Gaia Association

Policy brief

Ethanol for Cooking Programme in Ethiopia

1. Energy in Ethiopia

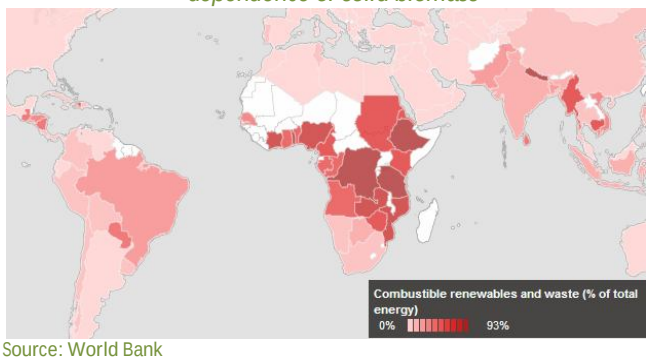
Ethiopia is a country of 94 million people in 18 million households with a total area of 1.1 million square kilometres. Its existing stock of infrastructure including energy is very low (even in Sub-Saharan Africa standards). Access to sustainable energy is also low where only 23% of the population and less than 5% of the rural population is connected to electricity. Access to sustainable sources of energy for domestic (such as cooking), productive (agriculture, rural enterprises), and social services is still very limited.

Ethiopia is a large, low income country with rapidly growing economy. Ethiopia's economy and population is growing rapidly; as a result its demand for energy is growing at even higher rates.[1] Although infrastructure expansion is a key agenda for the government and infrastructure investment has been sustained at high levels for the past decade there is still a large gap in terms of meeting demands.

Ethiopia depends on a limited set of energy sources to meet its energy requirements: electricity is generated mostly from large hydropower plants, transport is exclusively petroleum based, and cooking energy requirement in households is met mainly with biomass fuels. Limited diversity in supply exposes consumers to access risks. The hydropower dominated power system is exposed to climate variability, petroleum supplies are imported and suffer from international price volatility and foreign exchange availability, and access to biomass fuel supply for cooking has deteriorated due to declining biomass yields and stocks. Increasing diversity and improving sustainability is now given due attention: wind and geothermal energy are promoted for the power sector; electric railways are under development for transport; and cooking fuel alternatives, including liquid bio-fuels, are promoted for cooking.

Ethiopia's high dependence on non-sustainable source of energy, particularly biomass, for cooking has been a major concern over the past thirty years. The concern in the initial years was related to the potential contribution of biomass energy demand to deforestation and growing access problems to consumers (long collection distances and times). In recent years concern has grown due to the health impacts of cooking with biomass, and the contribution of non-sustainable biomass extraction to greenhouse gas emissions.

Ethiopia is one of only three countries in the world with highest dependence of solid biomass



Source: World Bank (http://data.worldbank.org/indicator/EG.USE.CRNW.ZS/countries?display=map)

2. Rationale for promoting ethanol as cooking fuel

Meeting cooking energy requirements sustainably calls for actions in three directions: improving energy efficiency, sustainable management of existing sources of energy, and introducing new sustainable fuels. Considerable effort is going into improving energy efficiency and management of resources for biomass fuels; relatively less effort is directed towards providing new sustainable fuels for cooking. Ethanol is one of the new fuels that are considered viable in the Ethiopian context because it is a clean domestic fuel with growing availability at competitive prices.

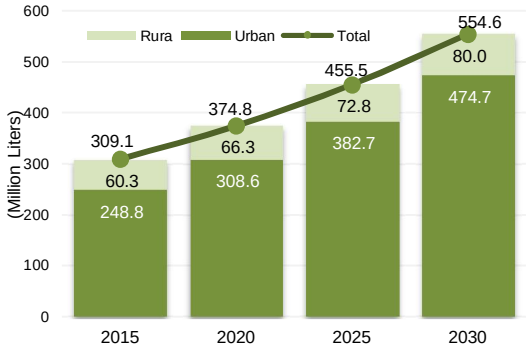
Ethanol is produced from sugarcane molasses in Ethiopia. Domestic annual production from sugarcane molasses alone may rise to 350 million litres in the next five years due to the expansion of sugar production in Ethiopia.[2] In addition to sugarcane molasses, Ethiopia has other potential feedstock for ethanol production including sugar crops, sweet sorghum, and crop waste (fruits, vegetables, sugar crops) which may increase potential output to 500 million litres or more annually.
Ethanol can be locally produced at small, medium or large scale. Small scale production enables localization of the ethanol production process, increasing the domestic content of ethanol produced in Ethiopia. Ethanol has a high energy to volume ratio which makes it ideal for transport (its storage and transport also does not require expensive equipment, unlike LGP for instance).

[1] According to the EEP, unconstrained electricity demand is growing at 2.1 times that of GDP, and demand for petroleum and other fuels is growing at high rates also.

[2] Potential ethanol production from government owned sugar factories alone is estimated at 350 million liters annually. The amount that will be available for cooking will be 250 million liters (setting aside 100 million liters for gasoline blending). This is enough to meet the cooking (excluding baking) energy requirements of 0.6 million households (i.e., 3% of all Ethiopian households).

At current market prices ethanol is a cheaper cooking fuel compared to kerosene and LPG; it is slightly more expensive than biomass; and much more expensive than electricity. However, social valuation of ethanol and the alternatives makes ethanol a cheaper cooking fuel compared to both petroleum and biomass fuels. The health and environmental benefits of ethanol compared to petroleum and biomass fuels further improves its competitiveness against petroleum and biomass cooking fuels

Demand Projection for Ethanol for Cooking



3. The national policy framework for promoting ethanol as cooking fuel

Ethiopia's vision for 2025 is to become a middle income country in a climate- resilient and green economy path. Climate resilience and green growth are promoted because of the vulnerability of the economy to climate variability (e.g. agriculture), resource limitations of continuing the current development path (e.g. expansion of cropland, increased livestock numbers), the financial risks of depending on traditional technologies (e.g. petroleum imports), and to reduce greenhouse gas emissions (CRGE, 2011).

Protecting and re-establishing forests is one of the four pillars of the green economy plan. Introduction of ethanol as a domestic renewable cooking fuel meets the aim of reducing forest degradation (replacing biomass fuels) and at the same time reduce the financial risks to the economy of dependence on imports (replacing petroleum fuels).

The Draft National Energy Policy (2013) identifies ethanol as a domestic renewable fuel that will improve the security and reliability of energy supply (as transport and cooking fuel). The policy identified the two barriers that have limited scale-up of ethanol as cooking fuel in Ethiopia as inadequate distribution system, and the high cost of purchasing ethanol stoves. The policy recommends increasing ethanol production and improving marketing and distribution for wider adoption of ethanol as cooking fuel.

The policy stressed the need for a systematic value-chain development approach to establish ethanol as a true alternative cooking fuel in Ethiopia. Actions spanning from research and development in technologies to investment and marketing need to be undertaken by government and private enterprise to achieve this goal.

The mission of the Science, Technology and Innovation (STI) Policy (2012) is stated as "creating a technology transfer framework that enables building national capabilities in technological learning, adaptation and utilization through searching, selecting and importing effective technologies in manufacturing and service enterprises." The current effort to manufacture components of ethanol distilleries (micro and small scale) and ethanol stoves are in line with the STI policy.

4. Issues that have inhibited the large scale adoption of ethanol for cooking in Ethiopia

The potential market for ethanol as cooking fuel is half a million or more households by 2025. The current market size is about 3,000 households, i.e., less than 0.5% of the potential. Although it has been ten years since ethanol has been introduced as a cooking fuel in Ethiopia its market is essentially limited to very few households in Addis Ababa. The market for ethanol as cooking fuel has not grown because of availability constraints, rising price for ethanol, inadequate public awareness and marketing, and limited distribution infrastructure and services.

a. **Availability of supply:** availability of ethanol for cooking has been uncertain since the introduction of the fuel for cooking ten years ago. This has inhibited existing distributors from investing in distribution and also on marketing the fuel. Uncertainty about long-term availability of ethanol in large volumes has also inhibited potential new entrants (such as petroleum companies) from entering the market. Although supply availability has improved recently with special allocation for cooking, however, the market was already depressed because of supply uncertainties in the past, the sharp price rise and distributors could not sell as planned. Investment requirements for ethanol distilleries are high at both large and micro scale. Large distilleries require several hundred millions ETB[3] while micro distilleries require relatively smaller amounts. For instance, a 1,000 litres/day distillery plant costs around ETB 5 million. Investment constraints from the public sector may be addressed by promoting private and foreign investment in ethanol distilleries. Private and foreign investment in ethanol distilleries will depend on competitive supply of sugarcane molasses from government sugar factories and also competitive pricing of ethanol for consumers.
b. **Alternative options for ethanol feedstock production and processing**: alternative feedstock that are viable in Ethiopia including sweet sorghum, sweet potato, sugar beet, cassava, prickly pear cactus, vegetable and fruit waste, have not been sufficiently explored as possible sources of ethanol production. Small and micro scale processing of feedstock with small and micro scale ethanol distilleries has also not been given sufficient attention in the past. Feedstock production and processing at small scale by private enterprises or cooperatives could supplement large scale production and processing by the public sector.

[3] USD 1 = 20.05 Ethiopian Birr (ETB) (10 December 2014)

c. **Ethanol pricing relative to alternatives**: ethanol is in competition with wood, charcoal, kerosene, LPG and electricity. The price for ethanol has eroded its competitiveness with these fuels making it less attractive to consumers. The expressed interest of the government to promote the fuel for its economic and environmental benefits does not appear to have been considered in setting its price.

d. **Public awareness and marketing**: the public is not aware of the existence of ethanol as a potential alternative cooking fuel. Very few households use ethanol for cooking, therefore, few have first-hand knowledge of ethanol as cooking fuel (they themselves using the fuel or seeing others use the fuel). There has also been no public awareness campaign to promote the fuel.

e. **Distribution capability**: existing ethanol distributors have very limited distribution capacity both financially (to purchase and distribute in significant volumes) and physically (storage and distribution facilities). Existing distributors of ethanol for cooking are essentially small enterprises for whom ethanol distribution is a secondary business. Potential large scale distributors (such as petroleum companies) have yet to enter the market because of supply uncertainties.

f. There are also inadequate **support for functions in the supply chain**: including technology adaptation (distilleries, stoves), R&D for feedstock, standards and regulations for ethanol fuel and stove, financing of investment and R&D.

5. Recommendations for large scale adoption of ethanol for cooking in Ethiopia

The commercial market for ethanol as cooking fuel is very small and limited to Addis Ababa. The market is not growing and probably shrinking because of uncertainties of supply and rising prices. On the other hand, potential availability of ethanol is high from state owned sugar factories (from public and private investment in ethanol distilleries from molasses waste). There is also potential to promote private investment in ethanol distilleries from a variety of feedstock including sugarcane, sweet sorghum, other sugar crops, and crop waste.

There is clear advantage in using ethanol for cooking rather than for other uses including as gasoline blend or export. Cooking can be the largest market for ethanol produced in Ethiopia; cooking with ethanol has multiple economic (at consumer level and nationally) and environmental benefits.

- **Household energy expenditure.** Households that are substituting ethanol will make savings on expenditure on ETB 136 per year and ETB450 per year on kerosene and charcoal, in their respective orders. The aggregate savings over the same period is estimated at ETB 5,131 million and the net present value 10.23% discount rate ETB 2,185 million.
- **Kerosene import substitution and foreign exchange.** The ethanol for cooking programme will allow the displacement of 1,747 million liters of imported kerosene. At the current import price of USD0.65/liter, USD1,135 million will be saved.
- **Avoided energy-related deforestation.** The Programmed will allow the substitution of fuel wood and charcoal amounting to about 33 million tonnes of Fuel wood Equivalent. At 75 tonne/ha of above-ground biomass, this is translated into an avoided deforestation of 441 thousand ha.
- **Job creation**. A total of 118 micro-distilleries of 1,000liter/day capacity will be required to fill the demand-supply gap. These will create approximately 17,200 new permanent jobs over the 15 year time horizon.
- **Green House Gas (GHG) emission reduction**. Over the 15 year period, the Programme will allow the avoidance of 65 million tonnes CO_2 equivalent. Based on a market price of USD5.00/tCO_2e, it could generate USD325 million in carbon revenues.

Private enterprises distributing ethanol as well as the public institutions that produce ethanol and promote its use as cooking fuel agree market development to be the key goal. Sustainable market development requires suitable policies and regulations, investment in ethanol production and distribution, promotion and marketing. The following actions need to be taken for ethanol to become a viable alternative cooking fuel in Ethiopia:

a. Increase ethanol production and ensure long-term availability.

- Increase ethanol production from government sugar factories through both government and private investment. Government should promote private investment (local, foreign, joint) in ethanol distilleries for the new sugar factories. There is already such a plan by the government but this plan must be pursued strongly. Investors also seek competitive and stable prices for inputs (molasses purchases) and outputs (ethanol wholesale) and government must provide long-term price incentives to attract private investment.
- Promote diversity of ethanol production feedstock (other than sugarcane molasses). Provide policy guidance for feedstock cultivation for ethanol production to increase and diversity ethanol production sources and to attract investment. The Bio-fuel Policy does not provide guidance on whether feedstock other than sugarcane molasses (and sugarcane) can be used as ethanol feedstock. Clear policy guidance on this will attract investment in ethanol distilleries.

- Ensure/secure/guarantee long-term (10 years) sustained supply of ethanol for cooking at growing levels from government ethanol distilleries. Guaranteed allocation of sufficient ethanol for cooking will increase market share for ethanol in urban areas. Allocation should be based on market demand assessment for the fuel.
- Increase R&D in ethanol distilleries and ethanol stoves to lower supply costs. Ethanol micro distilleries promote rural agro-industry. This is an area that is given high priority for investment by the government together with manufacture. Micro distilleries also promote rural commercialization which is a strategic focus for the agriculture sector. Investment in micro distilleries will therefore receive the investment incentives outlined above.

b. Price ethanol competitively to increase its market share.

