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United Nations Industrial Development Organization (UNIDO)

Tanzania Office

Assessment for potential of ethanol for household cooking fuel

Scoping Study Report (Draft)

Project Gaia Inc.

in collaboration with Ethio Resource Group

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1 Background

1.1 Demography and geography of Zanzibar

Zanzibar is a semi-autonomous state of the United Republic of Tanzania. Two main islands, Unguja and Pemba, with a total land area of 2,654 square kilometers, constitute Zanzibar. Unguja is the largest island of the two, constituting 63% of the total land area and providing a home to about 70% of the population[1]. According to the 2012 Population and Housing Census, the population of Zanzibar is 1,303,569 million, growing at a rate of 2.8% per year. About 57% of the population is rural. The government administration of Zanzibar is divided into five regions, three in Unguja and 2 in Pemba, and 10 districts.

1.2 Economy

The Gross Domestic Product of Zanzibar for 2012 at market price was Tzs 1,354.2 billion (USD 861 million) with a GDP per capita of USD 638. The main economy of Zanzibar is based on the service sector which accounts for about 52% of GDP. The agriculture, forestry and fishing sectors contribute about 35% to the economy while the industry sector accounts only for about 13%. Main subsectors in the service sector are water and electricity utilities, trade and repair, and transport and communication. From the agriculture, forestry and fishing sectors, crop production accounts for two third of the value from these sectors. The balance of trade has always been negative for Zanzibar and the gap is continuously growing. In 2012 Zanzibar's export earnings were Tzs 67,390.5 million while imports were Tzs 271,273 million, with a negative trade balance of Tzs 203,882.5 million. Vegetable products, mainly cloves, account for 94% of the total export earnings[2].

1.3 Development strategy of Zanzibar

The first Zanzibar Strategy for Growth and Reduction of Poverty (ZSGRP-I) devised a four-year strategy plan and identified major clusters of the strategy and goals for the clusters. Major clusters of the strategy were 1) Economic growth with reduction of both income and non-income poverty, 2) Social services and well-being and 3) Good governance and national unity. One of the operational targets of the goal for income poverty reduction was to ensure increased access to affordable and sustainable energy by 2010, the end of the strategy period for ZSGRP-I. Among several key interventions, formulation and implementation of the energy policy and promotion of sustainable use of natural resources, with mainstreaming of environmental norms into the island's development actives, were the most relevant ones for energy interventions[3].

As an output to ZSRP-I, the Zanzibar National Energy Policy was released in December 2010. The ZSGRP-I and the subsequent strategy plan for 2010 to 2015 (ZSGRP-II) were prepared to meet the targets set for Vision 2020 of Zanzibar.

Vision 2020 of Zanzibar clearly outlines the needs in the energy subsectors and sets Vision's policy on the sustained provision of energy. The policy objectives of Vision 2020 addressed not only the power sector but also traditional energy use by the household subsector. The policy objectives include the following, to:

[1] Zanzibar Strategy for Growth and Reduction of Poverty (ZSGRP-I) 2007 to 2010, January 2007.

[2] Office of the Chief of Government Statistician, Socio-economic Survey of 2013, Statistical Report, Zanzibar, March 2013.

[3] ZSGRP-I.

i. Establish an independent power supply system to reduce dependency on imported energy and the pressure on demand for forest resources.

ii. Develop and promote energy supply and management systems that will ensure reliable energy for all purposes at a reasonable cost.

iii. Encourage R&D on non-wood energy sources (such as solar, wind power and biogas) and on energy efficient domestic alternative sources of energy.

iv. Promote an efficient use of energy, ensure conservation of renewable and non-renewable energy sources and the protection of environment; and

v. Promotion of petroleum exploration activities[4].

