ASCENT

TECHNICAL GUIDELINES

Template for

Technical Documentation and Training Guide on Manufacturing and Appropriate Use of the Improved Cookstoves

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Acronyms and Abbreviations

ASCENT	Accelerating Sustainable and Clean Energy Access Transformation Program
E&S (ES)	Environmental and Social
LMICs	Low to Middle Income Countries
O&M	Operation & Maintenance
PIU	Project Implementation Unit
PPE	Personal Protective Equipment
OHS	Occupational Health and Safety
WB	The World Bank

1.0 INTRODUCTION

Rural families, especially women, face long hours collecting firewood and cooking over smoky open fires. The lack of access to clean cooking remains very acute in sub-Saharan Africa with only 17% of the population having clean cooking access. These aren't just environmental challenges; they're deep, structural issues of time, health, equity, and access. Fuelwood, charcoal, agricultural residues and animal dung produce high emissions of carbon monoxide, hydrocarbons and particulate matter. According to the World Health Organization (WHO), exposure to these emissions causes approximately 1.6 million premature deaths every year worldwide, with the gender and social impacts being skewed; women and children are primarily affected given their proximity to cooking fires and there is decreased opportunity for children due to the time spent collecting fuel. That's why clean cookstoves are not solely a climate solution – they are a societal one. Increasing access to and the adoption and consistent use of clean and efficient cookstoves and fuels has the potential to contribute to the achievement of UN Sustainable Development Goals (SDGs) related to poverty eradication, food security, health and well-being, education, gender equality, economic growth, reducing inequalities, sustainable cities, environmental protection, and climate change mitigation [ISO, 2023].

Cooking is a basic need of every household yet access to clean cooking is limited. There is a staggering reliance on solid-fuels and traditional methods of cooking, which are associated with significant costs to human health. Improved Cookstoves (ICS) are cooking stoves that use biomass (charcoal, wood, paper or vegetable matter) and are designed to maximise thermal and fuel efficiency, operate safely and minimise emissions harmful to human health. One key attribute of ICS is more complete and efficient combustion compared to the traditional stoves or open fireplaces. Stoves with improved efficiency have been introduced in developing countries since 1970. The objectives have been to reduce deforestation, save cooking time, reduce health impacts through a reduction in environmental emissions, save money, and improve cooking satisfaction. Cookstoves programs depend on the factors such as: compatibility of technical parameters of stoves with social expectations, consistency with local needs and culture, attitude of the users who are often afraid of adopting new technology, and the stove cost. Also, programs that use a "bottom-up" strategy, where users and local artisans play participatory roles in establishing a self-sustaining industry ensure success of the program.

This Standard Technical Guidelines on ***Manufacturing and Appropriate Use of the Improved Cookstoves*** provides "pragmatic good practice" ***Technical*** steps which should be used for ***Training potential users, Government Agencies, Implementing Entities, and Cook Stoves Manufacturers. The target group for this document is any stakeholder interested in evaluating the impacts of improved cooking,*** basic process of making ICS, such as: users, development organisations, non-governmental organisations, government bodies private sector companies, and donor or investors. The guidelines cover preparation of ICS meant for household use and institutional use aimed at supporting clean cooking interventions that reduce greenhouse gas (GHG) emissions from the burning of non-renewable woody biomass and/or charcoal for cooking in Eastern and Southern Africa (AFE) Countries participating in ASCENT. This involves use of energy-efficient biomass Improved Cookstoves (ICS), either within households (Household ICS) or at Institutions (Institutional ICS). These guidelines should be used while taking into consideration the relevant respective Country legal and regulatory requirements and standards, regarding technical, environmental and safety concerns related to the various types of cook stoves.

2.0 ENVIRONMENTAL AND SOCIAL IMPACTS OF COOKSTOVES

Around the world, three billion people rely on open fires and traditional cookstoves and fuels to cook food and to light and heat their homes – causing serious environmental and health problems. Over four million people globally die each year from exposure to household air pollution caused by cooking fires [WHO, 2014]. It is crucial to address the environmental and social impact of cookstoves for several reasons:

- Firstly, the use of traditional cookstoves cumulatively contributes to significant deforestation, which has adverse effects on the environment.
- Secondly, the smoke emitted from these stoves is harmful to human health, particularly for women and children who spend a considerable amount of time in the kitchen.
- Thirdly, the use of clean cookstoves can lead to a reduction in greenhouse gas emissions, which is essential in mitigating climate change.
- Lastly, the adoption of clean cookstoves can improve the livelihoods of women and girls who are often responsible for collecting firewood and cooking.

2.1.1 Environmental, Health and Safety Impacts of Clean Cookstoves

Reduction in greenhouse gas emissions: Traditional cooking methods, such as open fires and inefficient stoves, release large amounts of carbon dioxide, methane, and black carbon into the atmosphere. By using clean cookstoves, households can reduce their carbon footprint and contribute to global efforts to combat climate change.

Impact on deforestation: The use of clean cookstoves in Africa has a significant positive impact on deforestation and indoor air pollution. Traditional cooking methods involve burning wood or charcoal, which leads to deforestation and contributes to climate change. The use of clean cookstoves reduces the amount of fuel needed for cooking, which in turn reduces the demand for firewood and charcoal. This helps to preserve forests and reduce carbon emissions.

Indoor air pollution: Additionally, traditional cooking methods produce high levels of indoor air pollution, which can lead to respiratory problems and other health issues. Clean cookstoves, on the other hand, are designed to burn fuel more efficiently, which reduces the amount of smoke and harmful pollutants released into the air, and hence safer for use indoors. Incidents of eye irritation during cooking reduce. This has a positive impact on the health of individuals and communities who use clean cookstoves.

Health and Safety: The likelihood of accidental fires also reduces when using improved household cookstoves, compared to the open fire system, since the improved stoves have safety features, such as the fire being enclosed inside the stove.

Benefits for local ecosystems: Clean cookstoves have a significant positive impact on local ecosystems in Africa. Traditional cooking methods, such as open fires and inefficient stoves, contribute to deforestation and soil degradation. However, clean cookstoves reduce the amount of wood and charcoal needed for cooking, which helps to preserve forests and prevent soil erosion. Overall, the adoption of clean cookstoves in Africa has the potential to promote sustainable development and protect the natural environment.

2.1.2 Social Impacts of Clean Cookstoves

Empowerment of women and girls: The use of clean cookstoves in Africa has also led to the empowerment of women and girls. In many African countries, women and girls are responsible for collecting firewood and cooking meals for their families. This task often requires them to walk long distances, which puts them at risk of physical harm and limits their ability to attend school or participate in other activities. With the introduction of clean cookstoves, women and girls no longer have to spend as much time collecting firewood and can instead focus on other activities. Women spend less time collecting firewood hence reduction in risk of associated gender-based violence cases.

Economic benefits for local communities: Clean cookstoves not only have environmental and social benefits but also provide economic benefits for local communities. The use of clean cookstoves reduces the amount of fuel needed for cooking, which in turn reduces the cost of fuel for households. Additionally, the production and distribution of clean cookstoves create job opportunities for local communities, which can boost the local economy.

ICS are durable hence cheaper than ordinary household cook stoves in the long run. ICS have a high combustion and heat transfer efficiency, and thus increased cooking speed and saving valuable time resources for kitchen staff.

The associated health benefits outweigh the lifecycle costs of the ICS over its entire life from initial acquisition, development, use, maintenance and final disposal. At the household and village level, combustion of solid fuels produces pollution that is damaging to health and a large contributor to the global burden of disease; and imposes a high time burden on those collecting fuelwood, typically women and girls. At the community and national level, when fuel wood is harvested in unsustainable ways, its consumption contributes to the loss of forest and associated ecosystem services. Finally, at the regional and global scale, the burning of biomass and coal in inefficient household stoves, which represent roughly 15% of global energy use, releases large amounts of black carbon and carbon-based greenhouse gases.