- Implement social valuation of ethanol to ensure that non-financial benefits of ethanol are reflected in its price. Make rationale economic, social and environmental valuation of the benefits and costs of using ethanol for cooking, as gasoline blend or for export. Allocation and pricing of ethanol among the alternative uses should be based on such rationale valuation not on enterprise level decisions.
- Provide tax exemptions for ethanol if production cost for ethanol exceeds levels that make it competitive with other cooking fuels (this will of course depend on the economic/social price of ethanol).
- Provide long term outlook for price development for ethanol to ensure sustained engagement of investors in ethanol distilleries and ethanol distribution.

c. Integrate ethanol as a clean cooking alternative in the National Improved Cook stoves (NICS) program of Ethiopia. Clean cooking with ethanol will then benefit from national efforts for public awareness and education, standards and their regulation, financing, and RET enterprise development.

d. Distribution capability: provide incentives to existing distributors and potential new distributors to invest in distribution of ethanol.

- Attract large companies (e.g. petroleum distributors) to engage in ethanol distribution (through supply guarantees, attractive distribution margins)
- Provide alternative distribution models for ethanol (bottled ethanol, ethanol at the petrol pump)
- Provide investment incentives for ethanol distributors to invest in storage and distribution infrastructure; also provide low-cost safe designs for storage and distribution of ethanol.
- Develop and implement safe ethanol storage and distribution standards.

This policy brief is an output of the Holistic Feasibility Study of "A National Scale-up Program for Ethanol Cook stoves and Ethanol Micro Distilleries (EMDs)" project funded by DFID, with contribution from the Norwegian and Danish governments through the Strategic Climatic Institutions Programme (SCIP). However, the views expressed and information contained in this document are not necessary those of or endorsed by DFID or contributing governments, which can accept no responsibility or liability for such views, completeness or accuracy of information or for any reliance placed on them.

Gaia Association is an Ethiopian resident charity organization established in 2005 to promote the use of renewable ethanol fuels for household energy in Ethiopia. The Gaia Association seeks to reduce household energy dependence on imported petroleum and hazardous solid bio-fuels, improve indoor air quality by preventing smoke-related health problems, and increase user safety and quality of life.

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EMD and Ethanol Stove Technology Brief

Ethanol for Cooking Program in Ethiopia

1. INTRODUCTION

Ethiopia is highly dependent on woody biomass as cooking energy source in the form of firewood and charcoal which is severe consequence on the environment causing deforestation and land degradation. Indoor air pollution caused by solid biomass burning is also responsible for approximately 4.9% the total burden of disease among all age groups in Ethiopia.

On the other hand, ethanol, an industrially manufactured fuel from sugar containing feedstock is globally getting recognition as clean burning cooking fuel. GAIA Association, an Ethiopian resident charity organization established in 2005 has been promoting the use of renewable ethanol fuel for household energy in Ethiopia for the last decade. Nonetheless, this was not without challenge and the organization's effort couldn't penetrate enough to reach the potential market adequately.

Among the challenges are lack of reliable ethanol source and lack of local ethanol stove manufacturer with acceptable quality to realize its availability and affordability. Hence, as part of the*"Holistic Feasibility Study of a National Scale-up Program for Ethanol Cook Stoves and Ethanol Micro Distilleries"* conducted nationwide in 2014, this paper presents the findings with particular focus on analysis of small scale ethanol production technologies (ethanol micro-distilleries) and local production of ethanol stoves.

With a general objective of investigating the technical capacity, possibilities and challenges for the production of ethanol micro distilleries and ethanol stoves in Ethiopia, this paper discusses the following issues:

- The ethanol production and ethanol stove technologies and how that could be adopted to Ethiopia.
- Assessment of locally available technologies and skilled man power capacities; and identification of prevailing gaps that need to be filled.
- Issues that need attention for future development of local capacity to manufacture ethanol stove and EMDs spare parts and how that should be dealt with.

This study has used data inputs from: visit to relevant industries, the feedstock assessment results, and the international experience.

2. ETHANOL MICRO DISTILLERIES [EMDs]

Ethanol producing distilleries with production capacities in the range between 150 and 5,000 liters per day are referred as small scale or micro-distilleries. Micro distilleries are also characterized by their relatively low investment cost and low energy demand to recycle the byproducts to a level that can be put back to soil where raw materials are grown.

Ethanol production technology is determined by the type of feedstock to be used. Feedstock is mainly categorized as (a) roots and tubers (b) sugarcane and stems. Although there exist wide range of feedstock materials from which ethanol can be produced, most industrially used ones are sugarcane and cassava. However, ethanol production from sugarcane is commonly integrated with production of sugar in many cases to ensure economic viability.

Figure 1and **Figure 2** respectively show the flow diagrams of ethanol production from cassava and sugarcane to represent the two categories.

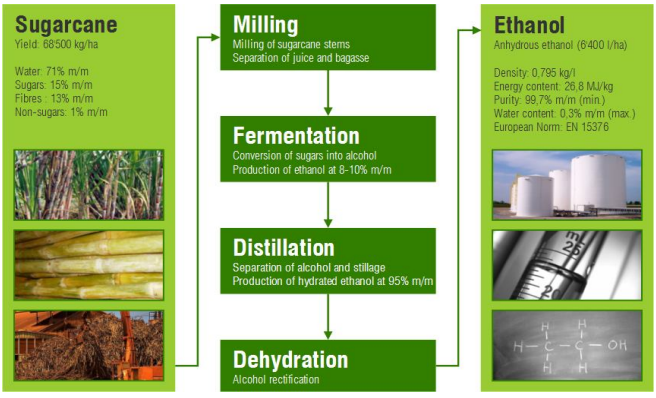


Figure 1: Flow diagram of ethanol production from sugarcane (or other stem type feedstock)

Production of ethanol from sugarcane and other stem type feedstock is more expensive as it involves crushing/milling to extract the juice. This is more pronounced when the production is in small scale.

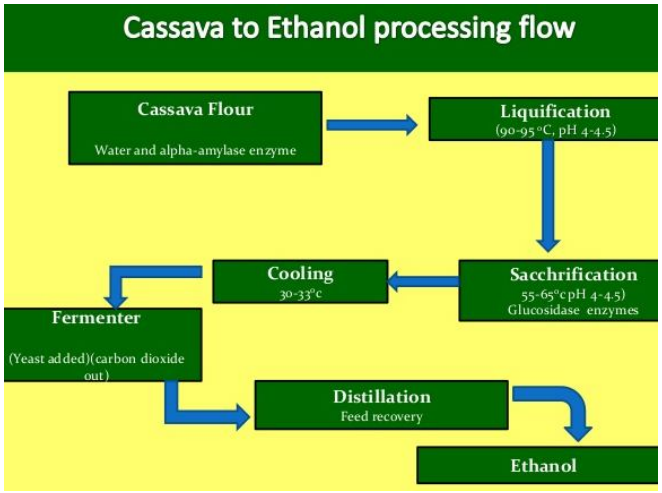


Figure 2: Flow diagram of ethanol production from cassava (roots and tubers)

For successful combustion in most ethanol stoves, the ethanol concentration of the produced ethanol should be at least 80%; although some stoves endeavor to burn ethanol with higher water levels.

2.1 Equipment and Process Layout for EMD

The different processes require appropriate equipment and hence space to install. The key physical components of EMDs are: crushers/grinders and mixers for raw material preparation, fermentation tank for biological fermentation, filtration and sedimentation mechanism in order to enrich the solution with the required nutrition (enhance distillation column performance and service life), rectification or distillation column, boiler to supply energy to distillation column, and the byproduct treatment unit for safe disposal or reuse. In addition,sufficient space is required to stock the raw materials and the produced ethanol.

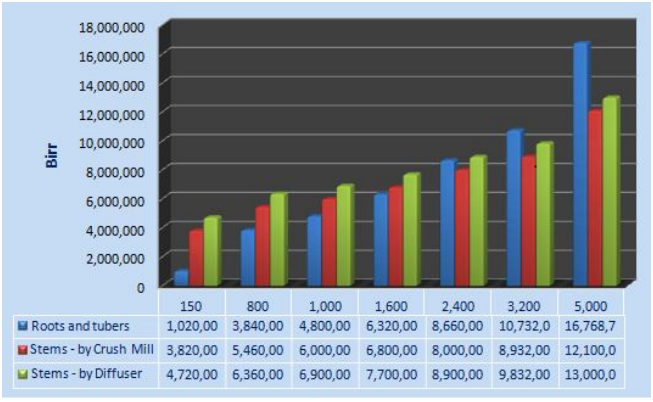
Figure 3: Typical plant layout for EMD

2.2 Investment Cost

Investment cost of EMDs mainly depends on the production capacity of the unit, type of raw material and the technology level an investor opts for. This study has compared the investment costs of EMDs with capacity ranging from 150 to 5,000 liters per day for feedstock variety of roots and tubers, stems using crush mill technology to produce juice, and stems that use diffuser technology to produce juice. The comparison figures are shown in **Figure 4**. Accordingly, the investment cost in Birr for a 150 liter per day capacity plant ranges from 1,020,000 for roots & tubers to 4,720,000for stems using diffuser technology.

The study also indicates that investment cost of EMDs using stem feedstock comparatively reduce as you go for higher production capacity. For smaller capacity EMDs from 150 to 1000 lit/day, initial investment is huge for stem based ones compared to feedstock of roots and tubers; however, the investment cost approaches to each other for higher capacity EMDs irrespective of the feedstock processed.

In general, the investment requirement to produce a liter of ethanol reduces with the increase of production capacity of the unit. Investment cost of EMDs using roots and tubers like cassava is lower compared to those using stem type feedstock like sugarcane at the low capacity end; whereas it is vice versa at the higher capacity end.



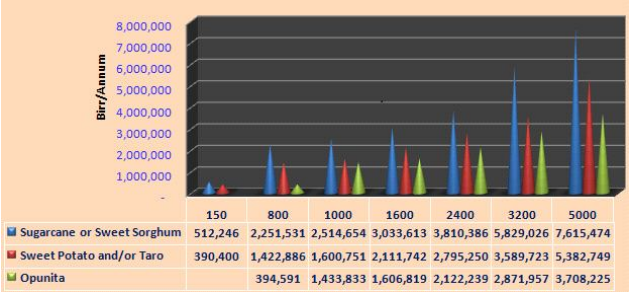
	150	800	1,000	1,600	2,400	3,200	5,000
Roots and tubers	1,020,00	3,840,00	4,800,00	6,320,00	8,660,00	10,732,0	16,768,7
Stems - by Crush Mill	3,820,00	5,460,00	6,000,00	6,800,00	8,000,00	8,932,00	12,100,0
Stems - by Diffuser	4,720,00	6,360,00	6,900,00	7,700,00	8,900,00	9,832,00	13,000,0

Figure 4: Investment cost of EMDs for capacity (150-5,000 liter/day)

2.3 Running Cost of EMDs

Operational cost of Ethanol production includes the cost of labor, various consumables such as chemicals and utilities such as electricity and water. The operational costs are directly proportional to the capacity of EMD measured in liters per day.

Figure 5 below illustrates how operational cost varies for ethanol production from different feedstock for EMDs with production capacity of 150 – 5,000 liter per day. The study show that operational cost sharply increases with the capacity for stem type feedstock like sugarcane while it is relatively flat for other feedstock types.



	150	800	1000	1600	2400	3200	5000
Sugarcane or Sweet Sorghum	512,246	2,251,531	2,514,654	3,033,613	3,810,386	5,829,026	7,615,474
Sweet Potato and/or Taro	390,400	1,422,886	1,600,751	2,111,742	2,795,250	3,589,723	5,382,749
Opunita		394,591	1,433,833	1,606,819	2,122,239	2,871,957	3,708,225

Figure 5: Annual Cost operational of EMDs

Electricity cost largely contributes to the high total production cost in EMDs using stem feedstock. However, generally speaking, personnel cost takes the lion share at around half of the totals in most EMDs.

2.4 Local Capacity to Produce EMDs

The survey made on local manufacturing industries show that significant number of EMD spare parts including sugarcane mills can be produced locally. Local capacity to manufacture water storage, mixing, fermentation, filtering and sedimentation units were also revealed; which in turn has high foreign currency saving potential. EMDs are scalable by nature and hence it is preferable to start with lower capacity EMD with growing prospect.

3. ETHANOL COOKSTOVES

According to the Global Clean Cooking Fuel Initiative (GCCFI), clean cooking fuels are considered as those that reduce indoor air pollution while addressing social and developmental issues. Ethanol stove cooking is very clean if made accessible and affordable to the needy.

Thus, the opportunities to manufacture ethanol stove locally ensure accessibility and affordability. Several efforts have been made to produce and disseminate ethanol stoves in Ethiopia. However the locally produced stoves lack quality and the need to build local ethanol stove manufacturing capacity is prevailing. This effort also needs to be complemented by reliable supply of ethanol for sustainable development of the sector.

GAIA Association, a local non-profit organization engaged in promotion of ethanol as cooking fuel is a single entity with best experience in Ethiopia that has made several efforts to adopt ethanol as alternative cooking energy source by distributing sample ethanol stoves and piloting.

3.1 Basic Components of Ethanol Stove

Knowing components of ethanol stove is the firststep in assessing possibilities of manufacturing respective components locally.

Ethanol Stove comprises three main components, namely: Fuel container (canister), Heat shield, and Main body for which add additional part details are shown on the below figure.

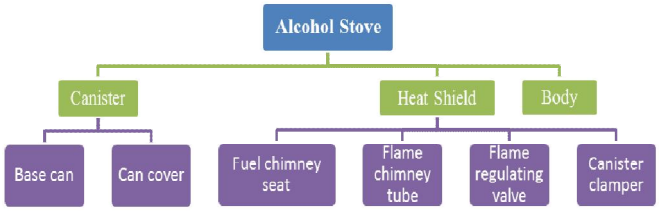


Figure 6: Basic components of ethanol stove

In its effort to identify more appropriate technology for Ethiopia taking cooking functionality in Ethiopia, safety, design features, simplicity for reverse design and manufacturing, availability of material, and aesthetics into consideration; this study has preferred to present ***Dometic AB*** stove as an example. Dometic AB is a stove made by Swedish based company and tested under a number of research topics in Ethiopia, more specifically by Gaia Association, and is proven safe and clean with an efficiency of 65%.

The stove has also been in use in Ethiopia for the past decade and had users in Addis Ababa, and refugee camps located in Ethiopian Somali regional state.

Figure 7: Dometic AB ethanol stove – single burner (right) and double burner (left)

3.2 Local Production of Ethanol Stove

The materials, manufacturing operations, required manufacturing machinery as well as skill of manufacturing technician was analyzed to assess the national capacity to produce ethanol stoves locally.

Hence, the findings indicate availability of the raw materials and required machineries to produce components and assembly. However, the need to set up designated ethanol manufacturing guideline and proper plant layout is important. In the meantime, it is also required to develop trained man power to pursue the manufacturing. An optimized ethanol stove workshop plant layout recommended by the study team is shown below.

