditional way of making charcoal in many parts of the world and may represent the simplest technology for charcoal production. In brief, the process of using an earth pit kiln begins by stacking wood in a pit, sealing it with a layer of grass and soil and starting carbonization by igniting the wood at one end. Earth pit kilns are typically large and large pieces of wood can be used. But can these kilns can also be built in small size and can thus, be suitable for families and even individuals.

Pit kilns are labor intensive since a pit must be dug into the ground. Ventilation may also be difficult to control and often carbonization is incomplete, producing only low-quality charcoal. To improve efficiency, pit kilns can be equipped with a chimney which allows the use of biomass other than wood, such as coconut shells.

2. Earth Mound Kiln

This is also a common kiln used for charcoal production. It can be constructed from locally available material. In brief, wood is collected and stacked in the polygonal shape of kiln. The wood is then covered with a layer of grass and the construction is sealed with soil. A small opening allows the control and monitoring of the process. When the kiln has been lit, it requires continuous attention for 3 to 15 days depending on the size. After the kiln has cooled down charcoal can be harvested. The main advantage of this type of kiln is that it can be constructed easily without cost at the harvest site.



Pic.1. traditional charcoal making

2.1.2. Constraints to sustainable wood fuel production

The constraints of the traditional technologies for charcoal production concern the difficulty in the mechanization of firewood loading and charcoal unloading.

a. Lack of technological development. In most developing countries wood fuels are still perceived as a primitive source of energy best suited to the poor and for subsistence use. As a consequence, there is little interest in rational management of supply, and forest resources are often harvested without regard to future sustainability. For example, improved charcoal kilns were introduced with efficiency gains of 30 to 40 percent (see Table below)

	Traditional	**Improved**	**Modern**
Energy Planning	None	Supply and Demand	Integrated
Type of Energy	Thermal	Thermal	Thermal electric
Forest Management	Open Access	Sustainable	Certified
Conversion	Traditional Kilns Eff. 8-12%	Improved Kilns Eff. 18-25%	Low Cost Retorts Eff. >30%
Marketing	Unregulated	Semi-Organized	Out grower Scheme
Consumption	Traditional Stoves • Eff. 5-15% • High CO2 & Emissions	Improved Stoves • Eff.20-30% • Medium CO2	Gasifier Stoves • Eff. 25-35% • Low CO2 Emission

b. **No regulation results in underpricing-** through the wood fuel value chain and low incentives for efficiency, both when wood is converted to charcoal and at the point of end use. In spite of this marginalization, commercial wood fuel value chains can be significant in scale, involve considerable investment, and provide a source of income for many urban and rural poor.

c. **source of global deforestation**- Wood fuel harvesting is no longer considered as the primary source of deforestation as it was in the 1970s. Now, it is understood that most permanent removal of tree cover results from the clearing of land for farming, itself a result of population growth and low agricultural productivity.

Box1. Underpriced Wood fuel - Jeopardize Sustainable Forest Management Weak law enforcement, a merchant oligopoly, and open forest access keep prices for wood fuel producers artificially low and render sustainable management unprofitable, made worthwhile only by external funds. Natural forests managed by local communities are in most cases overexploited, of low productivity, and in need of rehabilitation. This is unsurprising given that poor rural communities are often expected to bear the costs and risks of forest management, rehabilitation, and protection, while receiving only a low percentage of already deflated wood fuel revenue. Low wood fuel prices similarly disincentivize farm forestry, with high start-up costs (especially during the first year), high interest rates, high opportunity costs of land, and a long maturation period compared with (often subsidized) agriculture or livestock keeping.

Impact of charcoal production

Emissions the by-products of charcoal production are pyro acids, primary acetic acid and methanol, tars, heavy oils and water, the majority of which is emitted into the environment with the kiln exhaust. The emissions into air include gaseous emissions of carbon monoxide (CO), carbon dioxide (CO_2), methane, ethane and volatile organic compounds (VOC); emissions of the particulate matter (PM) coming from the un combusted tars and charcoal dust, and pyro-acids that may form aerosol emissions. The level of emissions depends highly on the technology used for the production, the temperature developed during the pyrolysis as well as on the moisture content of the wood. (Domac and Trossero 2008) presents a comparison of air pollutant emissions for different types of charcoal production. For example, emissions from traditional charcoal production methods in several African countries expressed in g per kg of charcoal produced are given as 450 to 550 for CO_2, 700 for CH_4, 450 to 650 for CO and 10-700 for NMHC (non-methane hydrocarbons). Such emission levels, especially that of methane, which has a high global warming potential (GWP), can be perceived as significant environmental impact on both regional and global level. The main reason for these rather high levels of air emissions is the incomplete combustion of wood and gaseous by-products of charcoal production, which are directly emitted into the atmosphere. In Africa, the emissions are usually released as part of the smoke into the atmosphere, posing an air-pollution problem. When inhaled the smoke can result in serious health issues of the charcoal producers. The local impacts of air pollution may be reduced by locating charcoal production sites at least 100 metres from villages (Mugo and Ong, 2006), although few data are available on the effectiveness of such a measure. The use of cleaner, more efficient technologies in charcoal production could also have huge health benefits (FAO, 2010). Air emissions from industrial charcoal production technologies, using batch kilns and continuous operated multiple hearth retorts, are considerably lower. These technologies allow the collection of the gaseous and liquid smoke arising from charcoal production, which can be used as energy source or to increase the efficiency of charcoal production. These technologies, however, have high initial investment costs. Another pollutant produced in charcoal making is charcoal dust, a black powdery residue that disperses quickly into the air and can cause respiratory illnesses. Many rural households use the dust for medicinal purposes, as an insect repellent and as a soil conditioner on farms, thus increasing their exposure to it (FAO, 2010).