2.1.3 E&S Mitigation Measures of using Clean Cookstoves

Use of Improved Cookstoves is typically a low E&S risk activity and poses more positive impacts than negative ones. The risks include E&S risks throughout the supply chain, from sourcing raw materials and production to the final product's use and disposal, poor OHS standards, unfair wages, child labor, or forced labor, potential exclusion of vulnerable or marginalized groups, such as ethnic minorities or women, from receiving the stoves. These impacts can be mitigated through implementation of mitigation measures recommended under Table 1 below:

Table 1: *Mitigation measures to address potential environmental, social, and health and safety impacts and risks associated with Production and Use of Improved Cookstoves.*

Type of potential impact or risk	***Summary Description***	***Mitigation measures***	**Implementation responsibility** *[PIU / Contractor / others]*
Construction/ Manufacture and use of the Improved Cookstoves			
Material Sources	Clay (vermiculite) is used for production of cookstoves and is obtained from wetlands.	• Clay should be extracted and used in accordance with the National Environmental laws and Regulations. • To minimize potential negative environmental and social impacts of the entire cookstoves manufacturing value chain from a life-cycle perspective, proper mitigation measures would include procurement provisions for manufacturers regarding materials sourcing and appropriate precaution practices throughout the manufacturing process.	*PIU, or Contracted Service provider/ Contractor*
Worker Occupational Health and Safety (OHS)	Exposure of workers and users to accidents and safety such as cooking-related burn injuries (especially children).	• Workers can be exposed to many hazards that require the use of the necessary PPE. This can include eye shield, eye goggles, leather gloves, leather apron, nose mask, industrial boots, helmet, overall, first aid kit, as needed. • Design the cookstoves to be raised above the ground to a minimum height that is not easily reachable by toddlers. • Sensitize users about safe cookstove usage practices, such as instability of pots and stoves, careful usage of	*PIU, or Contracted Service provider/ Contractor and Users*

Type of potential impact or risk	*Summary Description*	*Mitigation measures*	**Implementation responsibility** *[PIU / Contractor / others]*
		ground level stoves, ensuring proper cookstove design and construction to avoid open flames, keeping children away from cookstoves, and avoiding wearing loose-fitting and flammable clothing during cooking.	
	The use of liquid fuels such as kerosene and, to a lesser degree, ethanol, for cooking and lighting remains widespread in LMICs. Ingestion of these fuels is a significant source of paediatric poisoning in households that rely on these fuels.	• Sensitize users to store liquid fuels in locked enclosures and/or away from access-reach by children. • Use child-resistant containers to store liquid fuels. • Use distinctive colouring of liquid fuels.	*PIU, Users*
	Risk of accidents and violence during fuel collection, e.g. suffer back or other strains from long treks carrying fuel, snake or insect bites, Fuel collectors can be the target of violence, including verbal and physical attacks.	• Sensitize users on safety measures to follow while collecting fuel, especially going into the bushes, drawing from local context of the given area/ locality.	*PIU, or Contracted Service provider/ Local Leaders and Users*
Waste Generation	Improper management of generated waste arising from the end use materials.	• Dispose off generated waste in accordance with the Local Authority Regulations and Guidelines. • Collect and transfer recyclable waste to recycling facilities. This includes metal, paper, plastic, and wood.	*PIU, or Contracted Service provider/ Contractor and Users*
Labor issues	Child or forced labor. Improper grievance redress for workers Unfair terms of employment	• No child or forced labor can be employed by the service provider. • A child over the minimum working age and under the age of 18 will not be employed or engaged in	*PIU, or Contracted Service provider/ Contractor, and Users*

Type of potential impact or risk	*Summary Description*	*Mitigation measures*	**Implementation responsibility** *[PIU / Contractor / others]*
		connection with the project in a manner that is likely to be hazardous or interfere with the child's education or be harmful to the child's health or physical, mental, spiritual, moral or social development. • Companies should develop and implement a workers grievance redress mechanism. • Workers must have written contracts, in appropriate languages, outlining their working arrangements including signed codes of contract. • Unskilled workers should be hired from the local community to maximize local benefits as well as enhance a pool of artisanal workforce to maintain the cookstoves during use.	
Inadequate stakeholder engagement and exclusion of vulnerable groups	potential exclusion of vulnerable or marginalized groups, such as ethnic minorities or women, from receiving the stoves.	- Include women and other vulnerable groups in all stakeholder engagement. - Take into consideration the feedback from these groups in the project design and implementation. - Design GRM to make special provisions for addressing grievances from vulnerable groups. - Encourage employment of women, where possible with fair compensation.	*PIU, or Contracted Service provider/ Contractor, and Users*
	Cost and accessibility of clean cookstoves Despite the numerous benefits of clean cookstoves, their cost and accessibility remain a major challenge in Africa. The majority of households in rural areas cannot afford the high cost of clean cookstoves,	- Governments and non-governmental organizations need to invest in initiatives that make clean cookstoves more affordable and accessible to low-income households. This can be achieved through	*PIU*

Type of potential impact or risk	*Summary Description*	*Mitigation measures*	**Implementation responsibility** *[PIU / Contractor / others]*
	which can range from \$10 to \$100. Additionally, the lack of distribution networks and limited availability of clean cookstoves in remote areas make it difficult for households to access them.	subsidies, microfinance programs, and partnerships with local businesses to increase the availability of clean cookstoves in rural areas.	
	Cultural barriers and resistance to change Despite the numerous benefits of clean cookstoves, cultural barriers and resistance to change have hindered their widespread adoption in Africa. In many communities, traditional cooking methods are deeply ingrained in cultural practices and beliefs, making it difficult for individuals to switch to new technologies. Additionally, some people may view clean cookstoves as a symbol of modernity and associate them with Western values, leading to further resistance.	- Engage with local communities and involve them in the design and implementation of clean cookstove programs. This can help to build trust and ensure that the technology is culturally appropriate and meets the needs of the community.	*PIU, or Contracted Service provider/ Contractor, and Users*

Table 2: *Environmental and Social Monitoring Plan*

Impact	**Measurements (incl. methods & equipment)**	**Frequency**	**Implementation responsibility**	**Budget Required**
Community Health and Safety				
Worker Occupational Health and Safety (OHS)	**Method:** - Inspection and photographic documentation. **Indicator:** - PPE usage. - The record of injuries, accidents, violent incidents, indicating the number of injured workers in the project report specifying cause.	Daily	*PIU, Contractor*	

Poor onsite housekeeping and waste management	**Method:** - Visual site inspection. **Indicator**: - Presence of wastes at undesignated areas. - Presence of cluttered and poorly managed workspaces.	Weekly site inspection	*PIU, Contractor*	
Labour Issues (Child labor and Forced Labour)	**Method:** - Site inspection, checking and documentation of contractor employee records to demonstrate regular monitoring of child labour. **Indicators:** - Number of recorded employees below the age of 18.	Weekly site inspection	*PIU, Contractor*	
Stakeholder engagement:	- Highlights, including formal and informal meetings, and information disclosure and dissemination—to include a breakdown of women and men consulted and themes/ issues/ concerns coming from various stakeholder groups, including vulnerable groups (e.g., disabled, elderly, children, etc.) and resolution of issues. - Number of Reported Grievances. - Percentage of Reported Grievances closed out in agreed timelines.	Monthly	*PIU, Contractor*	

3.0 DESIGN AND CONSTRUCTION OF AN IMPROVED HOUSEHOLD COOKSTOVE

3.1 Introduction of Improved Household Cookstoves

3.1.1 Improved household cook stoves.

They are designed for household use and exist in both mobile and fixed versions. Based on the design, they can use charcoal or firewood.

3.1.2 Target market for household ICS

- ✓ Domestic firewood users in rural areas.
- ✓ Domestic charcoal users in urban or peri-urban areas.
- ✓ Small scale businesses like restaurants.
- ✓ Food venders.

3.1. 3 Challenges with dissemination of sustainable technologies

- Different stove qualities and types exist on the local market, and some poorly designed and low-quality stoves on the unregulated market may bias end users with regard to the energy saving qualities of well-designed stoves.
- Attitudes and perceptions regarding adoption of new technology (in comparison with methods that have always been used) often derail the uptake of this improved technology.
- For a carbon cookstove project to be successful, the literature suggests that financing is as important as the adoption and sustained use of the cookstove. Both challenges depend on key elements involving financing models, start-up costs, market research, product development, financing for users, outreach and promotion, and after-sales support and monitoring.
- Financing models which accept smaller cash contributions along with raw materials and labour from end-users, should be considered, since this promotes ownership and sustainable use of the ICS.
- Willingness to adopt and pay for clean stoves is a function of consumer awareness and the cultural contexts associated with transitioning to new and unfamiliar technologies.
- Lack of and/or poor-quality post-sales services and support becomes a barrier to the ongoing and sustained use of the ICSs. Therefore, it is critical to provide post-sales services in order to develop a successful project.