Vision 2020 of Zanzibar is clear about its objectives that household cooking energy is one of the primary sectors that need to be urgently addressed. It can be inferred from Policy Objective 1 of Vision 2020 that a substitute for use of forest resources for energy purposes (e.g. firewood and charcoal) through increased supply of reliable power was proposed as one alternative. Energy efficiency and alternative energy sources for all energy subsectors are also included in the objectives. The strategy documents ZSGRP I and II have not clearly integrated household energy issues, particularly cooking, into the national strategy plan of Zanzibar. Hence, apart from occasional projects by various organizations, there does not seem to have been a national-level intervention program in Zanzibar for household cooking energy. However, the government of Zanzibar is clearly cognizant of the fact that a household cooking energy problem does exist and they are aware of the associated environmental impacts from the overharvesting of wood fuels, such as the mangroves, and that this requires urgent intervention. This was especially clear to us in our discussions with Zanzibar Planning Commission Executive Director Amina Kh. Shaaban and Ministry of Lands, Housing, Water and Energy Principal Secretary Ali Khalil Mirza.

1.4 Objectives of the scoping study

This scoping study was initiated by UNIDO Tanzania Office anticipating that ethanol fuel, obtained as a by-product of sugar production, from the Mahonda Sugar Factory in Zanzibar, would be a potential clean cooking fuel option to at least partially address the household cooking energy demand in Zanzibar. Therefore, the main objective of this scoping study is to assess prevailing socio-economic conditions and the policy environment in preparation to conducting a wider technical and financial feasibility assessment of locally produced ethanol fuel for household cooking as an alternative to solid biomass fuels and kerosene. The study assesses the opportunities and challenges in promoting ethanol as a household fuel in Zanzibar. The assessment includes ethanol production and supply capacity of the only sugar factory in Zanzibar (Zanzibar Sugar Factory Limited), opportunities and challenges for introduction and promotion of ethanol fuel and stoves, identification of potential fuel supply chain, and discussions with major government stakeholders about the relevance of the project towards the national agenda of Zanzibar.

2 The Energy Sector

As with most sub Saharan African countries, biomass is the major source of energy in Zanzibar. The energy sector in Zanzibar is characterized by heavy reliance on biomass fuels, used primarily for cooking in the household and commercial sectors.

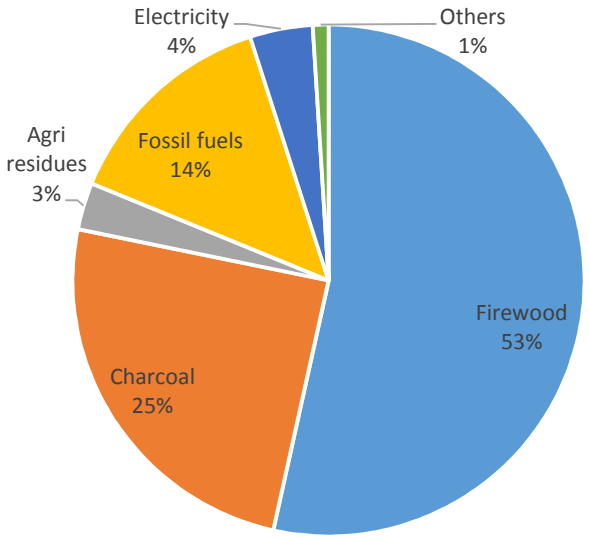
[4] Revisited Zanzibar Development Vision 2020, Zanzibar Planning Commission, October 2011.

2.1 Energy resources and supply

Forests and bush lands are major sources of biomass energy in Zanzibar. Reserved forests cover about 12,000 ha (5% of the land area), part of which is strictly reserved for biodiversity conservation while the rest is for exploitation of wood and non-wood products. Bush land and thickets cover 11,062 ha, about 45% of the total land area of Zanzibar, and are the major sources of wood products. Coral rag forests, which cover 98,329 ha of land, are being depleted at a rate of 530 ha per year. Coral rag forests and mangroves are heavily exploited for fuelwood and construction. Increasing demand for fuelwood and expansion of agricultural land have put heavy pressure on the biomass resources of Zanzibar. The balance between sustainable yield and actual harvesting of biomass is considered to be not sustainable[5]. Domestic demand for wood products is estimated to be 343% of the sustainable cut[6]. The director of Forest and Non Renewable Natural Resources, Sheha Hamdan, has placed the annual forest loss at 1,000 ha based on data from the national tree census of 1997 and recent studies conducted by INDUFOR of Finland (http://www.indufor.fi/) and the Zanzibar Department of Forestry[7].