Box 2: charcoal production and the greenhouse gas reduction

Measurements of kiln emissions carried out in the early 1990's suggest that the global warming impact of charcoal production may be much greater than the benefits of biomass charcoal use replacing fossil fuels. (Kammen and Lew, 2005) stress that it is crucial to assess the entire carbon balance of the charcoal cycle for impact on global warming, and conclude that when charcoal is produced in poorly operated kilns it is among the worst, if not the worst, cooking energy source in terms of global warming. The use of cleaner, more efficient technologies in charcoal production could significantly cut pollutant emissions, and at the same time bring huge health benefits

Self-Check –2	Written test

Name…………………………………………… ID……………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Give short answer. (8 point)

1. write the two methods of traditional charcoal making(2pts)
2. what is the range of traditional kiln efficiencies? (2pts)
3. List the main constraints of traditional charcoal. (4pts)

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 4 points Unsatisfactory - below 4 points**

Information Sheet 3- Introducing Modern Kilns

3.1. Introducing Modern Kilns

Charcoal is the solid residue remaining when wood is "carbonized" or "pyrolyzed" under controlled conditions in a closed space such as a charcoal kiln. Control is exercised over the entry of air during the pyrolysis or carbonization process so that the wood does not merely burn away to ashes, as in a conventional fire, but decomposes chemically to form charcoal. In the 1970s and 1980s, efforts were made to improve traditional charcoal making by equipping earth kilns with chimneys made from oil drums (Casamance kilns) and by introducing small-scale steel or brick kilns. These methods all rely on partial combustion of the wood charge to provide the heat necessary for carbonization, therefore, yields depend heavily on the moisture content of the wood. With good practice yields of 1 kg of charcoal from 4 to 5 kg of air-dried wood are possible. Yields of 1 kg of charcoal from 6 to 8 kg of wood are more common.

Basic principles of charcoal making

- Wood in addition to any moisture content is mainly composed of cellulose, hemicellulose, and lignin which are compounds of carbon, hydrogen, and oxygen.
- Charcoal is mainly carbon. The process of making charcoal is that of converting wood into carbon, i.e. carbonization.
- Carbonization is the process of heating the wood to remove the moisture and to break down by pyrolysis the wood compounds into carbon plus a range of volatile compounds containing the hydrogen, oxygen, and some of the carbon.
- Although the process is sometimes referred to colloquially as "charcoal burning", pyrolysis is quite distinct from complete combustion in which oxygen from the air combines with the wood compounds to eventually produce just carbon dioxide and water.
- The process of carbonization inherently involves the release of substantial amounts of volatile compounds which must be vented from the kiln.
- Removal of moisture takes place typically at temperatures of 110-150°C.

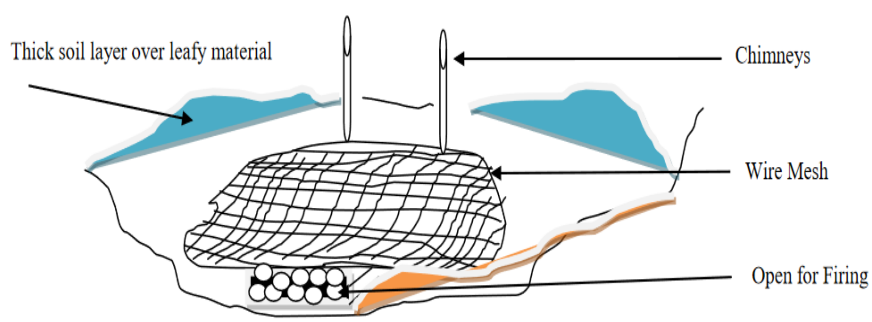
- Pyrolysis occurs at temperatures in the region of 260-380°C. Better purer charcoal is obtained with temperatures at the upper end of this range.
- The process of heating and removing moisture from the wood requires heat energy to be supplied, while the chemical reactions of pyrolysis are slightly exothermic, i.e. they release heat, but this is much less than that released by combustion.
- The process of carbonization can take place in the absence of air provided there is a source of heat, e.g. in a retort with external heating. In a kiln, however, heat is provided by burning directly within the kiln a proportion of the wood charge to be carbonized, and so a limited air supply is required.