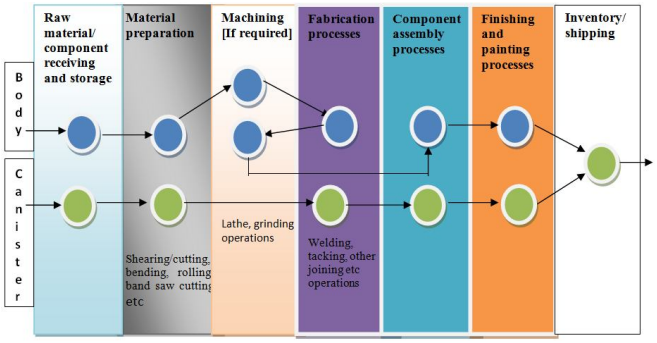


Figure 8: Optimized ethanol stove production workshop layout

4. CONCLUSIONS AND RECOMMENDATIONS

As concluding remark, to produce ethanol in EMDs for use as cooking fuel and manufacturing the stove in Ethiopia, more has to be done.

1. High commitment and policy support by the government to develop the sector in issues related to import of delicate spare part, feedstock production, land and utility provision, and human capacity development are needed.

2. Investment on EMDs to promote decentralized ethanol production from locally available feedstock in different parts of the country has to be encouraged.

3. Ethanol stove manufacturing is technically feasible in Ethiopia considering both the availability of raw materials and potential manufacturing of the machineries.

4. Building the technical capacity of skilled personnel is crucial to boost local production of EMD spare parts and ethanol stoves.s

5. In general, local assembly of EMDs with its significant number of spare parts produced locally; and local manufacturing of ethanol stoves is technologically achievable.

To enhance the capacity of locally available skilled personnel to produce EMD and ethanol stove parts with locally available facility, capacity development training in the following areas is recommended:

a. Develop their ability to design, adjust and construct equipment related to ethanol production.

b. Design proper plant layout to ensure efficient man and material movement.

c. Device proper jigs and fixtures, and tolerance technology to enable meeting quality and accuracy demand of EMDs and ethanol Cook stoves.

d. Enhance ability of welders to work with welding of stainless steel products (MIG and/or TIG).

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Feedstock Resources of Bioethanol

Ethanol for Cooking Programme in Ethiopia

Key Messages

- Biomass is the main sources of household energy that causes deforestation, soil erosion and depletion affecting food production and productivity. Sustainable household energy source is required to maintain soil fertility and save forests.
- Bioethanol can be produced from sugary, starchy crops and fruits such as cactus pear. These crops can be cultivated by entrepreneurs and EMD owners and small scale farmers in aggregate planting.
- Bioethanol production does not compete with food production rather it assists production and productivity.

1. Introduction

Agriculture contributes to 46% of the GDP, 87% of the export and 85% to the employment. Hence any shock to agriculture affects the entire economy. Natural resource degradation particularly forests and soils have been a major concern for increasing production and productivity of crops and livestock. Soil erosion, deforestation and utilization of agricultural residues and forests for household energy are depleting soil fertility and affect food production.

The main sources of household energy utilization in Ethiopia are fuelwood 67%, charcoal 7 %, dung 12% and crop residue 3%. Fuelwood and charcoal combined account for 74% and agricultural residue for 15%. The share of electricity is 3% and petroleum 15%. The results of the household energy survey indicated that the cost of household cooking was cheap for electricity, firewood, bioethanol, kerosene, charcoal and LPG in the order of importance. Hence cheap renewable and sustainable source of energy is required to save forests, maintain soil fertility and mitigate climate change at a household level. Utilization of crop residue as an energy source depletes the organic matter in the soil continuously. Maintenance of soil fertility has a profound effect on crop and livestock productivity as well as food security throughout the supply chain.

Policy

The government of Ethiopia has drafted biofuel development and utilization strategy as part of its green economy policy. The draft biofuel development and utilization strategy states the cultivation and sustainable utilization of biofuel feedstock for biodiesel and bioethanol production. It is intended that bioethanol would be promoted for household energy, small scale irrigation, rural energy and transportation.

Types of Feedstock

Bioethanol can be produced from sugary crops such as sugarcane and sweet sorghum or starchy crops such as sweet potato, taro or grains (Figure 1). The ecology, cultivation method and yield of the feedstock vary significantly (Figure 2). In the case of sugary crops the juice can be directly fermented in to alcohol where as in starchy crops the starch should be first converted to simple sugars and simple sugars to alcohol. In a very advanced technology bioethanol can also be obtained from cellulose and hemicelluloses materials such as forest and agricultural residue. However the investment cost for the latter case is very high and attempted only by few countries.

Figure 1. Various sources of bioethanol feedstock (sugarcane, sweet sorghum, sweet potato, cassava, taro, jack fruit, cactus pea and maize clock wise)

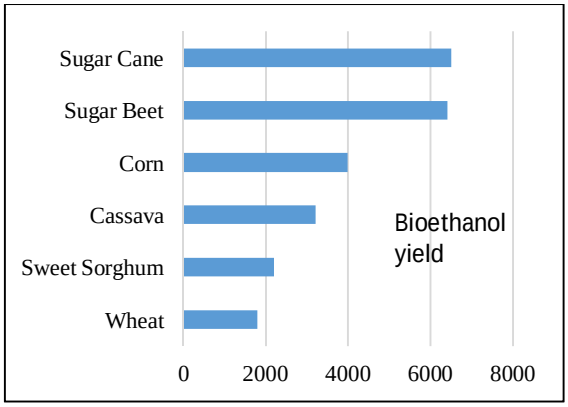

Figure 2. Bioethanol productivity per unit area for different crops (BNDES and CGEE 2008).

Potential feedstocks for small scale EMDS

Bioethanol feedstocks can be cultivated by small or large scale farmers depending on the size of the farm and technology involved. The feedstocks can be categorized into three groups. The first are surgery crops particularly sugarcane and sweet sorghum. Both are C4 plants and are highly productive; however sugarcane has very high water requirement and takes longer to mature. Sweet sorghum requires much less water and takes only 4-5 months to mature. The stalk of sweet sorghum is a by-product of grain and the high sugar content is a value addition to the crop. Studies at Melkassa Research Center indicated that the Brix value of Sweet sorghum could reach 22 with stalk yield of as high as 200 tons per hectare. Sweet sorghum is adapted in the lowlands, mid and highlands and varieties adapted for each ecology can be developed. Both crops can be grown by large or small scale farmers. Sugarcane is adapted in lowlands along river valleys. Molasses produced at the sugar factories can be a good source of feedstock. For example at Wonji Molasses is produced for nine months from October to June.

The second group of feedstocks are starch crops namely sweet potato, taro and cassava. Sweet potato and cassava are propagated using cuttings but the latter is short season crop. Both these crops are moisture stress tolerant. Cassava is now a major crop in Southern Ethiopia while sweet potato is popular both in Eastern and Southern Ethiopia. Taro is exclusively cultivated in a large scale in Southern Ethiopia particularly Wolita and Gamo Gofa Zones. Both these three crops are very productive and important for food security. The root of sweet potato is consumed as a food while its leaf is used as feed. Cassava is both a food and industrial crop which is used as raw material in the starch industry.

The third category is fruits particularly cactus pear which is largely cultivated in Eastern Tigray. A detailed survey was made in Erob Woreda of Eastern Tigray on the distribution and productivity of cactus pear. There is at least two million quintals of cactus pear production in Erob Woreda every year. However cactus is now threatened by a Cochineals insect. A second source of feedstock is mango fruits from juice houses in Addis Ababa and other large cities. The amount of mango fruits that available in Addis Ababa reaches about 18,000 quintals per year. However collecting the feedstock from juice houses will be very difficult and expensive. This option is only feasible if mango fruits can be obtained from juice factories in larger volume.

Yield per Unit Area

The feedstock yield per hectare is the highest for sugarcane and sweet sorghum. The bioethanol yield per hectare is high for cactus pear, sweet sorghum, sugarcane, taro, cassava and sweet potato in increasing order. This indicates that root crops are highly productive per unit of land as compared to sugarcane and sweet sorghum probably because root crops do not have fibber.

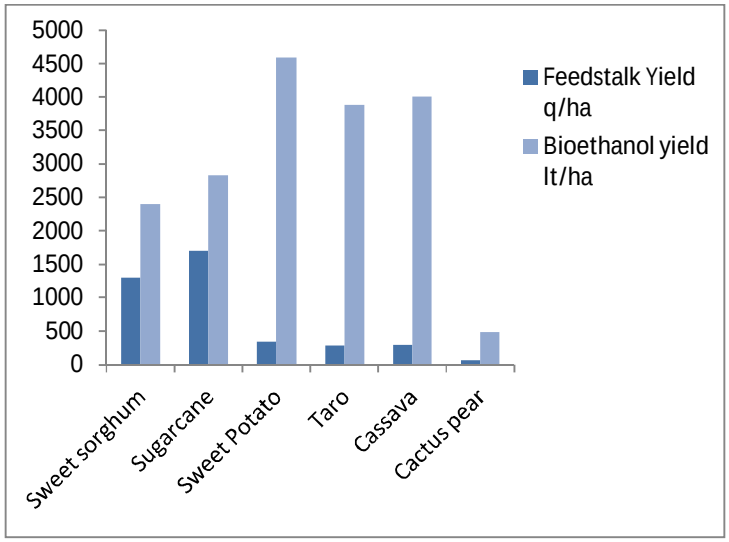

Figure 3. Feedstock in q/ha and bioethanol yield liter per hectare under Ethiopian condition (data for Sweet sorghum is own data from Melkassa Agricultural Research Center, for sugarcane from Wonji sugarcane growers Union and all others CSA 2006).

Ecology

The ecological requirement of feedstock alters its choice enterprise development. Sugarcane requires ample amount of water and warm temperature. The suitable areas are in the low lands and valleys along river banks. Sugarcane takes about one and half years for the first harvest and one year for the ratoons. However the crop can be harvested at any time throughout the year as required. Sweet Sorghum is similar to grain sorghum except its high content of sugar in its stalks. All grain sorghum growing areas such as East and West Hararghe,

Eastern Amhara, North Western low lands such as Gambella and Benishangul are highly suitable areas (figure 4). Most Areas in Tigray particularly Shire and Humera are also suitable. Sorghum is normally harvested during November to December and the stalks can be harvested during November.

Sweet potato is largely cultivated in North Shoa, Eastern and West Harraghe, Wolita, Sidama and Gamgofa Zones. This crop is highly productive and its tubers can stay in the ground for up to three months. In addition it can be planted at different times of the year so that it can be harvested for a longer period. Taro has a similar ecology with sweet potato however, it is only widely cultivated in Southern Ethiopia particularly Wolita and Gamo Gofa zones. Cassava is a worm season and drought tolerant crop. It is highly suitable in the Gamo Gofa Zone. It is newly introduced crop which is getting very popular within the Southern and Oromia region. It is highly productive and more research is required to identify the highly suitable areas.

Cactus is found in all water stress areas of Ethiopia but it is only considered economically important in Eastern Tigray particularly Erob Woreda. It is moisture stress tolerant and susceptible to the newly identified Cochineal pest. For some ecological reasons, cactus results in a very high yield in Eastern Tigray particularly Erob Woreda.

It appears that sorghum and sweet potato are distributed throughout the regions. Feedstock statistical data is not available from Afar region. It appears that Oromia, SNNP, Amhara, Gambella and Benishangul Gumz have significant amount of feedstock in order.

The land requirement and yield per unit area of sugarcane and sweet sorghum is similar. Both crops are cereals with similar brix value. However sweet sorghum takes less water and can be harvested within five months. It appears that large area is required for sugarcane and sweet sorghum because of their lower sugar content in their stalks; 60 Kg of sugarcane and 54 kg of sweet sorghum stalk is required to produce one liter of bioethanol as compared to 14 kg of cactus and 7.5 kg of root crops. Root crops are very productive and high yielders per unit area as compared to cereals. These crops are very attractive for entrepreneurs because of their response to inputs and modern cultivation. These crops could yield further more if managed by an entrepreneur. In addition to root crops and sweet sorghum; cactus is tolerant to moisture stress.

Enterprise Models

Feedstock cultivation for EMDs requires continuous supply. Therefore, one has to consider an enterprise based on available land and water. It will be difficult to assume one feedstock to run an EMD year round therefore, a combination of cereals namely sugarcane or sweet sorghum along with root crop complementary can be an alternative. In this study, four models of feedstock production are considered.

The first is sugarcane based where the feedstock is totally cultivated under irrigation. The best example is the Wonji Sugarcane Out growers Union which supplies 30% of the feedstock to the factory. The Union is planning to scale up the feedstock supply up to 70% in near future. Similar models can be considered for the EMDs.

The second can be cactus based in its area of production specifically in Erob Woreda in Tigray**.** Hence the cactus production can support an EMD of any size. In this case the cactus crop in Erob Woreda alone can serve at least three EMDs. However the harvesting month is maximum of six months, hence an alternative crop such as root crops and sweet sorghum can be planted alongside the cactus to serve the rest of the year. In addition the cactus plantation may need a study for aggregate maturity.

The third is Root Crop and Sweet Sorghum based enterprise**.** Root crops in combination with sweet sorghum can be good feedstock. The root crops namely taro and sweet potato as well as cassava have similar ecology with sweet sorghum they can be utilized in combination with rain fed or irrigated sweet sorghum.

The fourth is root crop based where different root crops can be grown in aggregation. The root crops namely sweet potato, taro and cassava are productive and require less land as well as water.

Cropping Calendar

An enterprise should carefully consider cropping calendar. If enterprise uses irrigation as an input in its production, feedstock can be available throughout the year. If an enterprise depends on sugarcane as a source of feedstock then the crop can be harvested in any time of the year because it uses irrigation any ways. Sweet sorghum cultivated under rain fed is only available in October and November while cactus is harvested from June to October. Among root crops sweet potato is harvested from January to March and September to December. Taro and Cassava follow similar trend. However sweet potato and cassava can stay in the ground for up to two months. Hence in any given ecology an EMD owner has to choose his/her

enterprise based on ecology and cropping calendar to obtain raw material throughout the year. Feedstock should be available readily at the right time and right quality and quantity.