- Operation and maintenance: It is recommended to focus on training stove promoters, who are hired and trained in the skills needed to carry on stove sales, installations and maintenance.

3.2 Types of households Improved Cookstoves (ICS)

There are several types of clean cookstoves, including improved biomass stoves, which use less fuel and emit fewer pollutants than traditional stoves, and clean-burning liquid petroleum gas (LPG) stoves, which emit fewer pollutants than traditional stoves and are more convenient to use. Other types of clean cookstoves include electric stoves and solar cookers, which use renewable energy sources and emit no pollutants. Each type of clean cookstove has its own advantages and disadvantages, and the choice of stove depends on factors such as availability of fuel, cost, and cultural preferences. (Carbonibus, Jul 5, 2023). Improved biomass stoves are the most commonly used in Sub-Saharan Africa countries because of their relatively low cost. They can further be categorized based on the fuel feeding/loading mechanism (*Global Alliance for Clean Cookstoves*):

- **Batch-operated** refers to stoves that are operated on a single load of fuel at a time.
- **Continuously fed** stoves require fuel to be loaded throughout the cooking process.
- **Gasifier** stoves are batch- or continuously fed using processed fuel (e.g., pellets, reduced size residues). Combustion occurs in two zones — the pyrolysis zone where fuel is heated to produce combustible gases, and the combustion zone where pyrolysis gases are mixed with air and combusted to produce heat. (Examples: Awamu Troika, Mimi Moto, Philips ACE 1).
- **Charcoal** stoves are batch-operated and fueled with charcoal or carbonized biomass, which is produced through pyrolysis to remove volatile matter leaving mostly carbon. (Examples: Kenyan Ceramic Jiko, Envirofit CH-2200, Burn Jikokoa).
- **Forced-draft / fan** stoves have air that is forced into the stove using a fan or blower to enhance turbulence and promote cleaner combustion (Example: BioLite HomeStove).
- **Rocket** (also known as side-fed) stoves are fueled with wood sticks or biomass residues that are continuously fed through the side of the stove, typically resting on a grate so that ash and charcoal can settle below. Air enters by natural- or forced-draft through the same opening as the fuel. (Examples: Grameen Greenway Smartstove, Envirofit G-3300, Ecozoom Zoom Stove). Rocket type is the most common one given its usability

and costs.

These stoves are classified based on a number of parameters. However, one unique attribute of all these ICS is the use of an insulating material (usually clay) for heat conservation.

3.3.1 The Cookstoves Design Considerations

Designing the cookstoves requires prioritizing the most important features and knowing when compromises can be made. For example, a user may prioritize a fast-igniting stove that saves time and fuel. An NGO may aim to distribute stoves or fuels that offer health and livelihood benefits. A national government may support efficient cookstoves to achieve reductions of greenhouse gases. Manufacturers aim to make a stove as inexpensively as possible to be competitive in the market. While it is challenging to meet the needs of every stakeholder, a successful product will incorporate multiple "design considerations" mentioned above.

Figure below summarises the key attributes to be taken into considerations when designing the cookstoves. *Source: (Clean Cooking Alliance (see https://cleancooking.org)*.

: INGREDIENTS FOR COOKSTOVE DESIGN

PERFORMANCE	AFFORDABILITY	USABILITY	
• Energy efficiency	• Sale price	• Time saved	• Portability
• Health pollutants	• Unit cost	• Weight	• Maintenance & service
• Greenhouse emissions	• Service life	• User interface	• Cleanliness
• Safety	• Fuel consumption	• Turndown ratio	• Attractiveness
• Durability		• Ease of ignition	
• Time		• Tending requirement	

Below are examples of design requirements for cookstoves, each with a measurable target.

- Cooks 1 kg of rice in no more than one hour.
- Weighs no more than 5 kg.
- Achieves 30% thermal efficiency.
- Uses materials available within the country.
- Additional cost of cookstove is recovered through fuel savings in less than one year.
- Parts of the stove that are most likely to fail can be easily replaced.
- Aesthetically pleasing to potential users.
- Achieves a Biomass Stove Safety score of at least 88.

3.3.2 The Design Process

Designers should include a range of stakeholders (e.g., community members, users, entrepreneurs, government officials) in the design process. This process of "co-creation" ensures that everyone with an interest in the solution can include their needs and ideas and contribute to a successful solution.

The needs identified by stakeholders are used to develop the design requirements, which is the list of the highest priority features. The next step is to brainstorm many design ideas including ones that are “outside-of-the-box.” Design requirements are then used to narrow down the ideas using objective information and measurements instead of individual opinions. If none of the design ideas achieve the requirements, then designers may need to consider other ideas or revise the requirements to be more realistic. Good design requirements include measurable targets or comparisons to existing solutions.

A structured design process can help designers create successful solutions that are more likely to meet their goals. The design process includes three phases:
1. Framing the Problem.
2. Creating a Solution.
3. Developing a Product.

Each phase includes three stages:
1. Gather information and insights to gain a better understanding.
2. Brainstorm different ideas and use a selection method to determine the best approach.
3. Test, implement and validate the approach before moving on to the next phase.

Performance Testing

It is difficult predict cookstove performance without measurements. Therefore, testing is an important tool that designers should use to develop their solution and to estimate potential environmental, health, social, and economic impacts.

Cookstove testing is usually done using standard methods, which include tests performed in the laboratory and the field. Laboratory testing is useful for gathering detailed measurements, including fuel efficiency and emissions, in a controlled environment. Field testing is used to understand how the product performs during use in a kitchen with real cooks. Updated laboratory and field-testing standards developed through the International Organization for Standardization (ISO) will help to make sure accurate, high-quality product testing is performed at centers around the world *[Each participating Country should consult their respective National Bureau of Standards, for possible in-country standards, which should be used and followed]*.

During early stages of the design process, simple tests can be performed to compare prototypes. Aprovecho Research Center (ARC) provides a guide for performing a simplified water boil tests that designers can use to evaluate prototypes (Bryden et al., 2006). Designers are also encouraged to work with Regional Testing and Knowledge Centers (RTKCs), which are located worldwide and provide cookstove testing and design advising services. RTKCs can help at any stage of design, manufacturing, and introduction to the market. In some countries, products can be certified for being efficient or low emissions based on testing. It is common for laboratory performance test results to be reported using the ISO International Workshop Agreement (IWA) Tier system. Tier ratings correspond to ranges of performance levels for efficiency, indoor and total emissions, and safety. Tier ratings provide a common language to help designers set goals for stove performance. For example, a designer might target Tier 2 thermal efficiency, Tier 3 CO and PM2.5 indoor emissions, and Tier 4 safety. A designer may also target Tier 3 thermal efficiency as a longer-term goal. This handbook references the Tier system for cookstove performance.