3.1.1. Types of Modern Kilns

1. Casamance Kiln

The Casamance kiln was developed in Senegal and is an earth mound kiln equipped with a chimney. This chimney, which can be made of oil drums, allows a better control of air flow. In addition, the hot flues do not escape completely but are partly redirected into the kiln, which enhances pyrolysis. Due to this reverse draft carbonization is faster than traditional kilns. and more uniform giving a higher quality of charcoal and efficiency up to 30 %. Comparative tests of the Casamance kiln and traditional mound kilns confirmed the advantages in terms of efficiency and shorter carbonization times due to the enhanced hot flue circulation.

Disadvantages of this kiln type are that it requires some capital investment for the chimney and it is more difficult to construct.



Pic.2 Casamance kiln

2. Drum Kiln

A. KEFIR type

This kiln is constructed by modifying the ordinary oil drum, with an adjustable lid specially fitted with a firing door. Wood is stacked over a metal grill placed inside the drum. Air movement is controlled through a chimney attached at the side of the drum. The drums are covered with soil during the process of charcoaling. The process takes 6-12 hours and recovery is about 28-30%. Each drum yields about ¾ of a bag.

Picture 3. KEFIR type

A. Kinyanjui type

Only small twigs of pollarding are used to make charcoal and whole trees are not felled allowing for sustainable production. There is also continuous improvement of the charcoal and wood using technology to enhance energy utilization, minimizing waste and reducing costs.

Picture 4. Kinyanjui type

2. Briquette Charcoal

A briquette is a block of flammable matter used as fuel to start and maintain a fire. Residues from agriculture and forestry e.g. bagasse, coffee husks, saw-dust, and coconut husks are a valuable source of raw material and can be used for producing briquettes. The briquetting process entails many steps. After collection, the wood or agro-industrial waste is dried before it is converted to charcoal in a charring kiln. The carbonized biomass is then mixed with water and locally-available binders such as starch, gum arabic, molasses, clay and others. Finally, the mixture (powdered charcoal and binder mixture) is pressed into briquettes. Piston and screw presses are the most widely used technologies where as in the developed countries roll presses are more common. The production capacity of screw presses is around 40 to 70 kg per hour. After a subsequent drying step, the briquettes will develop the required strength and stability. Forest and agricultural waste charcoal briquettes, with about 20% of clay, produce about 12 MJ/kg depending on the composition of charcoal.

3. The Meko Kiln (Biochar ltd)

Biochar in Thika has innovated a charcoal production kiln that does not involve direct contact of wood with the fire hence avoids charring during the carbonization process. This is at the prototype stage and studies may be necessary to determine various functionality parameters. This is an improved charcoal making technology. Unlike others, this technology recycles the pyrolysis gases from the charcoaling process.

The Meko kiln is designed to cause pyrolysis of dry wood to take place in an enclosed chamber where oxygen is eliminated or constrained so as to facilitate fast and complete carbonization of wood. The Meko kiln is attractive to the potential users because it is easy to assemble is mobile and therefore easy to transport.

Construction and the process:

The kiln contains two chambers, the inner which is basically a modified drum as the carbonization chamber while the outer is the firing chamber. The Meko Kiln design is simple and adheres to high safety considerations. Once the kiln components and instruction manual have been supplied, no additional technical knowledge is necessary to assemble the Meko kiln.

Wood is cut into small pieces of 1.5 cm diameter and arranged horizontally after being dried for a few days. The chamber is filled fully and sealed tightly not to allow any oxygen inside lest combustion takes place. Firing takes place in the outer chamber using the remains of the smaller end branches (withies) in the firing chamber. The chamber is closed after combustion attains a sustainable level and left and the temperatures in the combustion chamber reaches the required 4000 -5000 required for full carbonization. The combustion chamber is designed in such way that it has an outlet pipe that returns the pyrrolic gases to the firing chamber to assist in the burning and hence provide the necessary heat to raise the temperatures to over 400 degrees.

Portability

The Meko kiln is designed taking into consideration the requirement to move the kiln from one locality to another where felled timber is available. All panels of the Meko kiln are demountable and can be transported as flat-packed panels. In addition, the pyrolysis chamber is detachable from the kiln panels. The Meko kiln is also modular in design and can therefore be supplied in two, three or more charcoal pyrolysis chambers depending on the requirements of users.

Efficiency Traditional charcoal burning methods are not efficient. This is due to the fact that while burning charcoal some of the timber meant for charcoal is also burnt to ashes during the process of burning.

The Meko kiln has an isolated pyrolysis chamber which efficiently isolates oxygen from the starter fire and also traps and re-circulates all volatile gases externally to assist in the carbonization process.

The pyrolysis process leading to full carbonization only takes 10 hours and another 3 hours to fully cool. This is a clear diversion from the traditional earth kiln that takes 8-10 days to fully carbonize.