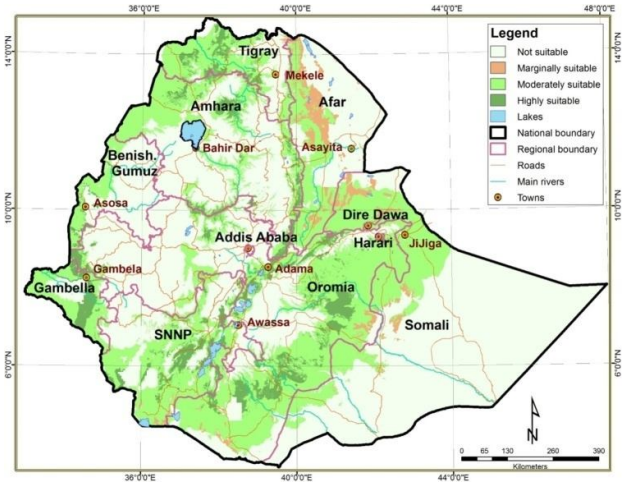

Figure 4. Land suitability map for lowland sorghum (Demeke Nigussie 2014).

Food Versus Fuel

The production and utilization of biofuels has been implicated to compete with food production. This study confirms that this is not the case and in fact bioethanol assists food production.

1. The major feedstock of bioethanol is molasses which is a by-product of sugar production. Molasses would be a source of pollution for the environment if not used for ethanol production. Hence ethanol production from molasses has three fold advantages.

2. Bioethanol from sweet sorghum does not affect grain production because the grain is used for food, the leaves for feed and stalks for bioethanol. Therefore, bioethanol production from sweet sorghum is actually promoting sustainable utilization of available resources.

3. Utilization of roots and tubers for bioethanol production would not affect food production if used by entrepreneurs.

4. Utilization of Bioethanol for household cooking saves forests and maintains soil fertility by increasing the litter, dunk and organic matter to the soil which otherwise would have been used for household energy.

5. Bioethanol can be used to generate energy for rural electrification and small scale irrigation to increase production and productivity.

This policy brief is an output of the Holistic Feasibility Study of "A National Scale-up Program for Ethanol Cook stoves and Ethanol Micro Distilleries (EMDs)" project funded by DFID, with contribution from the Norwegian and Danish governments through the Strategic Climatic Institutions Programme (SCIP). However, the views expressed and information contained in this document are not necessary those of or endorsed by DFID or contributing governments, which can accept no responsibility or liability for such views, completeness or accuracy of information or for any reliance placed on them.

Gaia Association is an Ethiopian resident charity organization established in 2005 to promote the use of renewable ethanol fuels for household energy in Ethiopia. The Gaia Association seeks to reduce household energy dependence on imported petroleum and hazardous solid bio-fuels, improve indoor air quality by preventing smoke-related health problems, and increase user safety and quality of life.

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Table 1. Summary of Economic Viability of Ethanol Production using micro- distilleries

Production Scenario	Economic Viability Indicator	EMD Plant Scenario						
		150 l/d	800 l/d	1000 l/d	1600 l/d	2400 l/d	3200 l/d	5000 l/d
Molasses (100%)	ENPV	(0.06)	4.61	5.94	10.94	17.43	24.05	38.76
	EIRR	9.4%	27.0%	27.5%	30.6%	32.0%	33.2%	35.2%
Sugarcane (100%)	ENPV	(1.11)	(1.08)	(1.26)	(0.41)	0.39	1.20	3.21
	EIRR	-21.4%	5.1%	5.5%	9.3%	10.8%	11.6%	12.7%
Mixed Feedstock	ENPV	(1.37)	(2.53)	(2.99)	(3.37)	(4.05)	(4.61)	(6.03)
	EIRR	#NUM!	-3.8%	-2.8%	1.4%	3.3%	4.3%	5.0%

1. Introduction

1. Like most Sub Saharan countries, the vast majority of the households in Ethiopia rely on traditional energy sources (fuelwood, charcoal, crop residues and animal dung) for their daily cooking and baking needs. Bio-ethanol offers opportunities for substitution of biomass energy sources and kerosene consumption in Ethiopia. However, the development of bio-ethanol in general and bio-ethanol for cooking has been hampered by poor institutional framework and lack of a comprehensive study on the technical and economic viability of ethanol for cooking.

2. Gaia Association financed by DFID, with contribution from the Norwegian and Danish governments through the Strategic Climatic Institutions Programme (SCIP) and in collaboration with the Ministries of Water, Irrigation and Energy; and Environment and Forest; the Horn of Africa Regional Environment Centre and Network (HoAREC&N); Sugar Corporation and Project Gaia Inc., has commissioned the "Holistic Feasibility Study of a National Scale-up Programme for Ethanol Cook Stoves and Ethanol Micro Distilleries (EMDs) in Ethiopia" the main objective of which was to contribute to the development of the bio-ethanol sub-sector in Ethiopia by analysing the feasibility of ethanol micro distilleries and ethanol fuel for cooking.

3. This report brief is an output of the Holistic Feasibility Study. However, the views expressed and information contained in this document are not necessary those of or endorsed by DFID or contributing governments, which can accept no responsibility or liability for such views, completeness or accuracy of information or for any reliance placed on them.

2. Market Analysis

4. **Relative Costs of Cooking.** The results of a relative cooking cost analysis, shown in **Figure 1**, indicate that electricity is the cheapest cooking energy source while LPG is the most expensive. Fuelwood is the second cheapest alternative (ETB 145/month) followed by ethanol (ETB 225/ month) and kerosene (ETB 237/month).

5. Where the cooking fuel needs of an average household are met by ethanol rather than kerosene and charcoal, this would result in lower monthly expenditure. Households shifting from kerosene and charcoal use will save about ETB 136/year and ETB 450/year, respectively. Thus, there would appear to be financial cost advantage to using ethanol as a substitute for kerosene and charcoal.

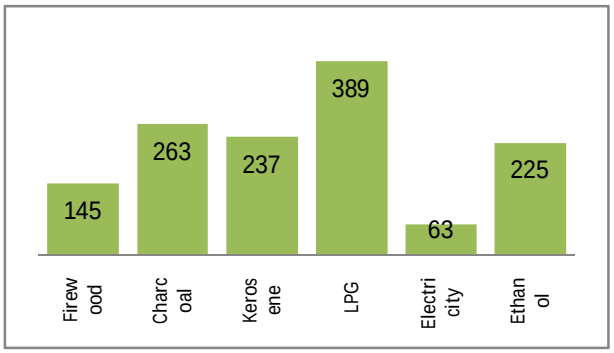


Figure 1. Relative costs of Cooking (ETB/month)

6. **Households Preferences Fuels and Stoves.** From the nation-wide household energy survey conducted as part of the present study showed that household's decision to use a particular fuel and stove for cooking is mainly based the following criteria: durability of stove, cheap stove, cleanness and convenience, safety, and speed of cooking. It was found that for 79% of households the fuel price is the most important determinant for cooking fuel choice followed by stove cost (8%) and safety (8%). Ethanol compares favourably in cooking cost amongst domestic cooking fuels. It is cheaper than LPG, kerosene and charcoal and only marginally costlier than cooking with wood fuel on an open fire. Ethanol is expected to score high on cleanness and convenience, safety, speed of cooking and durability of the stove; medium in fuel cost and low in cost of the stove criteria. On both financial and non-financial factors, ethanol will be preferable to currently available fuels and can be a major cooking fuel in Ethiopia.

7. **Demand for Ethanol for Cooking.** Based on the analyses of the relative cost of cooking and households' preferences, ethanol can be expected to a viable substitute for kerosene, charcoal and firewood. While ethanol is far cheaper than LPG, it would be difficult to assume that a significant number of high income households would shift to ethanol unless there was a scarcity of LPG in the market. As the relative costs of cooking with firewood is closer to ethanol, urban and rural households who purchase firewood are more likely to shift to ethanol given that it is cleaner, safer, and smokeless.

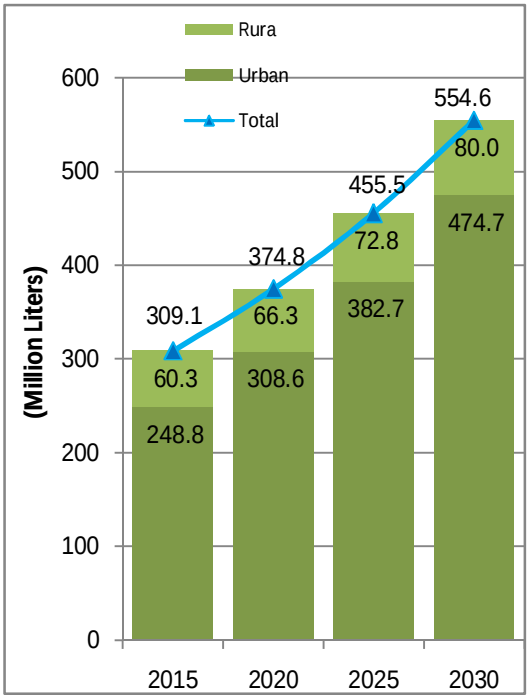


Figure 2. Demand for Ethanol for Cooking by Rural and Urban HHs

8. The market size for ethanol have been estimated on the basis of the following assumptions:

a. 100% of urban and rural HHs using kerosene will shift to ethanol. Currently an estimated 211,661 HHs(urban 188,201 or 89%; and rural 23,460 or 11%) are using kerosene for cooking and 52% (or 110,937) are found in Addis Ababa;

b. 75% of urban and 50% of rural HHs using charcoal will shift to ethanol. The number of HHs using charcoal as a primary cooking fuel is 767,666 (urban 727,452 or 95%; and rural 40,214 or 5%);

c. One-third of the urban and 50% of the rural HHs who purchase firewood will shift to ethanol. Currently 16 million HHs (2.8 million urban or 17% and 13.2 million rural or 83%) are using firewood as a primary cooking fuel and 71% and 4% of urban and rural HHs purchase firewood. Thus, 23.4% of urban and 2% of rural HHs are assumed to use ethanol instead of purchase firewood.

9. Based on the above assumptions, a total of 1.7 million HHs (1.4 million urban and 0.3 million rural) will shift to ethanol and the estimated total potential demand for ethanol could be as high as 300 million litres in 2015 (Figure 2). Of estimated demand 47% (144 million litres) would replace firewood and 23 percent (70 million litres) and 31% percent (96 million litres) will substitute charcoal and kerosene, respectively (Figure 3). The demand is further projected to increase over time at the population growth rate of 2.6% (4.4% urban and 1.9% rural) per year, from 309 million litres in 2015 to over 550 million litres in 2030.

10. The estimated demand for ethanol as a cooking fuel will be met by both the large-scale ethanol production factories as well as small-scale ethanol production plants. The current national plan, the Growth and Transformation Plan (GTP), envisages increasing ethanol production from around 27 million litres in 2014 to 340 million litres in 2029 and to 350million litres in 2020.

11. The projected ethanol production by large-scale net of projected demand for the gasoline-blend is expected to be destined for the demand for cooking. The volume of ethanol to be supplied by micro-distilleries is estimated by deducting from the aggregate demand the amount to be supplied by the large scale production net of the demand for gasoline blend (Figure 4).

3. Financial Analysis

12. **Financial Analysis of Ethanol Micro-distilleries.** The initial investment costs for the various ethanol micro-distillery plant scenarios range between ETB 1.7 million for the 150 litres/day distillery plant to almost ETB 30 million for the relatively larger plant (5,000 litres/day). The financial analysis of the micro-distilleries are conducted over a 15-year time horizon, both used a discount rate of 10.23%.

13. The financial analysis considered seven ethanol micro-distillery plants, producing 150 to 5000 litres per day. The following three production scenarios were used for the financial analysis of ethanol micro-distilleries:

Scenario 1: Molasses from large-scale sugar factories
Scenario 2: Sugarcane
Scenario 3: Mixed feedstock: sweet sorghum, sweet potato, cactus and cassava with a mix of 25% each on raw weight-basis

14. The financial net present values (FNPV) are negative for all the seven types of micro-distilleries using sugarcane and mixed feedstock production scenarios. The FNPV at 10.23% for the 5000 litres/day distillery plant using sugarcane is negative as there is a net loss of approximately ETB 26.3 million expected from this project and the FIRR for the same plant is negative 12.8% which is lower than the discount rate of 10.23%%.

15. The FNPVs for six of the seven distillery schemes (except for the 150/litres/day plant) using molasses as the feedstock are positive with the NPV increasing with size of the plants. The FNPV of the larger plant (i.e., 5000 litres/day) is estimated at ETB 18.2 million while that of the 800 and 1000 litres/day plants are ETB 0.8 million and ETB 1.2 million respectively. The 150 litres per day distillery scheme is not profitable – the FNPV is negative ETB 1.3 million. The financial internal rates of return (FIRR) for the different distillery plants using molasses range in their respective orders from negative 9.9% to 20.2% for the 150 litres/day and 5000 litres/day plants.

16. **Sensitivity Analyses.** Sensitivity analyses indicate that the financial viability of the distillery plant and production scenarios was found to be highly sensitive to changes in the prices of ethanol. A range of prices of ethanol were analysed from the ETB 7.56/litre and $15.12/litre. At an assumed price of ETB 10.4/litre, the production of ethanol from sugarcane and mixed feedstock will not be viable. Ethanol production from sugarcane becomes viable at a price of around ETB 13.23/litre using the 5000 litres/day distillery plant and at ETB 14.18/litre for distillery plants of 1600 litres/day and above. Similarly, the production of ethanol from mixed feedstock could become a profitable venture at ETB 15.12/litre for distillery plants of 1600/litres/day and above.