Comparative testing requires that design *variables* that can affect the results are maintained as constant as possible. The key variables to consider are listed in the Table below:

TABLE XXX: VARIABLES TO CONSIDER WHEN PERFORMING SIMPLE COOKSTOVE TESTS (Source: *Global Alliance for Clean Cookstoves*):

VARIABLE	IMPACT	RECOMMENDATION
AIRFLOW, VENTILATION, WIND	**High** – Variation in the availability and amount of air (oxygen) entering the cookstove changes the combustion conditions.	Tests are performed in a sheltered location with no apparent wind, but with some ventilation (open windows or door) so that the fire is not starved of air. Airflow is measured.
FUEL TYPE	**High** – Energy content (calorific value) varies for different types of fuel (e.g., hardwoods, softwoods).	Wood, charcoal, or other fuel used for testing come from the same source.
FUEL MOISTURE CONTENT	**High** – Moisture in the fuel reduces the efficiency and temperature of combustion.	Testing is conducted with fuel that has been left to dry and stored in a warm, sheltered location. Fuel moisture is controlled with a drying oven and measured with a moisture meter.
COOKING VESSEL (POT)	**High** – The type and condition of the pot affects heat transfer and smoke emissions from the fire.	Tests are performed using the vessel. Soot that has collected on the bottom of the vessel is either cleaned prior to each test or left blackened.
STOVE TENDING	**Medium** – Different cooks have different approaches to tending a fire (e.g., amount of fuel added to fire).	Designate one person to be the stove tender for all testing. Let them practice using the stove to become familiar with operation.
AMBIENT HUMIDITY	**Medium** – Large fluctuations during the test can affect combustion efficiency, but small fluctuations have negligible effects.	Tests are performed at similar times of the day (e.g., morning, afternoon). Understand that seasonal changes (e.g., monsoon, dry) will have some impact on stove performance. Humidity is measured.
AMBIENT TEMPERATURE	**Low** – Fluctuations in air temperature can result in a small variation in the heat from the stove lost to the surroundings.	Tests are performed in an indoor space with good overhead ventilation to remove hot exhaust gases. Ambient temperature is measured.

Figure 1: Improved household cookstove (*Source:* https://www.carbonibus.org/cookstove)

3.3.4 Tools required to make an improved household cookstove

- ✓ *Metallic drum*

  This is used for making stove stands and seals.

- ✓ *Stand mould*

  This is used for stove stands.

- ✓ *Compass*

  This is used to measure the diameters of the metal sheets to be cut into cylindrical shapes for the stoves steel cladding.

- ✓ *Hammer*

  This is used for working the steel and other metallic parts of the stove.

- ✓ *Chisel*

  It's used for cutting the metal sheets.

- ✓ *Tire level*

  It's used for working the metal cladding of the stove

- ✓ *Scissors (10ft and 12ft)*

  These are used for designing and cutting out compasses

- ✓ *Snap*

  This is used for riveting metal sheets at joints or sheet intersects
- ✓ *Measuring tape*

  This is used for making measurements
- ✓ *Straight edge*

  This is a metallic ruler used for making accurate measurements on the metal sheets
- ✓ *Painting brush*

  It's used for painting the finished stove body
- ✓ *Metal rail*

  This is used to roll the metal sheet into the desired curved form/shape
- ✓ *Grooving machine*

  This is used to groove the metal sheets to ensure appropriate hardening to enhance stove durability.

3.3.5 Materials used to make an improved household cook stove

- ✓ *28 gauge metal sheet*

  This constitutes the steel cladding of the cook stove.
- ✓ *Libits*

  These are used to uniformly join two ends of a cut metal sheet into the required shape.
- ✓ *Grog*

  This is adhesive material used to join the ceramic liner to the steel stove cladding.
- ✓ *Cement*

  This is used to reinforce liner adhesion to the steel cladding and hence serves as a binding additive.

  In the absence of grog, cement can be mixed with fine baked clay to attach the liner to the steel cladding.
- ✓ *Vermiculite*

  This is a key component of the insulation layer with advantages such as low density and low thermal conductivity.
- ✓ *Metal bars*

  These are used to make the pot rests.
- ✓ *Paint*

  This is used to improve the appearance of the finished stove, and to prevent rusting of the metallic stove cladding.

- ✓ *Liner*

  The liner body includes the grate where the fuel (briquette or charcoal) is placed, and contributes to the heat retention and hence energy saving properties of the improved cook stove.

3.4 HOW TO MAKE IMPROVED COOKSTOVES

3.4.1 Key Components of Improved Cookstove

- The main components of the improved household cookstove are the *ceramic/clay liners* and *steel cladding.*
- The **ceramic liners** have a *requisite quality standard*. They are usually made using moulds, are sun dried and then fired in a kiln.
- The clay should be of high quality and is carefully prepared before it is put in a mould.
- The **steel cladding** is used to clad the ceramic liner, after some technical metal sheet forming/working procedures.

3.4.2 Key Steps in the Process of Making Cookstoves

Figure 2: How to make Fuel-Efficient Stoves – *step-by-step* (*Source:* WFP, 2015)

The process of making improved cookstoves involves several steps, including gathering materials, mixing and shaping the clay, constructing the stove, and drying it. Here is a detailed step-by-step guide:

1. **Gather Materials**: Collect sand, clay, dry grass or millet husks, water, and three stones or bricks of equal size.

2. **Mix Clay**: Combine one part sand, three parts clay, one part husks, and one part water . Mix by hand or foot until firm, then shape into balls.
3. **Build the Stove**: Arrange the stones or bricks in a triangle to support the cooking pot. Form clay walls around the pot, about one hand-width thick.
4. **Insert Chimneys**: Form clay walls around the pot, leaving a small opening for inserti ng firewood. Cut two small chimneys inside for airflow.
5. **Dry the Stove**: Let the stove dry for three days. Remove and twist the pot daily so it d oesn't stick.
6. **Finalize the Stove:** Once dry, the stove is ready for cooking – using 70% less firewood and producing far less smoke.

3.4.3 HOW TO MAKE CERAMIC LINERS

If the liners are to be manufactured locally, the following are the general processes involved;

A). Preparation of the clay

1. *Mining the clay;*

The clay is mined, dried and broken up into small pieces.

2. *Sieving of sand*

- Specially prepared sand is used for liner production and not all types of building sand can be used.
- The sand is first sieved using a fine wire mesh to remove undecomposed organic matter and big stones. If these are not removed, working the clay would be difficult and the liners would easily crack.

3. *Mixing the clay and sand*

- If the quality of clay is not adequate (basing on laboratory quality tests), the clay is mixed with fine sand and water.
- The mixture is then pounded to crush any lumps. It's then wrapped in polythene and left for about 3 days so that the water penetrates sufficiently and makes the mixture workable.
- Tests are usually done on a particular clay type on site so as to establish the appropriate ratios for mixing the clay, sieved sand and water.
- The right mixing ratios are critical in ensuring the liners don't crack during drying, firing in a clean or shortly after assembly.

4. *Kneading the clay*

- The mixture of clay and sand is then squeezed, turned and rolled to ensure that the dough is homogeneously mixed and that there are no air pockets. This is referred to as kneading.
- The clay is then wrapped again in polythene and rested for two days to enhance its elasticity and make it more workable. This process is referred to as curring. During this process, the clay must be kept under a roof to prevent it from drying.
- When preparing the dough (clay-sand mixture) it's important to ensure that the dough is well rested so that it's plastic and readily workable, with no stones or lumps and the dough should be well mixed.
- Non clay particles that serve the same purpose as sand can be added to prevent clay shrinkage. These include termite soil and volcanic ash.

B). The Moulding process

The liner moulding process can be summarized in the following steps;

1. Mould preparation

- The mould's base plate and inside are wiped with wet cloth, and the inside wall of the mould is sprinkled with fine ash to ensure that the wet liner does not stick onto the inner surface of the mould.

2. Cutting the clay

- A block of clay is cut and kneaded against the moulding board to ensure evenness and removal of trapped air.

3. Making the clay slabs

- Two slabs of clay are made, each big enough to cover half the inside wall of the mould.
- The thickness ought to be more than the actual thickness of the anticipated finished liner to ensure that there's uniformity when paddling, and that there will be no need of adding more clay, just scrapping off the excess.

4. Inserting the slab inside the mould

The slab is inserted carefully to cover the inside wall of the mould. This is repeated with the second slap, ensuring that the edges overlap each other.

5. Sealing the seams

- The seams are compacted where the slabs join until the joints are invisible, care being taken to ensure that the seams have completely been sealed.

- If this is not done well, it could prove to be the point of weakness from where the liner may start cracking.

6. Positioning the paddle inside the mould

- The paddle is placed to the central stem to fit.
- Water is then sprinkled on the surface of the clay while rotating the paddle. The paddle blade squeezes the clay against the mould wall making the liner more compact, scrapes off any excess clay making the liner and top edges uniform.
- Once finished, the paddle is gently removed from the mould.

7. Removing the mould from the liner

- The mould body is lifted off the mould base, complete with the wet stove liner.
- The mould is then turned upside down onto a flat board. Let the mould alone and leave the liner in position to dry.