Picture 4. The Meko Kiln (Biochar ltd)

Table 1. Traditional and improved charcoal efficiency

Table 1: Efficiencies of various types of kiln		
	Production of 1 kg of charcoal from	Kiln efficiency
Traditional Kilns	8- 12 kg wood	8 – 12%
Improved traditional kilns	6 – 8 kg wood	12 - 17%
Industrial production technologies	5 – 7 kg wood	20 – 14%
New high-yield, low-emission systems	3 – 4 Kg wood	25 - 33%

Self-Check –3	Choice

Name…………………………………………… ID……………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Choose the correct answer. (10 point)

1. The essential requirement for wood carbonization is:

A. Source of heat B. inclusion of oxygen C. inclusion of water D. all

2. Wood in addition to any moisture content is mainly composed of

A. Cellulose B. Hemicellulose C. Lignin D. All

3. Better purer charcoal is obtained with temperatures at______________.

A. the upper end of 260-380°C.

B. the lower end of end of 260-380°C.

C. the middle end of 260-380°C.

D. the quality is the same throughout the entire range of 260-380°C

4. Traditional method of charcoal production

A. often produces very high yield B. often produce consistent quality

C. often produce environmental pollution D. all

5. Select incorrect statement.

A. The drum kiln for charcoal making have removable lid.

B. Metallic belt of rum kiln joins the lid to the drum

C. Drum kiln is suitable for household domestic charcoal production

You can ask you teacher for the copy of the correct answers.

***Note:* Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Operation Sheet 3- Introduce modern kiln

Objective: to introduce modern kiln

Materials needed

1. Drum kiln
2. Screw
3. Bolt and nut
4. Spade,
5. Measuring tape
6. Two-man cross cut sow
7. Bow sow
8. Splitting axe
9. Machete
10. Spade
11. Digging hoe
12. wood

Procedures:

1. Wear Safety cloths
2. Collect all materials, tools and equipment used for forest-based charcoal making.
3. Cut the wood into pieces of 80 cm length and split the bigger diameter logs to give an average diameter of 6-10cm.

- ✓ Stack the wood to air dry for 6 weeks to attain a moisture content of about 20%.
- ✓ Closely pack the seasoned/dried wood onto the metal grill in the drum
- ✓ Close the loaded drum with the lid that is fitted with a firing door and stack small pieces of wood at the firing section and light the kiln.

4. Allow the wood pieces at the lighting section to burn until the wood inside the drum catch fire and smoke starts coming out through the chimney.

- ✓ Close the door of the firing section. Cover the kiln with soil to prevent heat loss during carbonization. The entire drum is covered with soil.

5. Remove the chimneys when clear blue smoke is emitted thus indicating the wood is fully carbonized.

- ✓ Seal the chimney holder with grass and soil and leave the drum to cool for 12-24 hours to cool before removing the charcoal.
- ✓ Remove the soil covering the drum to hasten the cooling process.
- ✓ The carbonization takes 6-12 hours giving a charcoal recovery of 28- 30%. Each drum kiln has a capacity of about 0.4m3of wood and yields about 3/4 of a bag/sack.

LAP Test	Practical Demonstration

Name. ___________________________ID _______________ Date: ________________

Time started: __________________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 72 hours.

Task 1. Introduce modern kiln

LG #41	LO 3- Introduce improved energy saving stoves and biogas plant

Instruction sheet
This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics: • Identifying and introducing energy saving stoves • Promoting biogas plant This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, **upon completion of this learning guide, you will be able to**: • Identify and introduce energy saving stoves based on interest of local community and their efficiency. • Promote Biogas plant accordance with available inputs.
Learning Instructions:
1. Read the specific objectives of this Learning Guide. **2.** Follow the instructions described below. **3.** Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them. **4.** Accomplish the "Self-checks" which are placed following all information sheets. **5.** Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks). **6.** If you earned a satisfactory evaluation proceed to "Operation sheets **7.** Perform "the Learning activity performance test" which is placed following "Operation sheets" **8.** If your performance is satisfactory proceed to the next learning guide, **9.** If your performance is unsatisfactory, see your trainer for further instructions or go back to "Operation sheets".

Information Sheet 1- Identifying and Introducing Energy Saving Stoves

Introduction

The exploitation of energy from biomass has played a key role in the evolution of mankind. Until relatively recently it was the only form of energy that was usefully exploited by humans and is still the main source of energy for more than half the world's population for domestic energy needs.

Biomass is defined as mass per unit area of biological resources e.g. Total weight of a tree. Biomass is available in varying quantities throughout the world from densely forested areas in the temperate and tropical regions of the world, to sparely vegetated arid regions where collecting wood fuels for house hold needs is a time consuming and arduous tasks.

In recent decades, with the treats of global deforestation, much attention has been given to the efficient use of biomass in area where wood fuel is in particular shortage.

Although, domestic wood fuel users suffer greatly from the effect of deforestation, the main cause of deforestation is the clearing of land for agricultural use and for commercial timber or wood fuel use.