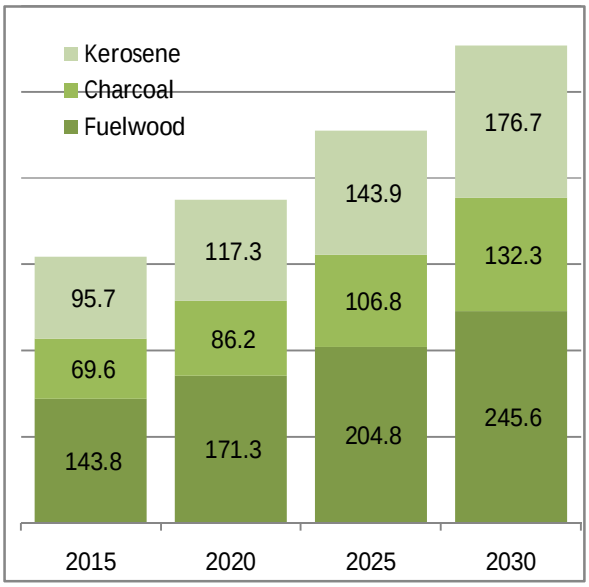


Figure 3. Demand for Ethanol for Cooking by Fuels Substituted

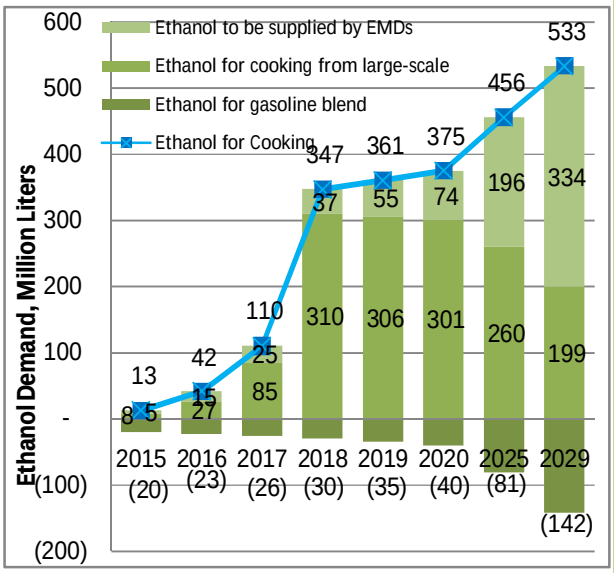


Figure 4. Ethanol Supply by Large Scale and EMD production

17. The feedstock price has a significant impact on the viability of the distillery plants. With a feedstock price of molasses at 0.73 per kg (up from the assumed price of ETB0.61 per kg), the FNPVs for the 800liters/day and 1000 litres/day distillery plants become negative and therefore not financially viable. Any increase in feedstock price will also result in an increased price of ethanol and reduce the viability of ethanol production.

18. **Financial Impact on Households.** The ethanol for cooking programme will bring substantial financial benefits to ethanol user households. Based on the relative costs of cooking, households that are substituting kerosene and charcoal with ethanol would save ETB136/year and ETB450/year expenditure on kerosene and charcoal, in their respective orders. The aggregate household expenditure savings over the 15-year time horizon would be ETB 5,131 million and the net present (at a discount rate of 10.23%) ETB 2,185 million.

4. Economic Analysis

19. The economic analysis accounts for monetary benefits that can be associated with ethanol use including value of avoided energy-related deforestation and GHG emission reductions and carbon revenue. Due to lack of relevant data and difficulties associated with the valuation of health impacts and time savings in monetary terms, the health and time saving benefits (from cooking and fuelwood collection) of ethanol use for cooking are not included in the analysis. The costs included in the analysis are the cost of producing ethanol. The economic benefits considered in the analysis are avoided deforestation as a result of reduced demand for fuelwood and charcoal CO2 emissions reductions and estimated carbon revenue. Other economic impacts are foreign exchange saving due to displacing imported kerosene as well as jobs created.

20. **Economic Viability of Micro–Distilleries** Table 1summarizes the ENPVs and EIRR, using an ethanol factory gate price of ETB 10.40/litre (US$ 0.52/litre), over a 15 year period, discounted at 10.23% for each of the plant and production scenarios. The ENPVs incorporate the avoided deforestation valued in terms of avoided tCO_2e emissions as well as GHG emission reduction.

21. The economic net present values (ENPV) are positive for micro-distillery plants of 800litres/day or more using molasses feedstock. The ENPV increases with distillery production capacity and ranges from ETB 4.61 million for the 800litres/day to almost ETB 40 million for the 5000 litres/day plant. The ENPV for micro-distilleries ranging 150 litre/day to 1600 litre/day plant scenarios using sugarcane feedstock are negative. On the other hand, under the sugarcane production scenario, only the 2400 litres/day above are economically viable: the EIRRs are above the assumed social discount rate of 10.23% and the respective ENPVs range ETB 0.39 million for the 2400litre/day to 3.2 million for the 5000l/day plant.

22. All micro-distillery plant scenarios using mixed feedstock are not economically viable. The ENPV for all plant scenarios using mixed feedstock are negative as there are net losses. The 150 litres/day plant scheme is not economically viable under all production scenarios.

23. **Sensitivity Analysis.** With the exception of the 150litres/day plant, all micro-distillery plants using molasses feedstock will be economically viable at ethanol prices of ETB 10.4/litre and upwards. If there was a 10% reduction in ethanol price (i.e., ETB 9.45/litre), the ENPVs of the three lower capacity plants will be negative while that of the relatively larger schemes will still be positive. At a price of ETB 10.4/litre, the production of ethanol from sugarcane and mixed feedstock will not be economically viable. Ethanol production from sugarcane becomes economically viable at a price of around ETB 13.23/litre and at ETB 14.18/litre for distillery plants of 1600 litres/day and above. Using the mixed feedstock all the distillery plants scenarios with the exception of the 150litres/day plant could become economically viable at ETB 15.12/litre. The ENPV for the 5000litre/day distillery becomes positive at ethanol price of ETB 13.23/litre.

24. **Valuation of Avoided Deforestation.** The ethanol for cooking programme will have positive impact on the forest cover due to reduction in fuelwood and charcoal use. Over the 15-year period, the Programme will allow a substitution of 33 million tonnes of fuelwood equivalent consisting of 22.5 million tonnes of fuelwood and 2.4 million tonnes of charcoal. The charcoal is converted into its wood equivalent based on wood to charcoal conversion efficiency of 23%. This is translated to 10.5 million fuelwood equivalent. The wood substituted is then converted into estimated reduction in deforestation using an average measure of standing wood volume of natural forest of 75 tonnes/ha1. Assuming that fuelwood and charcoal are derived from non-sustainable forests, the avoided deforestation over the 15 year period will be 441 thousand ha.

25. The economic value of the avoided deforestation is estimated based on avoided tonnes of CO2 equivalent and carbon density of 18 tonne/ha multiplied by 3.67 to convert to tonnes of CO2 equivalent. It is estimated that over 15-years, about 29 million tCO2e will be avoided. Based on an average price of ETB100/tCO2e (US$5/ tCO2e), the economic benefit at a discount rate of 10.23% will be ETB 1,168 million.

26. **GHG Emission Reduction and Carbon Revenue.** The ethanol for cooking programme will allow the avoidance of 65million tCO_2e. Based on a market price of U$5.00/ tCO_2e, US$325 million will be generated in carbon revenues (see Table 11). The present value the estimated carbon revenue net of al transaction costs (baseline determination and monitoring plan, validation, due diligence and annual certification fees) discounted at 10.23% is US$131.5 million.

27. **Foreign Exchange Savings.** Ethanol cooking fuel will substitute imported kerosene and thus saving scarce foreign exchange. Over a period of 15 years, the ethanol for cooking programme will allow the displacement of 1,747 million litres of imported kerosene. At the current import price of US$0.65/litre, the foreign exchange required for the importation of kerosene would have been US$1,135 million.

28. **Impact on Job Creation.** The ethanol for cooking programme will have significant benefits in terms of creating new employment opportunities. A total of 118 ethanol micro-distilleries of 1,000liters/day capacity will be required to meet the supply gap over the 15-year time horizon. These will create approximately 17,200 permanent jobs. This is estimated by multiplying the number of EMDs by 17 people per plant. Additional jobs will be created by the large-scale production plants. The programme will create new direct jobs in feedstock production in rural areas and in the marketing and distribution of the ethanol fuel and local manufacturing of alcohol of stoves in urban areas.

5. Conclusions

The market analysis has shown that ethanol is preferred on both financial and non-financial factors (cleanness, convenience, safety, speed of cooking and durability of the stove, etc.) to currently available fuels.

a. There is huge demand for ethanol as a cooking fuel in substitution of kerosene, charcoal and firewood. The demand is projected to increase from about 300 million litres in 2015 to more than 550 million litres in 2030.
b. A wide variety of factors affect the financial viability of ethanol for cooking. The type of feedstock used (molasses, sugarcane or mixed feedstock options), price of feedstock and price of ethanol have a significant effect on the financial viability of ethanol production using micro-distilleries. Ethanol micro distilleries using molasses are financially viable. The micro-distilleries using sugar cane as feedstock are only financially profitable if ethanol factory-gate prices are higher than the current price of ethanol. Ethanol production using mixed feedstock is not financially viable.
c. Ethanol for cooking programme in Ethiopia offers substantial economic benefits. There will be a positive impact on household's income resulting from expenditure saving on cooking energy; forest cover and GHG emission reduction. By substituting 33 million tonnes of fuelwood equivalent, the ethanol for cooking Programme will allow saving 441 thousand hectares from deforestation.

6. Recommendations

29. Based on the findings of the study, the following actions are recommended:

a. National Ethanol Programme - the Government should to adopt a national Ethanol Programme to articulate a clear long-term direction and coordinate actions.
b. Increase ethanol production from large-scale sugar factories and micro-distilleries. Government should promote private investment (local, foreign, joint) in ethanol distilleries for the new sugar factories and/or through Public Private Partnerships. The Government should also actively promote EMD.
c. Prioritise allocation of sufficient and stable ethanol fuel for cooking. Availability of ethanol for cooking has been uncertain since the introduction of the fuel for cooking ten years ago.
d. Rationalize ethanol pricing relative to alternatives: the Government should rationalize its ethanol pricing based on the economic, social and environmental valuation.
e. Research in agriculture to develop and diversify ethanol feedstock will be pivotal for improving productivity (yield/ha) and lowering the prices of feedstock and production costs of ethanol.
f. R&D in ethanol distilleries and ethanol stoves to lower supply costs. Ethanol micro distilleries promote rural agro-industry. This is an area that is given high priority for investment by the Government together with manufacture.
g. Comprehensive consumer information and marketing campaigns. The public is not aware of the existence of ethanol as a potential alternative cooking fuel.

[1] FAO, *Global Forest Resources Assessment 2000 Main Report*, Table 15.1, volume and above-ground biomass (total forest) http://www.fao.org/docrep/004/y1997e/y1997e0l.htm#bm21

Gaia Association

Household Energy Assessment

Ethanol for Cooking Programme in Ethiopia

1. Cooking Energy in Ethiopia

Sustainable and reliable supply of cooking fuel to the households, enterprises and institutions is one of the major critical issues of the energy sector in Ethiopia. Current practice of biomass cooking fuel harvesting and utilization are not sustainable in Ethiopia; this has already resulted in negative environmental and health consequences.

Major energy demand in the household sector is mainly for cooking and baking. Households, both in rural and urban areas, mainly depend on solid biomass fuels for their cooking and baking activities. Solid biomass is used by 99% of rural and 84% of urban households for cooking and baking[1]. Firewood is the prominent biomass fuel used by the households. Other biomass such as dung and agri-residue contribute to a relatively smaller portion of the cooking energy demand.

*Percentage of households by type of **major** cooking fuels (CSA, WMS, 2012)*

Cooking fuels	Urban	Rural
Firewood	63.31	90.85
Charcoal	17.54	0.23
Kerosene	4.93	0.17
Electricity	6.18	0.01
Others	8.04	8.74

Being aware of this fact, the government of Ethiopia gives due emphasis on wide scale dissemination of clean and fuel saving cookstoves, and introduction of alternative cooking fuels from renewable sources. Accordingly, the energy sector program for 2010 to 2015 and beyond planned to disseminating energy efficient cookstoves, introducing modern fuels such as biomass briquettes, sustainably produced charcoal, and biofuels of which ethanol is the main one.

Ethanol from molasses is a new fuel introduced in Ethiopia a decade ago. It has been increasingly produced and used mainly as transport fuel blended with gasoline. Its use as a household cooking fuel is limited but continuously increasing. The average annual ethanol production by the sugar factories from 2009 to 2013 was about 8 million litres. About 97% of the ethanol produced during these years was consumed as transport fuel. The remaining 3% was shared among various uses including beverages, clinical applications and cooking fuel in the households. Use of ethanol for cooking fuel has been between 250 to 600 thousand litres annually[2]. According to Ethiopian Sugar Corporation, ethanol production in 2014 reached 27 million litres. Completion of on-going expansions of existing sugar estates and planed development for new ones would increase annual production of ethanol over 134 million litres. This would provide surplus ethanol than the existing market as transport fuel can absorb. However, there is a long delay in the completion of the on-going expansion.

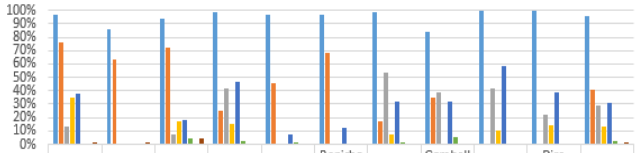
2. Cooking and baking fuels and stoves

Cooking fuels in households

Both urban and rural households may use a particular type of fuel as their major source of cooking energy. Households also use other types of fuels in addition to their major cooking fuels.

Fuelwood and charcoal are respectively used by about 96% and 41% of the rural households. Charcoal usage by the rural households is the highest in Tigray (77%) and the lowest in Oromia (25%). Charcoal usage by the rural households includes not only that purchased but also any leftover embers from firewood burning. It also includes households that use charcoal less frequent manner and in smaller quantities.

Distribution of rural households by type of fuels used for cooking and baking



	Tigray	Afar	Amhara	Oromia	Somali	Benishangul	SNNP	Gambella	Harari	Dire Dawa	All
Fuelwood	97%	86%	94%	99%	97%	97%	99%	84%	100%	100%	96%
Charcoal	77%	63%	73%	25%	46%	68%	18%	35%	0%	0%	41%
BLT	13%	0%	7%	42%	1%	0%	53%	39%	42%	22%	29%
Dung	35%	0%	17%	16%	0%	1%	7%	0%	10%	14%	13%
Crop residue	38%	1%	18%	47%	7%	12%	32%	32%	58%	39%	31%
Kerosene	1%	1%	4%	3%	2%	1%	2%	5%	0%	0%	2%
LPG	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
Electrcity	2%	2%	4%	1%	1%	1%	0%	0%	0%	0%	1%

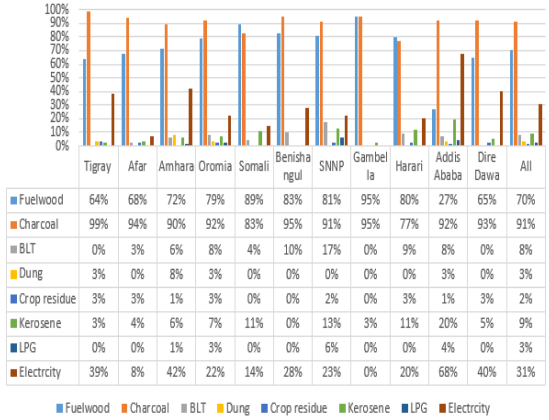
Fuelwood Charcoal BLT Dung Crop residue Kerosene LPG Electrcity

For urban households, charcoal is the most widely used fuel. About 91% of the urban households use charcoal for cooking. Firewood is the next most important fuel in urban areas. It is used by 70% of the households. Electricity (31%) and kerosene (9%) come to third and fourth level.