8. Making a fuel wood access opening

- The door template is placed against the stove and the door is cut out using a sharp knife.
- The edges are then smoothed out.

9. Marking positions for the pot rest

- Three pot rest positions are determined.
- One of these should be directly opposite the door with equal spacing between all the three pot rests, so as to guarantee that the cooking pot will be stable.

10. Making the pot rests

- A chunk of clay is taken and pressed into the pot rest mould, ensuring that the clay fills the mould.
- Excess clay is then removed.
- The pot rests are removed from the mould and placed on a smooth surface.

11. Attaching the pot rests

- Scratch the two surfaces which are to be joined and coat each surface with a thick watery clay mix.
- The top of the pot rest is then attached to the top of the liner and it's pressed to fit the appropriate position.
- The top of the pot rest ought to be 1cm higher than the top of the stove.

12. Finishing

The side of the stove is smoothened appropriately.

13. Liner drying

- Once the liners are removed from the mould, they are dried in a shaded area to allow a slow drying process.
- Direct sun drying causes the liners to crack. This drying phase takes about 2 days, depending on the weather.
- After the liners are completed, they are further dried for 2-3 weeks depending on the weather (i.e. if the weather is damp, the liners can be left to fry without being covered, but in dry and hot weather, the liners should be covered with polythene to slow down the drying process so as to enhance uniformity of the clay hence prevent cracking).
- Upon complete drying of the liners, they are placed on a dry surface and left to dry under the sun for 2-3 days so as to remove dampness.

14. Firing the liners

- Firing strengthens the liners and makes them brittle and impermeable.
- Firing of liners is done in kilns.
- Properly fired liners produce a sharp high pitch sound when tapped with a stick/finger, while poorly fired liners produce a dull sound.

C). Kilns

- A kiln is a large, insulated chamber that is heated to high temperatures (over 600°C) for the purpose of firing (hardening/drying) materials such as clay and ceramics.
- Kilns use wood fuel to generate high temperatures within a confined, insulated heating chamber.
- When the items to be fired (e.g. liners) are placed in the heating chamber over a time period of several hours, the heat from the kiln hardens the liners by removing water and bonding the particles together. This results in increased strength and durability of the liners.

N.B

- Making quality liners locally requires an efficient firing process in an appropriate kiln.
- Since construction of an quality kiln is quite capital intensive, it may be cheaper for locals to buy already made liners from established clay/ceramics factory sales outlets within the local area.

- Firing kilns also require a lot of wood fuel making their operation less environmentally friendly.

3.4.4 DESIGN AND ASSEMBLY OF THE STEEL CLADDING

The main elements that should be considered when designing an improved household cookstove can be summarized as;

- *Performance*

Ultimate performance of the finished stove should be premised on parameters such as;

- ✓ Energy efficiency
- ✓ Safety
- ✓ Durability
- ✓ Pollutant and greenhouse gas emission

- *Ease of use*

This can be premised on;

- ✓ Time saved by using the stove
- ✓ Weight of the stove
- ✓ User interface
- ✓ Stove portability
- ✓ Ease of fuel ignition
- ✓ Maintenance and service
- ✓ Attractiveness

- *Affordability*

This includes parameters such as;

- ✓ Fuel consumption
- ✓ Unit cost
- ✓ Sales price
- ✓ Service life

N.B

In summary, stove design should always be focused on the final user, for sustainability

Figure 2 below shows a plan view for the design of a household improved cook stove; dimensions $ø_1$, $ø_2$, $ø_3$ and $ø_4$ are dependent on the sizes of the available ceramic/clay Liners and the target stove user population

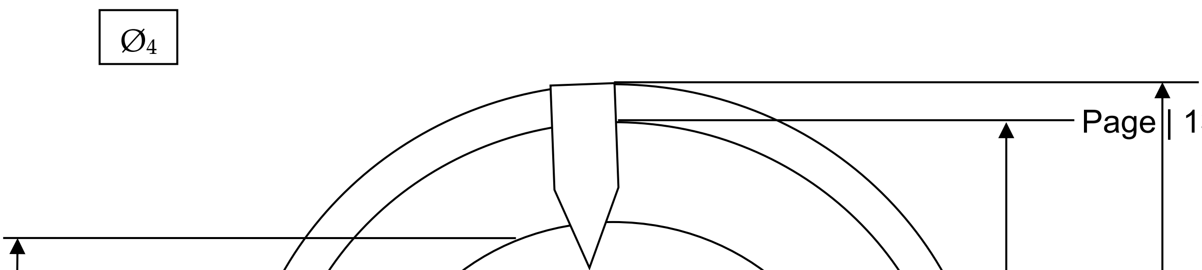


Figure 2: Top view of a finished household ICS

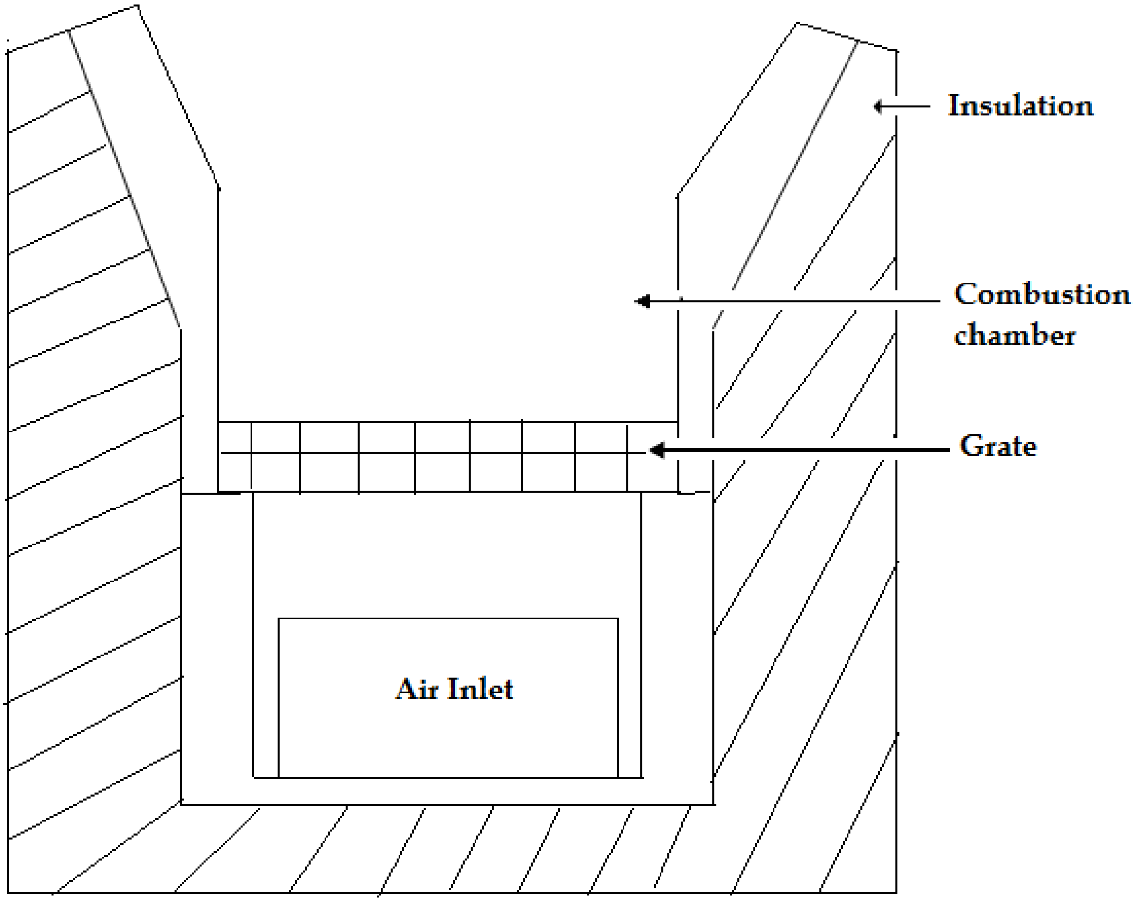
NOTE

During design and assembly, emphasis is always placed on the following;

- ✓ Insulation.
- ✓ position of the air inlet.
- ✓ size of the combustion chamber.