Biomass fuels account for 82% of the total national energy supply for Zanzibar of which firewood contributes 53% and charcoal (25%). Next to biomass, fossil fuels and electricity respectively make up 14% and 4% of the energy supply[8].

Figure 2.1 Energy supply by type of fuel



The biomass exploitation rate has been so high that prime hardwood species for charcoal making are no longer widely available. Discussions with residents in Ikisakasaka village confirmed that the mangroves in the area had been cut out and were no longer available. Only Casuarina (Australian Pine) and mango trees were available for charcoal.

The primary supply of charcoal in Zanzibar, about 80%, comes from the mainland of Tanzania. The quality of charcoal from the mainland is said to be better than local charcoal and as a consequence more costly. Charcoal production in Zanzibar, according to anecdotal information, is decreasing not because of conservation measures but because of scarcity of tree species suitable for charcoal making. Mostly non-charcoal species remain.

2.2 Energy use

In terms of energy consumption, the household sector takes the lion's share from the total national energy consumption. The household sector accounts for about 84% of the total energy consumption in Zanzibar. All other sectors together consume only 16% of the total.

[5] The Department of Commercial Crops, Fruits and Forestry, Zanzibar Biodiversity, Climate Change and Energy Crisis, March 2010.

[6] The Zanzibar National Forest Policy Analysis, Sustainable Management of Land and Environment II, (SMOLE II), October 2010.

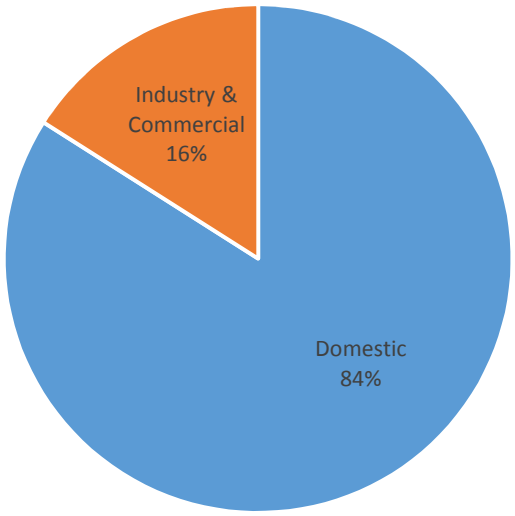
[7] Daily News Online, Tanzania's Online News Edition, http://dailynews.co.tz/index.php/features/13248-z-bar-keen-to-conserve-endangered-forests, accessed 3-3-14.

[8] Department of Energy and Minerals, Country Presentation on Energy Policy, Hahad Juma Baka, Zanzibar, May 2010.

Households almost entirely depend on biomass, mainly on firewood and charcoal for cooking. The proportion of firewood to charcoal in the households varies by settlement type. Firewood is the main cooking fuel for the rural households while charcoal is for the urban households.

According to the Department of Energy and Minerals, total amount of biomass fuels consumption was estimated at 1.4 million cubic meters per year (equivalent to 660,000 tons per year) mainly used for cooking in the domestic sector. (The SMOLE II report placed this at 941,000 cubic meters in 2010.) Institutions such as schools and hospitals also depend on fuelwood for cooking (Hahad Bakar, May 2010), as well as commercial establishments such as restaurants and street food vendors.

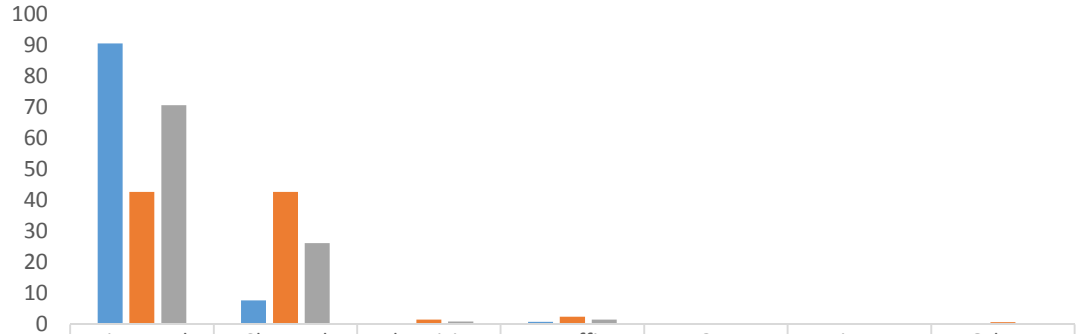
Figure 2.2 Distribution of energy consumptin by sector