[1] CSA, WMS, 2012. Statistical Report for 2011, Vol. 2.

[2] MWIE, Biofuels Directorate, July 2014

Distribution of urban households by type of fuels used for cooking and baking



	Tigray	Afar	Amhara	Oromia	Somali	Benishangul	SNNP	Gambella	Harari	Addis Ababa	Dire Dawa	All
Fuelwood	64%	68%	72%	79%	89%	83%	81%	95%	80%	27%	65%	70%
Charcoal	99%	94%	90%	92%	83%	95%	91%	95%	77%	92%	93%	91%
BLT	0%	3%	6%	8%	4%	10%	17%	0%	9%	8%	0%	8%
Dung	3%	0%	8%	3%	0%	0%	0%	0%	0%	3%	0%	3%
Crop residue	3%	3%	1%	3%	0%	0%	2%	0%	3%	1%	3%	2%
Kerosene	3%	4%	6%	7%	11%	0%	13%	3%	11%	20%	5%	9%
LPG	0%	0%	1%	3%	0%	0%	6%	0%	0%	4%	0%	3%
Electrcity	39%	8%	42%	22%	14%	28%	23%	0%	20%	68%	40%	31%

Households in rural areas obtain cooking fuel by collection, purchase or both. Percentage of rural households that do not purchase firewood but entirely depend on collected firewood is about 75%. Much of the fuel collection is done by women followed by female children each travelling an average distance of 25 to 30 km and spending 20 to 30 hours in a month. On the other hand, 22% of the rural households do not collect but purchase firewood. The remaining 3% obtain their cooking fuel by both collection and purchase.

In urban areas about 92% of households purchase their cooking fuel while only 6% of them depend on collected fuel.

Amount of expenditure for cooking fuel by the rural households varies between regions. On average, rural households spend about ETB 504 annually to buy cooking and baking fuels. This is about 3% of their total expenditure.

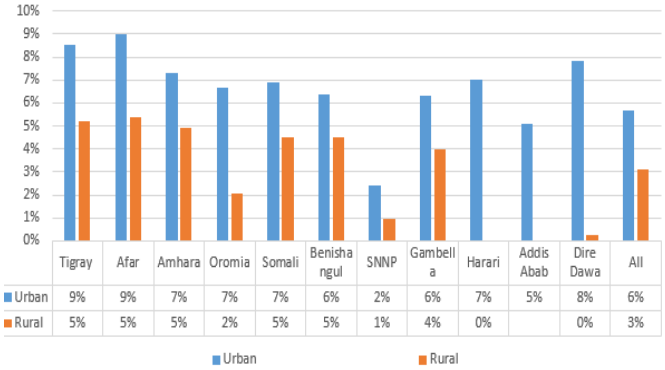
Average total expenditure of households on cooking and baking fuels by region (ETB/year)

Region	Urban	Rural
	Cooking Fuel	Cooking Fuel
Tigray	1,549	813
Afar	1,548	794
Amhara	1,263	988
Oromia	1,213	292
Somali	1,120	565
Benishangul	1,067	656
SNNP	1,036	163
Gambella	1,677	590
Harari	978	-
Addis Ababa	1,039	-
Dire Dawa	1,530	24
All	1,278	504

Gaia Association, Ethanol feasibility Survey, 2014

For urban households about 6% of their total expenditure goes for cooking and baking fuels. This amounts about ETB 1,278 per year.

Percentage of expenditure on cooking fuel over total household expenditure



	Tigray	Afar	Amhara	Oromia	Somali	Benishangul	SNNP	Gambella	Harari	Addis Abab	Dire Dawa	All
Urban	9%	9%	7%	7%	7%	6%	2%	6%	7%	5%	8%	6%
Rural	5%	5%	5%	2%	5%	5%	1%	4%	0%		0%	3%

Fuelwood is used in almost equal proportion for cooking (43%) and baking (57%) in rural areas. In urban areas, it is mostly used for baking (71%). There is, however, differences between regions in terms of proportion of fuelwood use.

Proportion of fuelwood use for cooking and baking by the rural households

Region	Rural		Urban	
	Cooking	Baking	Cooking	Baking
Tigray	41%	59%	37%	63%
Afar	43%	57%	35%	65%
Amhara	45%	55%	45%	55%
Oromia	39%	61%	26%	74%
Somali	37%	63%	31%	69%
Benishangul	47%	53%	14%	86%
SNNP	42%	58%	30%	70%
Gambella	56%	44%	19%	81%
Harari	37%	63%	29%	71%
Addis Ababa			36%	64%
Dire Dawa	42%	58%	15%	85%
All	43%	57%	29%	71%

Charcoal is the most important fuel in urban households. It is primarily used for cooking, boiling of water, tea and coffee, and re-heating food. Use of charcoal for baking is not very common. Only 2% of the urban households use charcoal for baking.

Per capita fuelwood consumption(kg/day)

Region	Urban	Rural
Tigray	3.0	1.1
Afar	1.6	0.9
Amhara	2.0	1.7
Oromia	1.8	1.2
Somali	1.1	1.1
Benishangul	1.7	1.2
SNNP	1.7	1.5
Gambella	1.9	1.2
Harari	1.5	1.4
Addis Ababa	1.8	
Dire Dawa	2.4	0.9
All	1.9	1.3

Gaia Association, Ethanol feasibility Survey, 2014

Per capita fuelwood consumption is estimated at 1.9 and 1.3 kg per person per day in urban and rural areas respectively.

Cookstove ownership in households

Use of cookstoves varies between regions and settlement types. Open fire or three stone, is the most widely used cookstove in rural areas except in Tigray. It is used by 72% of the rural households for cooking and baking. In Tigray, only 25% of the rural households use it.

Charcoal stoves are the second most important stoves for cooking for the rural households. Traditional charcoal stoves, including all metal and all clay stoves, are owned by 17%of the households. About 9% of the rural households use Lakech charcoal stove. Other types of stoves such as Upesi stoves, Tikikil and electric stoves are owned by 5%, 0.1% and 1% of the households respectively. Upesi and Tikikil are firewood stoves used for cooking.

Traditional closed stoves which are used for baking are owned by about 20% of the rural households. Ownership of traditional closed stoves is 98% in Tigray. Mirt and Gonzie are improved firewood baking stoves used by 4% and 1% of the rural households in all regions.

Flexibility of Open fire in terms of space utilization, ability to adjust for various end uses and sizes, and that it is a no cost and accessible stove makes it easier for households to own and use it. When affordable alternative cookstoves are not available, Open fire is usually the only known solution for most of the households. Rural households use Open fire for both cooking and baking.

In urban areas, cookstove ownership is different from rural areas. Charcoal stoves are the most prominent stoves used by over 90% of the urban households. Of the three types of charcoal stoves, Lakech charcoal stove has the highest penetration rate of 41% in urban households. Next to Lakech, traditional metal charcoal stoves and all clay charcoal stoves penetrated into about 33% and 21% of the urban households respectively. Next to charcoal stoves, Open fire and electric cookstoves are the second and third widely use stoves owned by 27% and 25% of the urban households respectively.

Stoves owned and used for baking in urban households include Open Fire (41%), electric injera stove (22%), Traditional Enclosed Stoves (21%), Mirt (5%) and Gonzie (1%).

Cooking Fuels and Stoves in Institutions

Institutions such as universities, hospitals, schools with feeding programs and correctional facilities prepare food for hundreds or thousands of people.

The major cooking fuel in institutions is fuelwood. Next to fuelwood, electricity is the second most important fuel. More than half of the institutions studied use electricity for either cooking or baking. The total annual fuelwood consumption by institutions for cooking only, without including baking, is estimated over 52 thousand tons per year. Open fire, electric stoves and enclosed fuelwood stoves are most common stoves in institutions.

Fuelwood stoves are ubiquitous in institution for both cooking and baking purposes. Some institutions have enclosed woodstoves with long chimneys. Electric cookers, boilers and ovens are also used by some universities and hospitals with modern kitchens. However, due to frequent power outages they mostly rely on their fuelwood stoves.

Cooking Fuels and Stoves in Enterprises

Enterprises including hotels, restaurants and cafeterias use both traditional and modern cooking fuels. Charcoal is the major fuel used by 82% of the enterprises. Fuelwood and electricity are the second and third most important fuels used by 56% and 51% of the enterprises respectively. Charcoal is the most preferred fuel for cooking (70%) while fuelwood is for baking (38%). Electricity is also used by 25% and 31% of the enterprises for baking and cooking respectively.

3. Potential market for ethanol fuel and stove

Major drivers for adoption of new stoves and fuels for households are prices of fuels and stoves, availability of fuel, and convenience of use which includes safety, cleanliness, smoke free and speed of cooking. For enterprises and institutions, reliability of fuel supply is most important than the prices of fuels or stoves.

Households that depend on collected fuels for much of their cooking fuel needs may not be able to afford a shift towards cleaner and costly fuels such as ethanol. Only 25% of the rural households and about 75% of urban households purchase cooking fuels. Even though over 90% of the households wished to use ethanol, it may not be an affordable alternative for the majority of them.

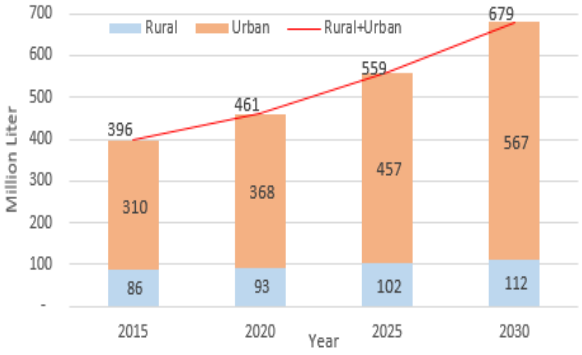
Over 90% of the cost of cooking is the cost of fuel. The cost of cookstoves is only less than 10% of the total cost of cooking. Households could make a one-time payment to acquire a clean cookstove. But, if the new fuel is much more costly than the cost of fuel that they are currently using, they may not be able to shift to cleaner fuels. Hence, potential market for ethanol could be from households that currently use kerosene for cooking, 50% to 75% of charcoal user households, and about 2% of rural households and 25% of urban households that use firewood for cooking. Since electricity is much cheaper and convenient to use, it is very unlikely for those households that use electricity for cooking to shift to ethanol. However, frequent power interruption could make some of them adopt ethanol stove as a backup.

Based on the above assumption, the number of households, in both rural and urban areas, that will potentially shift from their current cooking fuel to ethanol is estimated at about 1.7 million. Over 80% of these will be urban households. If all these household make a shift to ethanol, about 1.4 million ton of fuelwood, 138 ton of charcoal and 93 million liters of kerosene will be substituted annually. The potential demand for ethanol as cooking fuel by the rural and urban households for the current year is estimated at 381 million liters per year. Over 56%

of the demand for ethanol comes from fuelwood substitutions, while the demand from charcoal and kerosene substitution is 20% and 24% respectively.

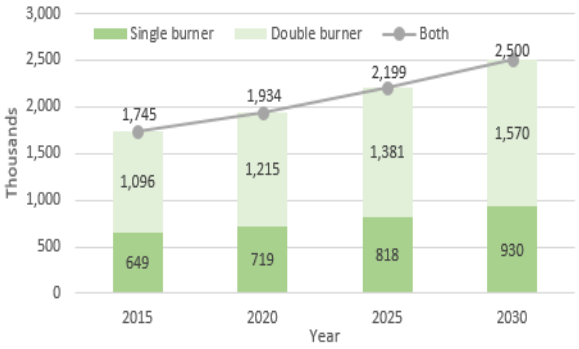
The demand for ethanol as cooking fuel by 2015 is estimated at about 396 million liter a year. By 2030, about 679 million liter of ethanol might be needed for household cooking.

Ethanol demand forecast between 2015 and 2030



Demand for single and double burner stoves was determined based on the preferences of households. About 43% rural and 36% urban households preferred a single burner ethanol stove. On the other hand, 58% of rural and 64% of urban households chose the double burner stove.

Demand projection for single and double burner ethanol stove by households



An estimated amount of 52 thousand tons of fuelwood can be substituted annually with 8.7 million liters of ethanol in schools, universities, hospitals, correctional facilities and military camps. The potential market for ethanol fuel can be higher if the demand from refugee settlements with communal cooking facilities and other training institutions are added. However, not all institutions purchase their cooking fuels. Almost all schools with feeding programs do not purchase cooking fuel and may not be considered as a market for ethanol fuel in the short to medium terms. Hence, the demand for ethanol fuel from institutions can be estimated at about 6.8 million liters per year.

The demand for ethanol from enterprises is estimated at about 69 million liters per year. It is estimated conservatively assuming an average consumption of 3 liters of ethanol per day. This assumption is taken considering that each of these enterprises, on average, prepare food for a minimum of 10 to 15 persons per day. In the current year, the demand for a single burner stove is estimated at 20 thousand and for that of the double burner is about 43 thousand.

4. Recommendations for effective marketing of ethanol for cooking

- Allocation of ethanol for cooking fuel should take economic, social and environmental benefits in to consideration. Better understanding of these benefits of ethanol will help pragmatic allocation of it to various end-uses.
- Ethanol is an indigenous renewable energy resources. Ethanol conversion technologies such as distilleries and cookstoves should be treated equally like other renewable technologies to get all incentives including promotion and duty tax exemptions.
- Safety and fuel efficiency standards must be put in place for all cookstoves. Cookstoves must meet the standard in order to get the incentives.
- Retailing ethanol in 5 to 10 liters from specialized outlets in the neighborhood markets and supermarkets would meet consumers' needs. Sales in larger volumes is preferred by institutions and enterprises.