A door is fabricated on the air inlet to reduce the inflow of primary air, whenever need arises, and to also achieve turndown, a feature reinforced by ensuring that the door seals well against the stove body.

Figure 3 below shows an A-A section of the typical household improved cook stove



3.4.5 FUEL PROPERTIES THAT INFLUENCE HOUSEHOLD ICS PERFORMANCE

The energy saving performance of the household ICS is not only determined by the design of the stove, but also by specific attributes of the fuel used. The major fuel properties that must always be considered include:

- **Size**
  - ✓ The smaller the size of the fuel particles, the greater the surface area.
  - ✓ This fosters greater interaction with oxygen in air hence faster heating up, and ultimately burning.

Recommendations

- ❖ Household ICS users are therefore advised to always use fuel of relatively small sizes. Size reduction can always be achieved for big size particles in a range of ways.

- **Density (mass per unit volume)**

- ✓ Fuels with higher densities generally burn at a slower rate and for a longer time period.
- ✓ Fuels with lower densities generally burn at a faster rate and for shorter time periods.

- **Moisture content**

  A high amount of moisture in the fuel has a number of disadvantages. These include;

  - ✓ Significant reduction in combustion and thermal efficiency.
  - ✓ Increased emissions.

Recommendations

- ❖ This is the reason why processed fuels such as briquettes should always be dried adequately.
- ❖ Users of household improved cookstoves should optimize their performance by always using dry fuels e.g. charcoal.

4.0 DESIGN AND CONSTRUCTION OF AN IMPROVED INSTITUTIONAL COOKSTOVE (IICS)

4.1.1 Introduction of Improved Institutional Cookstoves

- The IICS is a heavy-duty cooking utility for relatively large establishments (not households).

4.1.2 Target market for institutional ICS

- ✓ institutional firewood users such as schools and health centers.
- ✓ institutional charcoal users in urban or peri-urban areas.
- ✓ Small- and large-scale businesses such as restaurants and hotels.

4.1.3 Benefits of IICS

- *Fuel Efficiency*

  IICS are more fuel efficient than traditional charcoal stoves and 3-stone fireplaces due to their high combustion and heat transfer efficiency.
- *Durability*

  IICS are more durable than many currently used technologies for institutional cooking.
- *Saves money*

  Since it uses less fuel than traditional stoves per heating round, money that would have been used on excess fuel wood/charcoal is saved.
- *Saves time*

  Increased cooking speed when using these stoves redeems valuable time for the kitchen staff.
- *Safety*

  Incidents of fire hazards are reduced when using institutional improved cookstoves.
- *Reduced air pollution*
  - IICS emit less smoke and are hence safer for use indoors.
  - If used with charcoal briquettes, no smoke is emitted at all hence it results in zero indoor air pollution.
  - Eye irritations and respiratory health complications are hence reduced.
- *Easy to operate and maintain*

  No technical skills are required to use and maintain the stove, only basic maintenance like cleaning are required.

- *Environmental protection*
    - Their energy conservation features reduce pressure on forests through reduced deforestation.
    - Greenhouse gas emissions reduce to efficient biomass combustion.

4.1.4 Performance characteristics of an institutional ICS

- *Combustion efficiency*
    - ✓ This is how efficiently the stove consumes fuel (or the amount of energy that is turned into heat by burning).
    - ✓ Stoves with high combustion efficiencies require less fuel than those with low efficiencies.
    - ✓ This efficiency is achieved by adjusting factors that affect heat containment (such as insulation) and air flow during stove design so as to achieve complete breakdown of the fuel.
- *Fuel efficiency*
    - ✓ This is the percentage of heat energy produced during the combustion of fuel that is used to heat the contents in the cooking pot (food or water).
    - ✓ It is a measure of the amount of energy used to do work (cook food).
- *Heat transfer efficiency*
    - ✓ This is the percentage of heat released from combustion that enters a cooking pot.
    - ✓ Heat transfer efficiency is achieved by ensuring hot gases are kept in direct contact with the cooking surface and preventing leakage of heat.

Note

- A good and properly designed institutional ICS should have **high** combustion efficiency, **high** fuel efficiency and **high** heat transfer efficiency.

4.2 Tools and Materials required to make an institutional ICS

4.2.1 Tools required for brickwork

- ✓ *Spade*

  This is used for mixing building ingredients/materials as well as extracting soil from the foundation base.
- ✓ *Hoe*

This is used for digging the foundation base as well as mixing building ingredients.

- ✓ *Trough*

  It's used for carrying mixtures. It can also be used for measuring materials by volume.

- ✓ *Shovel*

  This is used for mixing building ingredients/materials as well as extracting soil from the foundation base.

- ✓ *Plumb line*

  It's used to inspect the vertical alignment of the laid bricks.

- ✓ *Spirit level*

  It's used to inspect the horizontal level for laid bricks.

- ✓ *Try square*

  This is used to inspect right angled corners.

- ✓ *Wheel barrow*

  It's used to carry construction materials to the site of construction for the improved cook stove.

- ✓ *Water drum*

  This is used for water storage at the construction site.

- ✓ *Jerry can*

  It's is used for ferrying water to the site of construction.

- ✓ *Trowel*

  This is used for smoothing the plaster or stove finishing.

- ✓ *Measuring tape*

  It's used for taking measurements.

- ✓ *Pick axe*

  This is used for digging the foundation base.

- ✓ *Sledge hammer*

  It's used for driving the foundation pegs into the ground.

- ✓ *Wall chisel*

  It's used to split, cut into or notch bricks and walls.

4.2.2 Tools required for metal fabrication

- ✓ *Chisel*

  Used for cutting metal sheets.

- ✓ *Measuring tape*

Used for taking linear measurements.

- ✓ *Try square*

  It's used for inspection of right angled corners.

- ✓ *File*

  It's used for smoothing metal edges.

- ✓ *Hacksaw*

  For cutting sections to desired lengths.

- ✓ *Anvil*

  It's a base for hammering.

- ✓ *Pick hammer*

  It's used for removing slag from welded metal parts.

- ✓ *Angle grinder*

  This is used for smoothing welded joints.

- ✓ *Wire brush*

  This is used for cleaning metal surfaces before welding.

- ✓ *Hammer*

  It's used for driving the chisel.

- ✓ *Arc welding set*

  This is used for joining metal pieces.

4.2.3 Safety Gear

- ✓ *Eye Shield*

  Protecting the eyes against radiation during welding.

- ✓ *Eye Goggles*

  Protection of eyes when grinding or cutting.

- ✓ *Leather gloves*

  Protection of hands from burns when welding or other risks.

- ✓ *Leather apron*

  Protection of the body and clothes during welding.

- ✓ *Nose mask*

  Protection against inhaling of toxic gases during welding.

- ✓ *Industrial boots*

  Protection of feet during workshop activities.

- ✓ *Helmet*

Protection of head during workshop activities.

- ✓ *Overalls*

  Protection of body during workshop activities.

- ✓ *First Aid Kit*

  Treatment of Injuries.

4.2.3 Materials used to construct an improved institutional cook stove

• Fired bricks.	• Vermiculite.
• Curved bricks.	• Micar.
• Cable cover bricks.	• Tiles.
• Fire bricks.	• Adhesive and grout.
• Clay pipes.	• Angle bars.
• Metallic chimney pipes.	• Top rings.
• Sand.	• Fire shelves.
• Water.	• Ash scoop.
• Cement.	• Grate.
• Grog.	•

<u>NOTE</u>

The quantities of these particular materials (and market substitutes/alternatives) depend on the size of the stove and availability in the local area.