2.3 The household energy situation in Zanzibar

Main cooking fuels for urban and rural households in Zanzibar are charcoal and firewood. A cooking fuels consumption survey of 2010 showed that firewood is the primary cooking fuel for rural households while charcoal is the primary fuel for urban households. About 90% of the rural households and 43% of the urban households in Zanzibar depend on firewood for cooking. Charcoal, however, is used only by 8% of the rural households and by about 52% of urban households. Very few households, about 2.4% in urban and less than 1% in rural, use paraffin for cooking. Paraffin is primarily used for lighting in Zanzibar.

Figure 2.3 Percentage distribution of households by type of fuel used for cooking[9]



	Firewood	Charcoal	Electricity	Paraffin	Gas	Biogas	Others
Rural	90.7	7.7	0.4	0.8	0.1	0.2	0.1
Urban	42.7	42.7	1.5	2.4	0.3	0	0.7
Total	70.8	26.2	0.9	1.5	0.2	0.1	0.3

Charcoal and paraffin are urban fuels and only very few households use them for cooking. Preference for cooking fuels by household depends on the availability and price of the fuel and its convenience to use.

[9] Office of Chief Government Statistician, Household Budget Survey 2009/10, Final Report, May 2012.

Despite scarcity of locally produced charcoal and its rising price, there is apparently a general trend of shifting from firewood to charcoal by both urban and rural households. Comparison of biomass cooking fuel consumption for 2004/05 and 2009/10 shows a shift by 5% from firewood to charcoal. Total national level charcoal consumption increased from 21.2% to 26.2% with a corresponding decrease of firewood from 75% to 70.8%. This perhaps is due to the preference of households for a cleaner fuel even though it is more costly. It is also an indication that convenience of use is a governing factor that influences household choice of cooking fuels. But price of cooking fuel also governs the choice that households make. Price of paraffin and electricity have become prohibitively expensive for households to use for cooking. The decline of kerosene and electricity usage for cooking from 2004/05 to 2009/10, from 2% to 1.5% for kerosene and from 1.3% to 0.9% for electricity, could indicate the limit that households are able or willing to pay for cooking energy. When fuels become unaffordable, lower income households have little choice but to revert back to cheaper options. In one of the villages visited, Ikisakasaka, because of the scarcity of hardwood charcoal species, households in the village no longer use charcoal as they once did; they now burn wood directly.

3 Household cooking energy conditions in Zanzibar

3.1 Key household energy issues

Household cooking energy issues are diverse and touch every aspect of life. As in most of sub Saharan African countries, household energy issues include difficulty of access and scarcity, and the attendant social, economic and environmental consequences. Cooking fuel supply constraint due to over-exploitation of the available biomass resource is perhaps the major household energy issue in Zanzibar. Forest areas have been cleared under the pretext of agricultural land expansion but a driving force is fuelwood sales. Cooking fuels generally are expensive in Zanzibar. Cleaner fuels such as liquid petroleum gas (LPG) and electricity are unaffordable to the majority of households. Paraffin or kerosene, despite the current subsidy, is still about one US Dollar per liter[10].

In many least developed countries, including Zanzibar, cooking is a household chore traditionally relegated to women. It involves not only the actual cooking but also the acquisition of cooking fuels. With increasing scarcity of firewood and charcoal, households either pay higher prices for fuels or spend more time collecting and travelling with heavy loads to obtain sufficient fuel for cooking. Clean cooking options are inaccessible to the majority of households in Zanzibar. Indoor Air Pollution (IAP), as a result of burning solid fuels, affects women and children disproportionately. Unsustainable use of wood fuels leads to deforestation, which in turn affects hydrology, erosion of land, biodiversity, the health of coastal ecosystems and fisheries and, in the case of the mangroves, the natural buffer of the island that allows it to withstand monsoons, waves, high tides, heavy storms, land erosion and salt water intrusion[11].