1.1. Identifying and introducing energy saving stoves

2. Energy saving stove

The term 'stove' refers to a device that generates heat from an energy carrier and makes that heat available for the intended use in a specific application. Cook stoves are made to transfer the generated heat to food, with the purpose to get it cooked, refined etc. and therefore edible for human consumption. Thus a 'stove' features the combination of heat generation and heat transfer to a cooking pot if the food is cooked in a liquid, or a griddle, plancha etc. if the food is baked on a hot surface or roasted without liquid.

Cookstoves are commonly called “improved” if they are more efficient, emit less emissions or are safer than the traditional cook stoves or three-stone-fires. The term usually refers to stoves which are burning firewood, charcoal, agriculture residues or dung.

I. Energy efficiency- describes the heat transferred into the pot in relation to the overall energy generated by the stove within a defined task (e.g. Water Boiling Test, WBT). higher efficiency can i.e. be achieved by

- Better combustion of the fuel by providing an insulated combustion chamber around and above the fire, which leads to a better mixing of gases, flame and air. This enhances the temperature of the fire with the following consequences
- Maximum transfer of heat of combustion from the flame and the hot gases to the cooking pot.
- Minimum loss of heat to the surroundings.

II. Specific fuel consumption -describes the fuel used per unit of food cooked or boiled water, e.g. how much wood was used to cook a liter of beans.

When we talk about the efficiency of stoves, we usually compare the **specific fuel consumption** of a specific stove to either (a) a benchmark or (b) the specific consumption of another stove.

III. Lower emissions than baseline stoves or open fires emit are further characteristics of improved stoves. Emissions are byproducts from the incomplete combustion of fuel that are discharged into the air. They can be very harmful for human health and environment. Chimney stoves address the problem of indoor air pollution very effectively, because they lead all emissions to the outside. However, it is important to use a stove with good draft. If smoke can flow out of the fuel entrance, or leak in other ways into the room, harmful emission levels will rise. Even some stove designs have fewer emissions than others, the fuel properties still have a big influence: even the best stove can hardly burn wet wood properly.

Improved cookstoves (ICS) can take many shapes: they can be portable or fixed installed in a kitchen; they can be made of different materials such as metal or clay; they come with or without a chimney; and they can have different sizes for households, institutions or small enterprises. Regarding ICS for fuelwood, savings between 25-65% per stove per household are realistic when used correctly, while improved charcoal stoves usually save around 25-35% compared to traditional charcoal stoves.

Much of the research and development work carried out on biomass technologies for rural areas of developing countries has been based on the improvement of traditional stoves. This was initially in response to the threat of deforestation, but has also been focused on the need of women to reduce the fuel collection times and improve the kitchen environment by smoke removal.

1.1.1. Types of energy saving stove

For this purpose, types of efficient stoves will be distributed, including Mirt stoves and Tikikil stoves. Mirt stoves are specifically made for injera baking for which over 50% of firewood is used in Ethiopian households. Mirt stoves are closed, but the same mitad is used as for traditional injera baking. households. Mirt stoves are closed, but the same mitad is used as for traditional injera baking.

1. **Wood saving stove: -** It provided with buffers to force and guide the heated air to circulate the pot before escaping through the chimney.

Benefits:

- ✓ Very cheap
- ✓ Save fire woods
- ✓ Improve the hygiene
- ✓ Save the time and energy
- ✓ Save the cost of fuel wood
- ✓ Reduce environmental degradation
- ✓ Can manufactured from locally available material

Picture(a): Wood Saving Biomass Stove

2. Confined Biomass Stove (Non-Wood Biomass Stove)

It has the same purpose as wood saving stove, the only difference is, it use wood scraps, maize straw, teff straw, dry grass, dry leaves, nut shells etc as an input material but these materials can be used as an input for wood saving stoves.

Picture(b): Confined Biomass Stove

Picture (c) Improved stove

The following table gives information on the amount of energy loss in % when introducing improved kilns and/or improved stoves in comparison to the usage of firewood. For example, if one converts wood to charcoal using a traditional kiln (with efficiency of 8%) and then burns that charcoal on a traditional stove (with efficiency of 20%), there is a resulting energy loss of 73%.

Table 2: Energy Losses Converting Wood fuel to Charcoal (using various stoves)

		Traditional Stove 1	Traditional Stove 2	Improved Stove 1	Improved Stove2
	Efficiency	**20%**	**24%**	**30%**	**35%**
Traditional Kiln1	**8%**	73%	68%	60%	53%
Traditional Kiln 2	**12%**	60%	52%	40%	30%
Improved Kiln 1	**14%**	53%	44%	30%	18%
Improved Kiln 2	**18%**	40%	28%	10%	-5%

1.1.2. Policy and Strategy

Following are some of the major highlights from the policies and strategies of the country.

A. National Electrification Strategy

National electrification strategy outlines the plan to electrify the villages without energy access. The Off-grid Master Plan (by Power Africa) will be integrated. The Strategy is currently under internal review (2017). Coordinator should be a Directorate of Energy, electrification fund should be financed via a levy on power sales, "realistic tariff regime", off-grid electrification for 100,000 businesses and households/year.