This assessment of ethanol use for cooking is an output of the Holistic Feasibility Study of "A National Scale-up Program for Ethanol Cook stoves and Ethanol Micro Distilleries (EMDs)" project funded by DFID, with contribution from the Norwegian and Danish governments through the Strategic Climatic Institutions Programme (SCIP). However, the views expressed and information contained in this document are not necessary those of or endorsed by DFID or contributing governments, which can accept no responsibility or liability for such views, completeness or accuracy of information or for any reliance placed on them.

Gaia Association is an Ethiopian resident charity organization established in 2005 to promote the use of renewable ethanol fuels for household energy in Ethiopia. The Gaia Association seeks to reduce household energy dependence on imported petroleum and hazardous solid bio-fuels, improve indoor air quality by preventing smoke-related health problems, and increase user safety and quality of life.

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This Market Aspect of the holistic feasibility study focuses on consumers' awareness, attitude and perceptions towards ethanol fuel and stove and those of competing products, preferences and buying habits, analysis of most promising distribution models/ market mapping and value chain analysis and the proposed the market penetration strategy.

Background

The social, economic, health and environmental implication of cooking fuel acquisition and consumption is very high. Over thirteen million households collect their cooking fuels. A typical household spends 500 hours annually on fuel collection1. Women and girls are discriminately affected with the adverse impacts of cooking fuel collection and use. Indoor air pollution is responsible for approximately 4.9% of the total burden of disease among all age groups in Ethiopia2. Excessive exposure to smoke due to burning of dry biomass for cooking is one cause of respiratory diseases which is responsible for up to 12% of total deaths in Ethiopia3 and Indoor air pollution is responsible for approximately 4.9% of the total burden of disease among all age groups in Ethiopia

Heavy dependence and unsustainable use of biomass is a severe burden to the biomass resource base, with the amount of wood consumed[4] for cooking estimated at 76.5 million tons plus charcoal that is interpreted as fuelwood equivalent of 28.6 million tons annually, and the amount of animal dung and crop residues consumed are 22.8 and 19.7 million tons annually. Such heavy reliance on, and inefficient use of, biomass fuels makes consumption exceed the sustainable yields. This means that a large portion of the biomass consumed is not-renewable and contributes to greenhouse gas (GHG) emission.

Recognition of the impacts has led government and non-government organizations to run energy efficiency and alternative fuel promotion programs in Ethiopia since the mid-1980s. A variety of clean cook stoves including efficient wood and charcoal stoves, ethanol stoves, and electric stoves have been disseminated. However, the fact of the higher population, the extended geographical location, financial constraints of the households to procure clean energy products, lack of proper integration among different development partners, lack of choosing the right product that are affordable and also can easily be adopted by the rural households, market barriers, etc. hinders the success of these initiatives so as to reach to the majority of the households.

Coming to intervention related to promoting ethanol as cooking fuel **Gaia Association, and two other private enterprises** played key role in collaboration with the current Ministry of Water, Irrigation and Energy. The main objective of introduction of ethanol is to use it as an alternative to non-sustainable and highly polluting fuels, whether imported petroleum fuels or locally gathered/manufactured solid biomass fuels.

However, though UNHCR scaled up the program to cover around 4,000 Households in two refugee camps due to the socio economic benefits of ethanol for cooking, the promotion ethanol couldn't go beyond the dissemination of a couple of thousands of clean cookstoves.

The **main challenges that hinders the large scale dissemination of ethanol as a cooking fuel** is that

- unsustainable supply of ethanol/supply interruption
- time to time increment of ethanol price
- the relative high cost of ethanol stoves
- lack of standards on the product (both the stove and fuel) as to-date there is no national standard established on ICS and related fuels
- though there are valuable skills and mandates of different enablers (development partners) there is lack of proper integrated effort among them
- lack of awareness about ethanol use for cooking at different levels (at higher level as well as at households/users level
- fear that the price of the stove and the fuel could be higher that can be out of the reach of the public at large
- the fact that financial loan is not well acquainted to ICS related intervention
- lack of proper financial mechanism to promoters as well as users to support the intervention
- lack of incentive or existence of special interest rate for loans to encourage loan takers especially the stove/fuel users
- lack of risk fund (for financial institutions as per their experience on promoting RE technologies)
- lack of use of the Social Corporate Responsibilities (SCR) opportunities of different potential organisations for the promotion of ICS
- medias overlooked the social benefits of such products and do not give special consideration on their price rates for promoting such products

[1]ESMAD-Biomass Energy Report Final
[2]Source: Indoor air pollution-National Burden of Disease estimates- World Health Organisation 2007
[3]Source: WHO: Department of Measurement and Health information, December 2004
[4] Biomass Energy Strategy (BEST)-December 2013

Partners

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Major findings of the survey

The survey targeted to cover rural and urban households, commercial sector and social services. For the case of social services the survey managed to cover only selected universities, hospitals and schools with the size of 12 universities, 9 hospitals and 4 schools with school feeding program. As the survey team could manage to find only four schools in the surveyed regions, the numbers of schools that are covered through this assessment is very minimal. However, knowing this situation, this report tries to indicate some of the major points that felt worth to do so. Therefore the percentage figures given below as the survey result should also be understood considering the above surveyed size of the social services mainly the school.

Fuel Type Use:

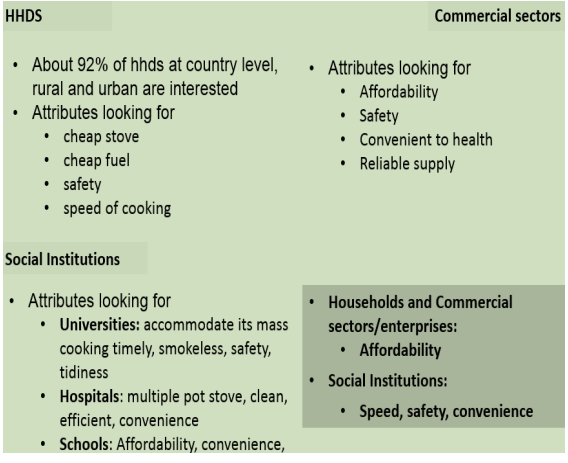
Cooking fuel use trend in the surveyed households showing high dependence on fuelwood and charcoal.

- 95% of the urban households are using charcoal followed by 51% and 32% of the respondents that are using fuelwood and electricity respectively. Kerosene and LPG are used by 9% and 1% of urban households respectively
- 87% of the rural households are using fuelwood and 43% are using charcoal. The share of BLT, Crop residues and Dung is still countable especially in the surveyed rural households with the percentage of 25%, 20% and 4 % respectively
- Charcoal is the prominent types of fuel that is used by most of the **commercial sectors** followed by fuelwood and electricity with the percentage of 37%, 26% and 23% respectively.

Interest to use ethanol fuel and stove/Awareness about Ethanol

Households: High interest regardless of very minimal awareness about ethanol fuel and stove, differences in existing fuel type use and quintile categories.
Social Institutions and Commercial Sectors: High interest regardless very minimal awareness about ethanol stove and fuel in both market segments.

Main attributes looking for – from new types of stove and fuel



Buying behaviour-Purchase Decision:

Households: Though husbands are the main decision maker on procuring other household items, coming to cooking stoves it is the wives/women who are the main decision maker which can be related to their close relationship with the cooking stove.

Source of money for purchasing:
Urban households: husband, husband & wife, wife (with close share)
Rural households: mainly husband
Social Institutions: the management of the institution is the main decision maker on the procurement of items like cooking stoves

Consumer buying behaviour -Willingness to pay:

Willingness to pay is also one of the key characteristics of consumers buying behaviour.

Households: only 32%, 27% & 29% of the surveyed households at urban, rural and country level respond are fitting within the range of the current ethanol fuel price. Similarly only about 20% of households respond at country level is within the range of the existing locally produced single burner stove and while almost zero respondents that fit to the current price of double burner stove. Hence**, affordability will be the main challenge** for both the fuel as well as the stoves.

Commercial Sector& Social Institutions: With the current price of ethanol that is ETB 14.00, though the cost of ethanol does not seems to be a major problem still affordability can be a main challenge for the stove.

Preferred Mode of Payment-Ethanol Stove

Though almost half of the respondent households that are willing to pay for the stove are ready to pay in cash still significant sizes are looking for credit payments of six months.

Therefore;

- ***There is a need to establish credit scheme***
- ***The credit scheme might also increase the adoption rate of the stove***

Preferred Volume of Ethanol to buy at once

- ***Preferred pack size***
  - ***Households- 5, 2 & 1 litres***
  - ***Social Service - > 10, 10 & 5 litres***
  - ***Enterprise – 5, 10 & 2 litres***

Existing distribution models-Cooking Devices

The survey result indicated that household's stove acquisition model is mainly market based except fuelwood stove where 51% in urban and 57% in rural areas are self-built or three stone stoves. The respond acquired from those households revealed that **shops are the prominent market place for the modern stoves** that are using modern fuels (LPG, Kerosene, and Electricity) and **open/local market are for the traditional stoves/improved stoves** that are using traditional fuels like fuelwood and charcoal.

However, the share of charcoal user households that responded that they bought their charcoal stove from shops is also significant. This might be due to the portable nature of the charcoal stove. 30% of the surveyed urban households owned/purchased electric mitad and almost all of them pay in cash which is a positive indication for the adoption of the clean cook stove providing its acceptance.

Existing distribution models-Cooking Fuels

Similar to the cooking devices/stoves the distribution models/sales outlets of fuels are also depends on the nature of the fuel and its availability in the respective settlements.

- Supermarkets & fuel stations are found to be the main sales outlet place for LPG and fuel stations for kerosene though in the rural areas kerosene is bought from retailers.
- Retail and whole sell based local market is the basic sales outlet place for charcoal and fuelwood.

Similarly supermarkets/mini markets, fuel stations and local market can be the potential sales outlet to outreach to the public at large.

Supply of ethanol fuel and stoves

Ethanol fuel

Currently the sole supplier of ethanol fuel is the sugar factories which has targeted to produce 2.25 million tons of sugar and 181,604 meter cube ethanol and using up to 44,340 meter cube ethanol for blending purposes by the end of the GTP period. If the volume of the ethanol production is going to achieve the intended plan; the supply of ethanol that will be used as cooking fuel will not be a problem at all as the production much exceeds the amount that is allocated for blending purpose. In 2007 EC the corporation plan to produce 134.6 (000'm3) or 134.6 million litre of ethanol which is quite enough to enable the scaling up project to kick off without a problem of supply. Though there is a need to address other related issues like pricing, sustainable supply, standard, etc. If the EMD project is going to kick off it will definitely buffer the supply volume to the rural areas if the price and the quality competes with the one that is supplied by the sugar corporation.

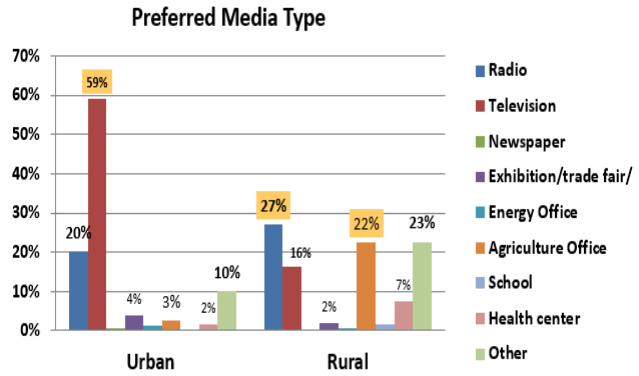
Ethanol stoves

According to some local Enterprises, if the market is well developed and sustainable demand is going to be created; there is a possibility of producing 500 ethanol stoves per month. However, there is a need to engage more enterprises that can be actively involved in the production as well as distribution of the stove. In addition to that, until the local production is strengthening to the level of satisfying the demand that will be created, there might be a need to push the intervention that has been started by Gaia Association which is the pilot testing of locally assembled Flat pack (Start Stoves).

Reason for fuel shift

- ***Fuel price plays significant role in shifting from one type of fuel to the other in almost all types of fuels***
- ***Shift to better quality fuel is mainly for low grade fuel users that is fuelwood***
- ***Therefore for effective promotion of ethanol pricing of ethanol for cooking should be done systematically***

Promotional Tools



Both Social Services and Enterprises has also same respond as urban households

Market potential for ethanol fuel and stoves

There is significant interest on the use of ethanol fuel and stoves by all consumer segments (Households, social services (hospitals, schools and universities) and commercial enterprises (hotels, restaurants and coffee/tea rooms) that have been covered through this assessment.

However, for the success of the project there is a need to create a successful marketing strategy that capitalise on the result of the market mapping, considers potential market segments as well as mix of the market factors.