3.2 Fuel and stove market

Cooking requires expenditure on both a stove and fuel. But consumers know that it is largely the cost of fuel that determines the cost of cooking. As fuel prices increase in Zanzibar, households are required to pay more for cooking and hence are very careful about their choices of fuels. Urban households, due to the nature of their dwelling space and, presumably, their higher income, tend to be willing to pay more for

[10] We observed that diesel fuel is currently selling for 2,225 Tzs while kerosene is selling for 1,685 or approximately one USD. We assume this subsidy on kerosene is at least a bow by the government to the effort to replace or reduce the use of wood fuel.

[11] Department of the Environment, The Status of Zanzibar Coastal Resources, Marine and Coastal Environmental Project (MACEMP), April 2009.

cleaner fuels than rural households. A preliminary assessment of fuel prices in Zanzibar is presented in Table 3.1.

Table 3.1 Fuel prices in Zanzibar urban market (price collected in April 2014)

#	Type of fuel	Price in TZs (Tzs/kg)	Price in USD (USD/kg)
1	Electricity (> 50 kWh)	400 Tzs/kWh	0.25 kWh
1	Gas (LPG) -15 kg bottle	65,000 (4,333 kg)	40.00 (2.67)
2	*Kerosene/ Paraffin (Liter)	1,685	1.05
3	Diesel (Liter)	2,225	1.39
4	Firewood (< 20 kg)	1,500 (75 kg)	0.94 (0.05)
5	+Charcoal (15-20 kg Sack)	14,000– 20,000 (1,000 kg)	9-12 (0.6)
6	Charcoal (30-40kg Sack)	45,000-50,000 (1,250 kg)	28-31 (0.78)
7	Charcoal (0.5 kg retail bag)	1,000 - 1,500 (3,000 kg)	0.63-0.94 (1.88)

**Kerosene price previously was equal to that of diesel but recently reduced through subsidy.*
+Charcoal prices vary significantly depending on the quality. Charcoal from the mainland has higher prices.
(Sources: Zanzibar market place for traditional fuels, filling stations for petroleum fuels)

With a retail price of Tzs 75/kg, firewood is the cheapest fuel in Zanzibar. Kerosene is the next cheapest fuel. Charcoal is the next, after kerosene, and compared to charcoal prices in other markets, is relatively expensive. Price of charcoal varies between Tzs 1,000 to Tzs 3,000 per kg., depending on the mode of purchase and the fuel market place. Poorer households who cannot afford to purchase in sacks pay more in retail purchases. Clean fuels such as electricity and gas are distant for the majority of households in Zanzibar. With the current revised tariff of electricity, Tzs 400/kWh for consumptions above 50 kWh per month, electricity does not seem to be an affordable cooking fuel even for the better-off urban households. The recent subsidy on paraffin may attract more households to use it for cooking. But the trend on kerosene as a commodity is steadily up. Currently, only 1.5% of households use paraffin for cooking. The recent electricity and paraffin price revisions could make many charcoal and electricity user-households shift toward paraffin for cooking. Even though the relatively low price of paraffin means an additional cooking fuel for those who can afford it, increased consumption of paraffin imposes a burden on government and the island economy, because of the subsidy and also because of the fact that kerosene is an imported fuel. Zanzibar's costly intervention to subsidize kerosene should perhaps be regarded as a temporary intervention that should be eliminated when possible, when more sustainable solutions are obtained. Thus, the search for alternative cooking fuels for the households is a matter of priority for Zanzibar.

Prices of cookstoves in Zanzibar markets vary greatly. Charcoal stoves with clay liners cost between Tzs 5,000 to 10,000 depending on the quality and size of stove. Kerosene wick stoves costs around Tzs 15,000. The most expensive stove is a gas (LPG) stove. A double burner gas stoves costs about Tzs 110,000 and with gas cylinder, hose and regulator about Tzs 165,000. Households could be willing to pay for a relatively expensive cookstove if the fuel, which is a recurrent cost, is affordable. For gas stoves, however, the issue is not only the cost of the stove but also the cost of the fuel.