4.3 CONSTRUCTION OF THE INSTITUTIONAL IMPROVED COOKSTOVE

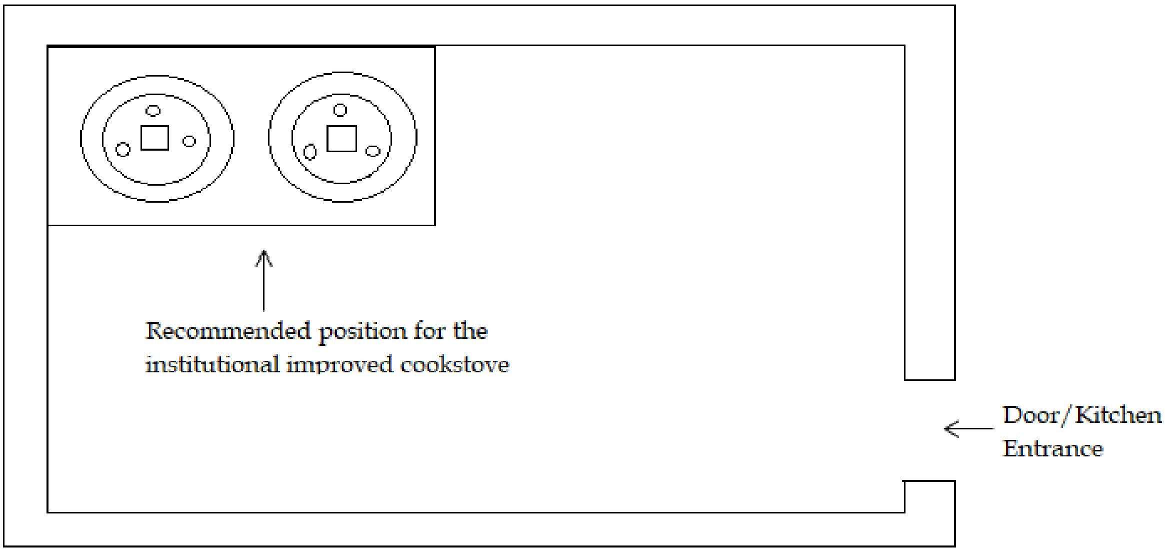
4.3.0 Planning the stove

4.3.1 Mapping out the position of the stove

- ✓ Select a corner in the kitchen where the stove will be built.

- ✓ A corner is preferred to safeguard the stove from direct intake of cold air.
- ✓ A corner position also reduces the likelihood of accidental damage to the stove.

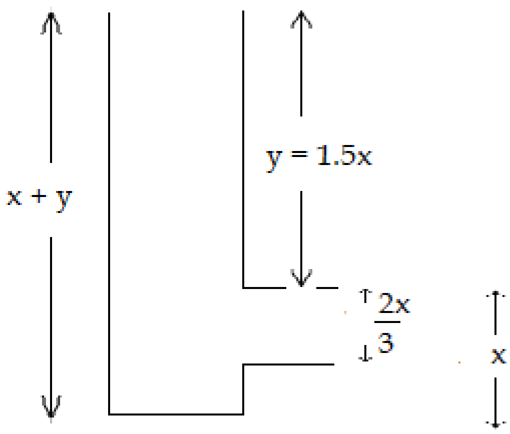
The *figure 4 below* shows the correct positioning of the institutional cookstove in the kitchen shelter.



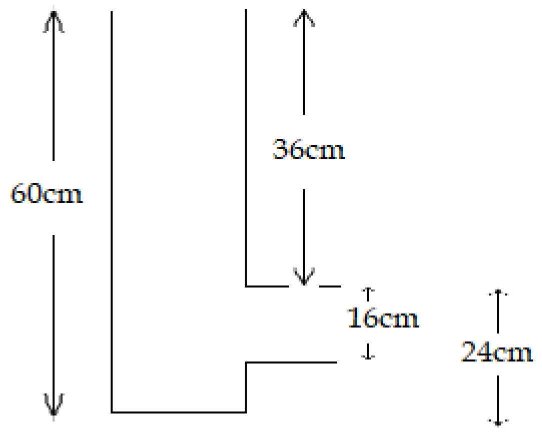
4.3.2 Determination of the dimensions of the institutional cookstove

- *Width of the combustion chamber*

The diameter of the largest pot/saucepan that is used for cooking at the institution is used to set the dimensions of the cooking chamber. Generally, the cooking chamber dimensions will be set out in the ratios indicated in the figure below;



For instance, if a 250 liter saucepan (of diameter 84 cm) is the largest used to cook at the institution, then **x** will be equal to 24cm, resulting in dimensions indicated in the figure below;



- *Inner diameter of the curved bricks assembly*

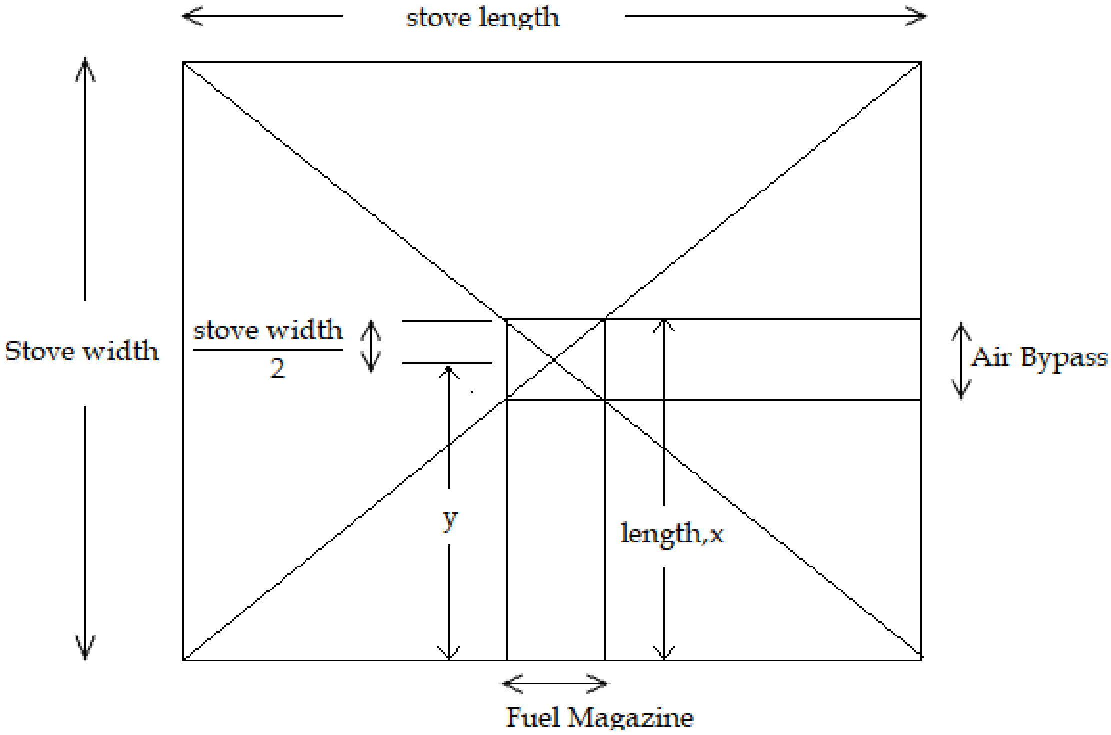
  This is obtained by adding 2X2 cm to the measured diameter of the saucepan (for which the stove is being designed).
- *Curved bricks and insulation width*

  These are obtained by adding 2X dimension of a single curved brick, and adding 2X6 for the corresponding width, respectively.
- *Outer brick wall dimensions*

  These depend on the width of the bricks being used for the outer brick works.

4.3.3 Determining the dimensions of the combustion chamber fuel magazine

- ✓ Draw an outline of the cookstove with its outer dimensions on a piece of paper.
- ✓ Draw diagonals on the piece of paper and mark out the position where the diagonals intersect.
- ✓ Measure the distance between the intersection point of the diagonals and the center point of the fuel magazine opening, and this translates to the distance, **y**, from the fuel magazine opening to the center of the combustion chamber, as illustrated in the Figure 5 below.



- ✓ The total length of the combustion chamber fuel magazine, **x** is then determined as;

  $x = y + (\frac{1}{2} \text{ X stove width})$

- ✓ Map out these dimensions as a floor plan, where the institutional cook stove is to be built.

4.3.4 Building the stove

4.3.4.1 Preparation of the mortar

- ✓ Mix fine sand and cement in a volumetric ratio of 3:1.
- ✓ Blend the mixture thoroughly to homogeneity, slowly adding water to make the mortar easy to mould.

4.3.4.2 Preparation of the insulation mortar

- ✓ Mix grog and cement in a volumetric ratio of 2:1.
- ✓ Blend the mixture thoroughly by adding water to achieve homogeneity, using a shovel.