B. Energy Development

1. Fuel wood plantation: encouragement of the private sector and different communities to be involved in plantation schemes,

2. Conversion of biomass in different forms of energy purposes: enhancing conversion efficiency in charcoal making, encourage and promote the modern use of agricultural residues and dung (Biogas etc.),
3. Hydro power development: utilization of the vast hydropower potentials (of which only about 2 % is currently utilized),
4. Other Energy sources: the policy states that whenever the economic potential is realized geothermal, coal, solar, wind and other sources of energy shall be used to generate electricity or other energy services,
5. Oil exploration and development of the natural gas potential.

D. Energy Conservation and Efficiency

1. Improving the energy efficiency in the transport sector, the agriculture sector, the industry and at household level is to be enhanced,
2. Regarding the household sector, enhancing the supply of fuelwood, encouraging fuelwood substitution and taking other measures to narrow the gap between energy demand and supply, such as the promotion of fuel-efficient stoves.

E. Encouragement of Private Sector to be Involved in Energy Sector

The Energy policy also dedicates a special section for the encouragement of the private sector to be involved in the development of the Energy resources of the country specially by being involved in the construction of energy structures, a field that has been and still is seen to be mainly the responsibility of the government.

F. Environmental Policy of Ethiopia

The policies are:

1. To adopt an inter-sectoral process of planning and development which integrates energy development with energy conservation, environmental protection and sustainable utilization of renewable resources,
2. To promote the development of renewable energy sources and reduce the use of fossil energy resources both for ensuring sustainability and for protecting the environment, as well as for their continuation into the future.

I. Conservation Strategy of Ethiopia

1. Boost technical and social research on the design of improved cooking stoves,
2. Promote local manufacture and distribution of improved charcoal and biomass stoves
3. Locate, develop, adopt or adapt energy sources and technologies to replace biomass fuels.

Development of Alternative Energy Resources and their utilization are to: Acquire, develop, test and disseminate appropriate and improved energy use technologies (e.g. improved stoves, charcoal kilns, solar powered cookers and heaters).

Self-Check –1	Written test

Name…………………………………………… ID……………… Date……

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions. (10 point)

1. _______refers to a device that generates heat from an energy carrier and makes that heat available for the intended use in a specific application.
   A. Stove B. cook stove C. improved stove D. All
2. Cookstoves are commonly called "improved" if they contain one of the following A. more efficient B. emit less emissions C. safe D. All
3. Which of the following cannot describe high energy efficiency of stove?

A. Better combustion of the fuel

B. Maximum transfer of heat to cooking pot.

C. Maximum loss of heat to the surroundings

D. None

4. The benefits of wood saving stove includes one of the following except,

A. Very expensive C. Save fire woods

B. Save the time and energy D. Save the cost of fuel wood

5. Energy development policy of Ethiopia emphasis on one of the following

A. Fuel wood plantation

B. Conversion of biomass in different forms of energy

C. Hydro power development

D. All

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 5 points Unsatisfactory - below 5 points**

Information Sheet 2- Promoting Biogas Plant

2.1. Promoting Biogas Plant

2.1.1. Biogas

Biogas- is alternative energy sources generated from cow dung, leaves grasses, branches, through an aerobic respiration of methane. Biogas is produced using well-established technology in a process involving several stages: Biowaste is crushed into smaller pieces and slurrified to prepare it for the anaerobic digestion process. Microbes need warm conditions, so the biowaste is heated to around 37 °C. It is the mixture of gases produced by the breakdown of organic matter in the absence of oxygen, primarily consisting of methane and carbon dioxide. Although what's mostly released is methane (between 50-75%, depending on the number of carbohydrates present in the mix) and carbon dioxide, other gases are released too in smaller quantities.

As biogas production happens in the absence of oxygen, this process is also referred to as anaerobic digestion. Simply put, there's a fermentation process that breaks down organic matter, turning what once was waste into a source of energy that can be used to heat, cool, cook, or for regular electricity production, once it's burned.

Biomass- Defined as mass per unit area of biological resources e.g. Total weight of a tree

Table 3. Composition of biogas.

Compound	Formula	% by volume
Methane	CH_4	50–75
Carbon dioxide	CO_2	25–50
Nitrogen	N_2	0–10
Hydrogen	H_2	0–1
Hydrogen sulfide	H_2S	0.1 –0.5
Oxygen	O_2	0–0.5

Source: www.kolumbus.fi, 2007[15]

2.2. Biogas Plant

A biogas plant is where biogas is produced by fermenting biomass. The substrate used for the production of this methane-containing gas usually consists of energy crops such as corn, or waste materials such as manure or food waste. The fermentation residue left over from the substrates at the end of the process can be used as fertilizer.