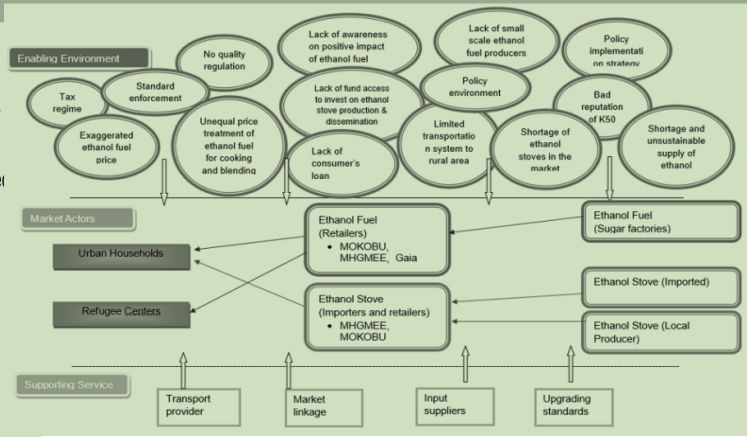
Promotion and Marketing Strategy

Market Mix Model

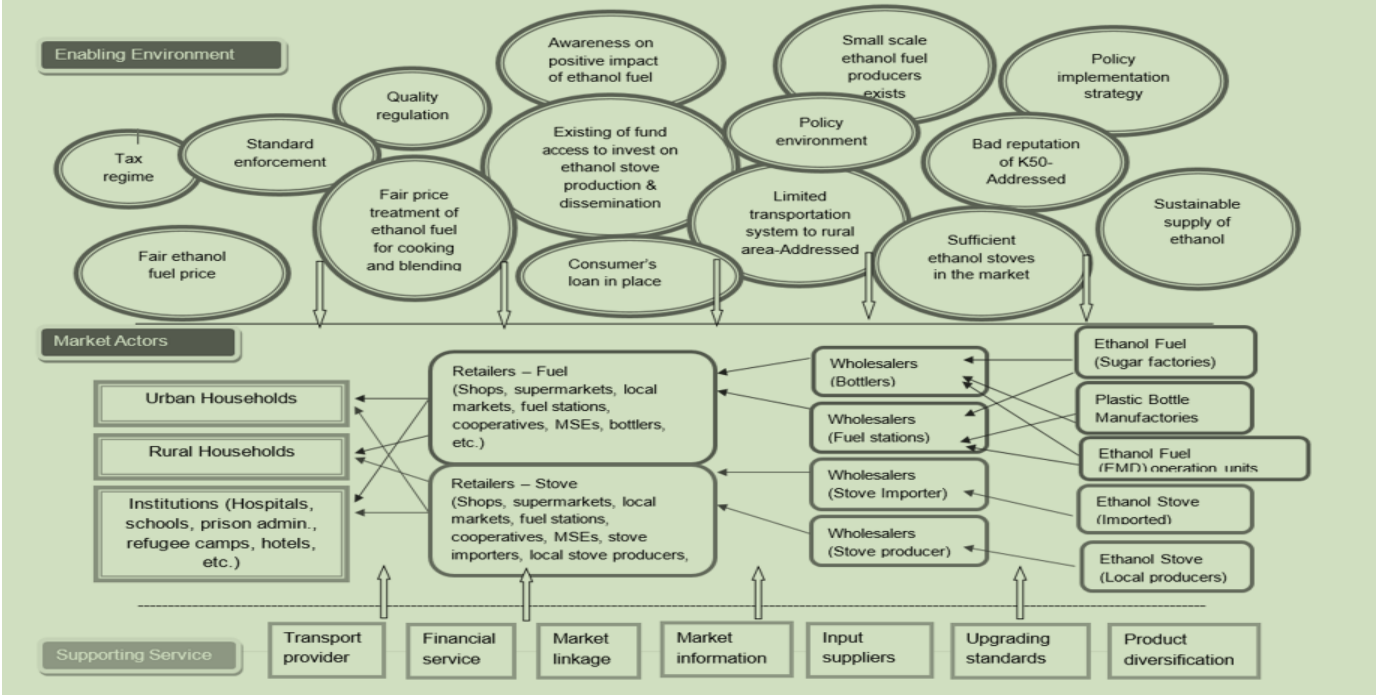
When marketing any products there is need to create a successful mix of the following market factors to the right pe and with the right people:

- the right product (with sustainable supply & standard)
- sold at the right price
- in the right place
- using the most suitable promotion
- to the right people

Existing Ethanol Fuel and Stove Map



Proposed Ethanol Fuel and Stove Map



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Private Sector Development Brief

Ethanol for Cooking Programme in Ethiopia

- **Introduction**

Private Sector Development

Ethanol is commercially supplied to about 3,000 households in Addis Ababa. In addition, the UNHCR provides ethanol for cooking for 3,500 households in refugee camps. Commercial consumers are supplied by two private enterprises that provide both the fuel and stove to them. Private enterprises and smallholders are engaged in sugar cane production as out growers to state sugar factories and for supply in the open market; smallholders also produce other potential ethanol feedstock including sweet sorghum, sweet potato, beetroot, prickly pear cactus and other sugar and starch crops. Private enterprises provide support activities in the ethanol supply chain including finance (private commercial banks), parts and equipment, and transport.

The present commercial market for ethanol for cooking is about 0.15 million liters annually (supplied to fewer than 3,000 households). The market for ethanol as cooking fuel is still very small, as is the business volume and income. Market development is essential for the engagement of more and larger ethanol distributors in the business as well as to increase ethanol production. Coherent and sustained market development is the most important action for making ethanol a true cooking fuel alternative. Such coherent market development will have policy and regulatory, promotion and marketing, financing, R&D, and other market support dimensions.

Market barriers for ethanol as cooking fuel

Private enterprises are currently engaged in the distribution of ethanol fuel and stoves for cooking. Two private enterprises now supply 0.15 million litres of ethanol annually to about 3,000 households in Addis Ababa. Private enterprises and smallholder farmers provide feedstock to state owned sugar factories that produce ethanol; other smallholder farmers produce crops that are suitable for micro and small scale ethanol production including sweet sorghum, sweet potato, beetroot, cactus, fruits and vegetables.

There is no private investment in fuel ethanol production in Ethiopia at present but this is expected to change in the future as the government plans to promote private investment in ethanol production from molasses waste from state owned sugar factories and private investors are keen to invest in ethanol production. There is also potential for micro and small scale production of fuel ethanol by the private sector because of foreign and local investment in sugarcane production as well as the potential for ethanol micro distilleries from the feedstock listed previously.

Ethanol fuel and stove distributors have made significant commitment and investment (within their capacity) to increase market for the fuel and stove; and they have been in the business for a decade or more.

Their main challenges are related to ethanol supply:

a) ***Supply guarantee for cooking*:** ethanol was not always available for cooking in the past; supply availability improved recently with special allocation for cooking but then the market was depressed because of supply uncertainties in the past and the sharp price rise.
b) ***Price competitiveness and stability*:** ethanol is in competition with electricity, LPG, kerosene and charcoal in the markets where it is distributed. The sharp price rise has diminished its competitiveness and depressed the market for the fuel and stove. Ethanol fuel and stoves must be priced to be competitive in the market.
c) ***Distribution capacity*:** distribution capacity of existing distributors must increase and new entrants, including petroleum distribution companies, must take part in distribution if ethanol is to become a truly competitive alternative in the cooking fuel market in Ethiopia. Existing distributors are essentially small (medium) enterprises with limited distribution capacity (physical and financial).
d) ***Quality standards for ethanol distribution and for ethanol stoves*:** ethanol distribution facilities must meet applicable safety and environmental standards (there are none today). Ethanol stoves must be safe for consumers and provide the benefits expected (energy efficiency, IAP and GHG reduction).
e) ***Technical and business capacity of micro enterprises*** that may produce ethanol stoves (as well as distribute ethanol fuel) is low.

Potential for production of ethanol through alternative feedstock and technologies

Ethanol micro distilleries (EMDs) are a potentially viable alternative for ethanol supply to rural consumers. EMDs will produce and distribute ethanol to local consumers thus reducing transport and other distribution costs. EMD operators may also distribute ethanol stoves to their consumers. The challenge for rural ethanol distribution will be the competitiveness of ethanol with low-cost and no-cost fuels such as charcoal and fuelwood. EMDs must also provide ethanol all year round, which depending on the feedstock used for EMDs may not be feasible.

Private enterprises have shown interest to invest in ethanol distilleries. Local investors seek to invest in ethanol distilleries to process waste that may be available from state sugar factories. Commercial sugarcane farms now in the initial stages of farm development may also invest in ethanol plants depending on viability of such investment at prevailing market conditions. EMDs may also be potentially viable for production of ethanol from a variety of feedstock identified earlier.

Private investors face the following challenges:

a) ***Feedstock availability, access, pricing:*** private investment in ethanol distilleries from molasses waste from state sugar factories will depend on stable availability and competitive pricing; EMDs also face the challenge of sourcing sustainable and competitively priced feedstock. Ethanol production will also depend on the retail price that is regulated by the government which must provide sufficient margins for producers and distributors as well as be competitive with other cooking alternatives in the market.

b) ***Investment finance:*** investment requirements for ethanol distilleries are high at both large and micro scale. Large distilleries require several hundred million Birr while micro distilleries (capacity of 1,000 liter/day) cost Birr 5 million or more. A consortium of local private companies initiated a plan to invest in ethanol distilleries but failed to raise sufficient capital. Raising capital for EMDs will also be a challenge because these require substantial investment in a rural setting.

c) ***Market development:*** the viability of both large and micro scale ethanol production will depend on the market for the fuel (its consumer size and its price). The current market is very small and not growing; investors will be wary of making such sizable investment with market uncertainties.

d) ***Price competition with existing cooking alternatives:*** current retail price for ethanol is not competitive with alternatives (electricity). Ethanol producers face the challenge of supplying ethanol at competitive prices to the alternatives (because production costs may be high, particularly for micro distillers).

e) ***Policy clarity regarding cultivation of crops dedicated for ethanol production:*** the Biofuel Policy does not provide guidance on whether feedstock other than sugarcane molasses (and sugarcane) can be used as ethanol feedstock. Clear policy guidance on this will attract investment in ethanol distilleries.

Ethanol market development support

Smallholder farmers of sugarcane, sweet sorghum, sweet potato, beetroot, prickly fruit cactus and fruits are potential sources of feedstock for micro distilleries. A micro distillery requires daily input from scores of smallholders and needs to have long term contracts with supplier groups. Feedstock producers may therefore be organized into cooperatives to ease supply. Such cooperatives also have the potential to invest in EMDs and use ethanol fuel as well.

EMD investors will benefit from the current feasibility study which points to viable feedstock, technologies, and markets. EMD investors will also benefit from on-going pilot programs for EMDs. Further support can be provided through project specific feasibility studies and technical support for installation and operation for the initial group of commercial EMDs.

There is some local capability to supply EMD components. This capability can be improved with technical association of local companies with international EMD suppliers. R&D on distillery equipment manufacture should also be initiated at MOWIE (in collaboration with METEC or other private companies).

Ethanol stoves are supplied by two private companies in Addis Ababa: one imports the stove while the other manufactures it. In addition, MOWIE has trained MSEs to produce an ethanol stove developed by the AETDPD. The two current suppliers of ethanol stoves are medium scale enterprises with sufficient technical and financial capacity to meet short-term supply requirements. MSE stove producers will need technical skill upgrading as well as investment in manufacture equipment (i.e., transition to medium scale manufacture with mechanized equipment).

Ethanol fuel and stove suppliers require market development support from the government. Such support includes first guaranteeing ethanol supply, then providing marketing support in market information, fuel and stove promotion.

Financing investment in ethanol production and marketing

The government seeks private investment in ethanol distilleries based on molasses from state sugar factories. Investment costs for ethanol plants are high.[1]Local private investors have formed a consortium to exploit this opportunity but they are yet to raise the required capital. International companies are also interested to invest in large ethanol distilleries if input and output prices are competitive as discussed earlier. Financing for large ethanol distilleries for local companies may be available from the Development Bank of Ethiopia. Joint investment of local and foreign companies will be an attractive option to raise the capital (and foreign exchange) for such projects. Investment in EMDs can be financed by local private or government banks.

Existing distributors of ethanol stoves have made initial investment in land and equipment with equity and financing from commercial banks. Existing stove producers and suppliers are able to raise the required capital from commercial farms. MSE ethanol stove manufacturers will receive loans from MFIs.

Ethanol fuel and stove suppliers have the potential to receive financing from the renewable energy finance available at the DBE. The Scaling-up Renewable Energy Project (SREP, a World Bank fund) has allocated funds for renewable energy financing that ethanol stove business may also use.

Policies and regulations for promotion of ethanol as cooking fuel

Existing ethanol fuel distributors have invested in ethanol fuel distribution and ethanol stove production. Petroleum distribution companies have shown interest to invest in distribution when the market for ethanol as cooking fuel becomes large enough to warrant such investment. Although there are no distillery equipment manufacturers in Ethiopia at present evaluation of the manufacturing sector indicates the feasibility of local production of micro distillery components.

The government provides incentives for private investment in manufacturing including provision of land for manufacturing facilities, import duty exemptions for capital goods and raw materials, and access to concessional finance from the Development Bank of Ethiopia. Government support for the micro and small enterprise (MSE) sub-sector is high where MSEs are provided workspace, technical and business training, and financing from MFIs. Ethanol stove and distillery equipment manufacturers, micro to large scale, will receive these supports.

Ethanol micro distilleries promote rural agro-industry. This is an area that is given high priority for investment by the government together with manufacture. Micro distilleries also promote rural commercialization which is a strategic focus for the agriculture sector. Investment in micro distilleries will therefore receive the investment incentives outlined above.

In order to ease investment in commercial agriculture the government has created a central database of agricultural investment land at the Ministry of Agriculture. Investors can identify and select land that is suitable for their investment. The MOA database contains land set aside for investment in four regional states: Afar, Benishangul-Gumuz, Gambella, and SNNP. Agricultural investment land in the other regional states is allocated by regional governments. Attractive land lease rates apply in all regions.

Conclusions and recommendations

The commercial market for ethanol as cooking fuel is very small and limited to Addis Ababa. The market is not growing and probably shrinking because of uncertainties of supply and rising prices. On the other hand, potential availability of ethanol is high from state owned sugar factories (from public and private investment in ethanol distilleries from molasses waste). There is also potential to promote private investment in ethanol distilleries from a variety of feedstock identified earlier.

There is clear advantage in using ethanol for cooking rather than for other uses including as gasoline blend or export. Cooking can be the largest market for ethanol produced in Ethiopia; cooking with ethanol has multiple economic (at consumer level and nationally) and environmental benefits (indoor to greenhouse gas mitigation).

[1] Investment in ethanol plants range US$0.5-1.0/liter of ethanol output. A 20 million liter/year output ethanol plant will cost US$20 million or ETB400 million. A micro distillery of 0.3 million liter/year output (1000LPD) cost US$0.25 million (ETB 5 million).

Private enterprises distributing ethanol as well as the public institutions that produce ethanol and promote its use as cooking fuel agree market development to be the key goal. Sustainable market development requires suitable policies and regulations, investment in ethanol production and distribution, promotion and marketing.

a) *Policies and regulations*:

- Make rationale economic, social and environmental valuation of the benefits and costs of using ethanol for cooking, as gasoline blend or for export. Allocation and pricing of ethanol among the alternative uses should be based on such rationale valuation not on enterprise level decisions.
- Guarantee allocation of sufficient ethanol for cooking for five years at prices that will increase market share for ethanol in urban areas. Allocation should be based on market assessment for the fuel.
- Provide policy guidance for feedstock cultivation for ethanol production to increase and diversity ethanol production sources and to attract investment.

b) *Investment*:

- Government should promote private investment (local, foreign, joint) in ethanol distilleries for the new sugar factories. There is already such a plan by the government but this plan must be pursued strongly. Investors also seek competitive and stable prices for inputs (molasses purchases) and outputs (ethanol wholesale) and government must provide long-term price incentives to attract private investment.
- Once the market starts to develop the government should provide incentives for private companies, including petroleum distribution companies, to invest in ethanol distribution. This could be in the form of attractive distribution margins.

c) *Marketing and promotion*:

- Sustained marketing and promotion should follow once supply at competitive prices is guaranteed. Ethanol fuel and stove distributors are willing and able to conduct such promotion together with the government.

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