Table 3.2 Prices that households pay for cookstoves

#	Type of fuel	Price (Tzs)	Price (USD)
1	*Gas (LPG) stove-double burner	110,000	69.00
2	Kerosene/Paraffin (wick stove)	15,000	9.00
4	Firewood (Open Fire)**	--	--
5	Charcoal	5,000-10,000	3.00 to 6.00

**An additional Tzs 55,000 or more will be needed for the gas cylinder, regulator and hose.*
*** Improved combustion wood stoves, such as rocket stoves, sell for $35 and up.*

3.3 Comparative cost of cooking

For ethanol fuel to be accepted it should first be cost competitive with existing cooking fuels. Table 3.3 presents the cost of cooking with various fuels and stoves on the basis of useful energy, net energy needed to prepare food. Prices of both fuels and stoves vary greatly. Different stoves have different performance abilities. Some are more efficient than others. Some fuels contain more energy than others per unit of measuring weight. The analysis below considers these factors.

Table 3.3 Comparison of cooking costs in Zanzibar – on useful energy basis (April 2014)

1200 MJ useful energy per household per year	*Fuel*	Wood	Charcoal	Ethanol	Gas	Paraffin	Electricity
	Stove	3-stone	Metal/clay	CC stove	1-burner	Wick stv	Hot plate
	Unit	kg	Kg	Liter	kg	Liter	kWh
Energy content of fuel	MJ/(kg,lt,kWh)	18.96	28.2	24.8	44.7	35.3	3.6
Retail price of fuel	Tzs/(kg,lt,kWh)	75	1125	1500	4333	1680	400
Stove life	Year	3	3	10	10	3	5
Stove efficiency	%	12%	25%	59%	60%	40%	60%
Stove price	Tzs	-	7,500	48,000	100,000	15,000	15,000
Useful energy cost	**Tzs/MJ**	**32.96**	**161.04**	**109.79**	**178.15**	**124.45**	**188.91**
Energy cost	Tzs/MJ	32.96	158.31	101.82	161.56	118.98	185.19
Stove Cost	Tzs/MJ	-	2.7	8.0	16.6	5.5	3.7
Relative to the least-cost stove + fuel		1.0	4.9	3.3	5.4	3.8	5.7
Rank		1	4	2	5	3	6

Firewood with open fire is the cheapest cooking fuel/system. It should be noted that price of firewood is much cheaper than the other fuels and open fire is free of cost. Ethanol fuel with the CC stove (the CleanCook stove) is the second cheapest option. Even though the price of the stove seems expensive, it actually is not when considered over its extended life. The price of ethanol, Tzs 1,500 per liter, is assumed for the Zanzibar Sugar Factory for its first test-production sales. This price might be able to be set lower. Paraffin is the third most affordable fuel. Next is charcoal, and next, gas and electricity. Because of the recent subsidy, paraffin competes with charcoal. It is evident that more households will shift upward from charcoal to paraffin and downward from electricity to paraffin. It should also be noted that the electricity tariff was revised in November 2013. Two more tariff revisions are yet to be made before 2015, so the price of electricity will continue to increase.