4.3.4.3 Setting out the foundation

- ✓ Peg out the foundation using sticks.

- ✓ Excavate the foundation with width 30cm and to adequate depth (at least 30cm).
- ✓ In case the kitchen already has a concrete floor, the two steps above are skipped.

4.3.4.4 Doing the combustion chamber and outer walls brick works

- ✓ Do the brick work for the foundation up to the first course, with an allowance for the air inlet and firewood magazine.
- ✓ The air inlet and firewood magazine ought to be constructed using firebricks, and so is the combustion chamber wall.
- ✓ Raise the combustion chamber walls and outer walls to the required height as per the design calculations.
- ✓ Build a support wall behind the firewood magazine to avail extra support against any likely impacts of firewood insertion.

4.3.4.5 Insulation layer between the combustion chamber and outer walls

- ✓ Fill the space between the combustion chamber and outer brick walls with cement mortar and grog.
- ✓ Slant the mortar finish slightly downwards to the top of the combustion chamber.

4.3.4.6 Setting up the saucepan stabilizer

- ✓ The saucepan stabilizer is centered on the stove, taking into consideration the center of the combustion chamber.
- ✓ Build the circular brick wall up to the top using insulation mortar, replacing the saucepan (with the desired volume) as often as necessary so as to ensure the 2cm gap is maintained.
- ✓ Some brick space is maintained in the last course of the circular bricks as a provision for the chimney.
- ✓ The gap between the circular brick wall and the outer brick wall is filled with insulation material (e.g., vermiculite).
- ✓ Fix the chimney and then set the top slab.

4.3.4.7 Stove finishing

- ✓ Fix the chimney and set the top slab, ensuring that no finishing works are undertaken before the top slab sets.
- ✓ Cover the slab with grog and mortar cement.

- ✓ Weld the angle sections/bars into a frame that fits the outer stove edges, so as to protect the stove edges from damage.

The photos below illustrate different styles of stove finishing that can be applied to institutional improved cookstoves

Plate-1

Plate-2

Plate-3

4.4 RECOMMENDED END USER PRACTICES TO ENSURE STOVE LONGEVITY

- Due to the relatively high initial investment cost required to set up an institutional improved cookstove, end users are encouraged to adopt good use practices to avoid the need for frequent repairs.
- Even the best well-built stove, constructed with the best quality materials may not complete its designed service life due to poor use habits.
- This section sets out some recommendations to guarantee stove durability.

4.4.1 Good Stove Use Practices

a. Before first time stove use

- Leave the stove to perfectly dry and set after construction before using it for the first time.
- Kitchen staff should be adequately trained on how to use the improved institutional cookstove.

b. Efficient cooking practices

- Gently insert fuel wood into the firewood magazine to avoid impact on the chamber walls.
- Split the firewood into relatively well sized pieces for more efficient burning/ combustion.
- Use dry firewood
    - to limit the possibility of excessive smoke/emissions which pollute the atmosphere.
    - Wet firewood loses most of its heat value in driving off excess moisture/water and hence very little heat is passed on to the cooking pot/saucepan.
- Dry preserved food (such as beans) can be soaked for some hours prior to cooking so as to reduce the amount of energy required for cooking such food.
- Light the fire after adequate pre-preparation for the food to be cooked so as to minimize wastage of fuel wood/biomass energy.
- Cover the saucepan with a lid to enhance pressure buildup in the saucepan. This softens the food resulting in faster cooking and savings on biomass fuel.
- Use appropriately sized saucepans for meal preparation. Using undersized saucepans results in fuel wood wastage and raises the risks of accidental burns and fires.

- Limit unnecessary impact on the stove walls whenever possible so as to avoid denting the stove finishing, which will result in avoidable repairs.

c. Cleaning the stove

- Clean the stove only when it is not in use to avoid burns and accidents.
- The stove should be cleaned after it has fully cooled.
- Clean the stove surface with a moist rag in case of any food spills during food preparation.
- Gently scoop out the ash in the combustion chamber or firewood magazine always, before lighting the stove.

d. Stove maintenance and repair

- Users are encouraged to regularly inspect the stove body, finishing and firewood magazine for any wear and tear, and notify relevant authorities in the event of any such observations.
- Technical personnel, preferably the service provider who installed the stove (not local artisans) should always be consulted for any stove repair works in case need arises.

e. Safe Handling of Cookstoves

- ***Flames surrounding the cooking vessel and emerging from the fuel chamber:*** Flames that touch the cooking vessel must not come into contact with hands or clothing. This prevents the risk of burns to people in the vicinity. Users are encouraged to keep children away from the cookstoves.
- ***Sharp edges and points:*** Sharp edges and tips can entangle clothing and cause the stove to overturn. Therefore, the outer surfaces of a stove must not catch or tear clothing or risk cutting your hands during normal use.
- ***Tilting the cooking stove:*** The cooking stove must be stable to maintain a vertical orientation when in operation. Burning charcoal can be expelled from the firebox or spilled when the stove tips over. This can cause eye burns and lead to fires.
- ***Obstructions near the cooking surface:*** The areas surrounding the cooking surface should be flat so that cooking vessels moved from the stoves do not collide with protruding parts and spill boiling contents onto hands or children.

4.4.2 Quality Control

At the producer level, quality control this includes selecting the right producers and ensuring that they are suitably qualified. The Country teams should develop own methods to select the most appropriate producers using the following criteria:

- Education and skills including basic literacy, artisan skills, entrepreneurship and professional experience.
- Their level of interest and the compatibility of stove production with their current employment.
- The availability of workshop space and access to basic commodities.
- Personal factors, such as reputation, communication skills and reliability.

After being selected, producers have to be given the support they need to produce the newly introduced technology through:

- Training in special technical skills, entrepreneurship, quality management.
- Financial support; for example, a loan, credit, or a grant.
- Starter packages with moulds, tools, manuals, tables of measures.

Once the producers have been selected, and have been provided with skills through workshop training schemes, a quality control system should be established, as shown in the table below..

Components of a Good Quality Control System

Testing and certification of design models or prototypes.	The Country teams should work with their respective National Bureau of Standards to get Benchmark Certification for all the stoves used in the project. After approval of the design model it has to be assured that all stoves produced later have the same quality as the prototypes.
External control of the stove quality and the production organisation.	In some cases this is only done during the initial introductory phase by the project. To maintain a high quality over a long time it is recommended that a constant quality control system is set up. For example, every month an inspector visits the producers and checks the stoves. In addition, the stoves can be regularly checked by the ASCENT project or by the Department of Energy. If the producer maintains a high quality for a long period of time, only random samples are checked.
Identification of every stove with serial number	Each stove should leave the production site with a serial number and a certificate that serves as warranty (granted by producer).

	Certification of producers and serial numbers of stoves in Malawi (Photos: GTZ)
Systematic registration of the stoves by the producer, when sold to whom.	These records are important to document the project's impact. And they help the stove producer - even if they initially refuse to keep records. They get a better overview about the market and can adjust the number of certificate plates or labels to the real number of produced stoves. A record booklet can be used by illiterate people.

Although monitoring and control of these 'over the counter' technologies at the workshop gate is easy to operate, it is very difficult and laborious to assess the later use, performance and lifetime of the products in the end users household.

REFERENCES

1. Developing Energy Enterprises Project East Africa (DEEP EA), Technology Fact Sheet-Improved Cook-Stoves Production.
2. Handbook for Biomass Cook stove Research, Design and Development. A Practical Guide for Implementing Recent Developments. Global Alliance for Clean Cookstoves, MIT D-Lab.
3. Household Cookstoves, Environment, Health and Climate Change: A New Look at an Old Problem. 2011. The World Bank.
4. Northern Uganda Energy Study. Centre for Research in Energy and Energy Conservation (CREEC), CEDAT, Makerere University.
5. Institutional Cook stove Manual. 2008.GTZ-PREEP, MEMD.
6. Clean cookstoves and clean cooking solutions - Guidelines for social impact assessment, First edition 2023-11, ISO Technical Report/TR 19915:2023(E).
7. Clean Cooking Alliance (see https://cleancooking.org).