The biogas is produced by the micro bacterial decomposition of the substrate in an oxygen-free environment, i.e. under anaerobic conditions. To do this, the substrate is pumped into the fermenters. The substrate is stored here under anaerobic conditions and is periodically shifted by agitators to avoid the formation of surface scum and sinking layers. This also allows the biogas to rise more easily. Unlike in the decomposition of biomass under aerobic conditions (for example, composting), under anaerobic conditions the micro bacterial organisms can only use a small part of the energy contained. The anaerobically non-usable energy is contained in the "waste product" of biogas in the form of biomethane.

Before being fed into the gas grid, this crude biogas from the biogas plant still has to be processed in a processing plant to attain natural gas quality, which means that substances such as carbon dioxide, hydrogen, oxygen and sulfur are filtered out. To do this, it is desulfurized by an iron-containing filter material, or its sulfur content is released by the addition of oxygen. In a final step the gas is dehumidified and can then be used to generate electricity and heat, which is why many biogas plants have combined heat and power units (CHP). The purified biogas can also be fed into the gas grid and transported to points of consumption. A meter measures how much "green gas" was fed in. In this way, besides being piped to industrial customers, biogas can also be made available to bio-CNG dispensers at service stations for natural gas vehicles.

One key differentiator of biogas plants is their mode of operation. Depending on the substrate, the fermentation process is wet or dry. For substrates such as manure with a high liquid content, wet fermentation is always used. Dry or solid-state fermentation is used for stackable organic biomass such as municipal biowaste. A distinction can also be made between agricultural and industrial biogas plants.

1. Bio gas plant Installation

A) Selection of model

Selection of a plant model appropriate for a particular agro-climatic condition depends on several variables.

- ✓ Availability of construction materials and skilled man power
- ✓ The feed materials intended to be used since it decides the node of slurry flowing digester
- ✓ Climatic condition
- ✓ Soil characteristics.

B) Selection of size

Size of the gas holder is generally a function of the amount of biogas required at a time and the amount of gas produced. Furthermore, decided by

- ✓ Retention time allowable
- ✓ Temperature of the area
- ✓ Quantity of feed material available

C) Selection of site

The following factors must be carefully kept in mind for selection of site

- ✓ The site should be close to the supply of input material to save time and effort in carrying it to the plant
- ✓ Installing plant close to the points of biogas use.
- ✓ The site should be 10 to 15 meters away from shallow wells in order to prevent contamination
- ✓ It should be free from any intrusion of trees, the roots of which may creep into the digester and cause damage
- ✓ The location should be in the sun direction but not in the low lying areas
- ✓ The location should have suitable foundation conditions.
- ✓ The site intended should have enough space for construction of plant and slurry pits.

Basic component of all types of a biogas plant

- Foundation
- Digester

- Inlet
- Outlet
- Gasholder

Stages in biogas production- Biogas is produced using well-established technology in a process involving several stages:

1. Biowaste is crushed into smaller pieces and slurrified to prepare it for the anaerobic digestion process. Slurrifying means adding liquid to the biowaste to make it easier to process.
2. Microbes need warm conditions, so the biowaste is heated to around 37 °C.
3. The actual biogas production takes place through anaerobic digestion in large tanks for about three weeks.
4. In the final stage, the gas is purified (upgraded) by removing impurities and carbon dioxide.

2. Types of biogas plant

According to the gas storage as well as the mode of flow of slurry through the plant they can be classified in to three groups.

1. Fixed-dome Plants

A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensation tank. The costs of a fixed-dome biogas plant are relatively low. It is simple as no moving parts exist. There are also no rusting steel parts and hence a long life of the plant (20 years or more) can be expected. The plant is constructed underground, protecting it from physical damage and saving space. While the underground digester is protected from low temperatures at night and during cold seasons, sunshine and warm seasons take longer to heat up the digester. No day/night fluctuations of temperature in the digester positively influence the bacteriological processes. The construction of fixed dome plants is labor-intensive, thus creating local employment. Fixed-dome plants are not easy to build. They should only be built where construction can be supervised by experienced biogas technicians. Otherwise plants may not be gas-tight (porosity and cracks).

Picture(1): Fixed Dome Biogas Plant.

2. Floating Drum Biogas Plants

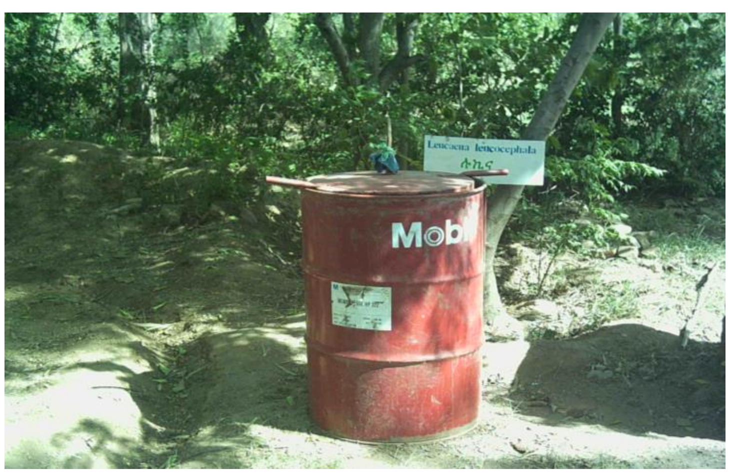
Om 1956, Jashu Bhai J Patel from India designed the first floating drum biogas plant, popularly called Gobar gas plant. Floating-drum plants consist of an underground digester (cylindrical or dome-shaped) and a moving gas-holder. The gas-holder floats either directly on the fermentation slurry or in a water jacket of its own. The gas is collected in the gas drum, which rises or moves down, according to the amount of gas stored. The gas drum is prevented from tilting by a guiding frame. When biogas is produced, the drum moves up adn when it is consumed, the drum goes down.

If the drum floats in a water jacket, it cannot get stuck, even in substrate with high solid content. After the introduction of cheap Fixed-dome Chinese model, the floating drum plants became obsolete as they have high investment and maintenance cost along with other design weakness

Picture (2): Floating Biogas Plant

3. Batch type biogas plant

This type of biogas can be constructed using a number of barrels, then the barrel will filled (charged)with organic materials and the gas will start to be produced few weeks later. The digestion process is interrupted as soon as the rate of biogas production gas slowed down to the point that continued digestion would be uneconomical, then the plant is cleaned out and refilled. batch type is usually suitable in area with low annual precipitation.



Picture (3) batch type biogas plant

4. Balloon Plants

A balloon plant consists of a heat-sealed plastic or rubber bag (balloon), combining digester and gas-holder. The gas is stored in the upper part of the balloon. The inlet and outlet are attached directly to the skin of the balloon. Gas pressure can be increased by placing weights on the balloon. If the gas pressure exceeds a limit that the balloon can withstand, it may damage the skin. Therefore, safety valves are required. If higher gas pressures are needed, a gas pump is required. Since the material has to be weather- and UV resistant, specially stabilized, reinforced plastic or synthetic caoutchouc is given preference. Other materials which have been used successfully include RMP (red mud plastic), Trevira and butyl. The useful life-span does usually not exceed 2-5 years. **Advantages**:

- Standardized prefabrication at low cost,
- low construction sophistication,
- ease of transportation,
- shallow installation suitable for use in areas with a high groundwater table;
- high temperature digesters in warm climates;
- uncomplicated cleaning,

Disadvantages:

- Low gas pressure may require gas pumps;
- scum cannot be removed during operation;
- the plastic balloon has a relatively short useful life-span and is susceptible to mechanical damage and usually not available locally. In addition, local craftsmen are rarely in a position to repair a damaged balloon. There is only little scope for the creation of local employment and, therefore, limited self-help potential.

Biogas guideline data

Suitable digesting temperature	20 – 35°
Retention time	40-100 days
Biogas energy content	6 kWh/m³ = 0.6 l diesel fuel
1 cow yields	9-15 kg dung/d = 0.4m³ gas/d
1 pig yields	2-3 kg dung/d = 0.15 m³ gas/d
gas requirement for cooking	0.1-0.3 m³ /person
1 lamp 0.5 m³ /d (about 0.13-0.15m³/h)	0.5 m³ /d (about 0.13-0.15m³/h)
1 kWh electricity	1 m³ gas

- 1 Kg firewood => 0.2 m³ biogas.
- 1 Kg dried cow dung => 0.1 m³ biogas
- 1 Kg Charcoal => 0.5 m³ biogas
- 1 Liter Kerosene => 2.0 m³ biogas

✓ 8 – 10 m³ biogas plant produces 1.5-2 m³ gas and 100 liters digested slurry per day using dung from 3-5 cattle or 8-12 pigs. With that much biogas, a 6-8-person family can:

✓ cook 2-3 meals

✓ operate one refrigerator all day -burn two lamps for 3 hours

✓ operate a 3-kw motor generator for 1 hour

Self-Check – 2	Written test

Name………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Part I. Choose the correct answer (6pts)

1.___________is alternative energy sources generated from cow dung, leaves grasses, branches, through an aerobic respiration

A. Biomass B. Biogas C. Biogas plant

2. The gas produced from biogas is

A. methane B. ethanol C. hydrogen D. All

3. _____mass per unit area of biological resources e.g. Total weight of a tree

A. Biomass B. Biogas plant C. Biogas

Part II. Give short answer (8pts)

1. what is Biogas plant? (2pts)
2. List down source of biogas(3pts)
3. Mention components of biogas (3pts)

You can ask you teacher for the copy of the correct answers.

Note: **Satisfactory rating - 7points Unsatisfactory - below 7 points**

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AKNOWLEDGEMENT

We wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

We would like also to express our appreciation to the TVET instructors and respective industry experts of Regional TVET Bereau, TVET college/ Institutes, Holeta Polytechnic College, East Africa Skills for Transformation and Regional Integration Project (EASTRIP) who facilitate the development of this Teaching, Training and Learning Materials (TTLM) with required standards and quality possible.

This Teaching, Training and Learning Materials (TTLM) was developed on June, 2021 at Adama, Pan- Africa Hotel.

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