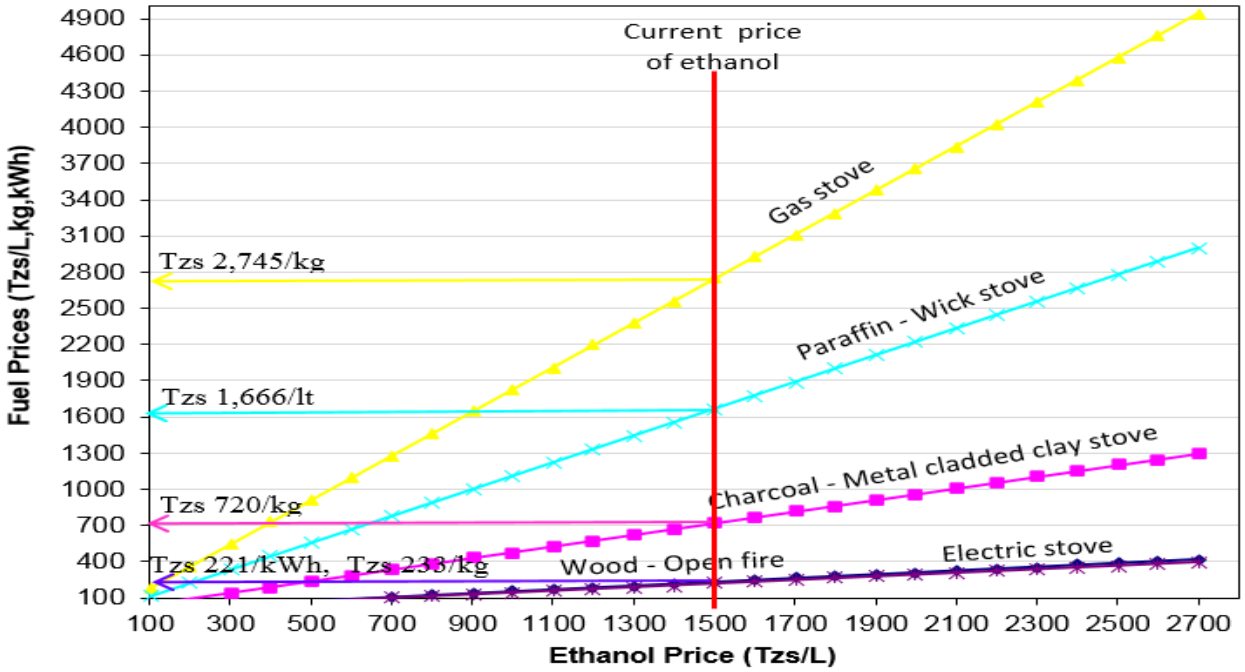
Table 3.4 shows the potential of ethanol to displace other fuels. A liter of ethanol is almost equal to a liter of paraffin but slightly lower. The impact of ethanol towards protection of the biomass resource is immense. A liter of ethanol can displace 6.4kg of wood or 2.1 kg of charcoal.

Table 3.4 Amount of fuels displaced by a liter of ethanol using CleanCook stove

Type of fuel	Wood	Charcoal	Paraffin	Gas	Electricity
Type of stove	Open Fire	Metal clad clay liner	Wick stove	Gas	Electricity
Unit	kg	kg	Liter	kg	kWh
Amount	6.4 to 10	2.1 to 4	0.9 to 1.2	0.5	6.8

Figure 3.1 shows price elasticity where ethanol can be cost competitive with other fuels. Cooking with firewood using open fire breaks even with ethanol at a price of Tzs 233/kg. Current firewood price is only Tzs 75/kg, indicating that it is much cheaper to cook with firewood than ethanol (assuming Tzs 1,500/lt). Price of paraffin should come down to Tzs 1,666/lt to break even with ethanol. For charcoal, gas and electricity to compete with ethanol their prices should come down to Tzs 720/kg, Tzs 2,745/kg and Tzs 221/kWh respectively.

Figure 3.1 Comparison of cost of cooking with various stoves and fuels (assuming ethanol at Tzs 1500/lt).



Our initial conclusion is that ethanol will compare closest in price to subsidized kerosene but will be less than kerosene. This would allow the Government of Zanzibar to remove its subsidy on kerosene when there is enough ethanol available to substitute for kerosene. The ethanol may not need any subsidy at all, unless the government wishes to promote the uptake of ethanol by rural households that now depend on open fires. The ethanol should penetrate the urban households without any subsidy.

3.4 Opportunities and challenges to ethanol use for household cooking

Opportunities to use of ethanol as cooking fuel in Zanzibar

Conditions seem opportune for promoting ethanol as a cooking fuel in Zanzibar. The burden that the demand for cooking fuels places on the economy and the environment is well-understood now more than ever by government and by the public. Demand for affordable substitute fuels that are environmentally friendly is high. Promotion of ethanol as cooking fuel in Zanzibar is in line with all government-sector policies. As a locally produced fuel it may have special appeal for Zanzibar's citizens.

Conditions in Zanzibar offer some unique opportunities for an ethanol stove fuel business. One of these is the prohibition on beverage alcohol, which is often not the case elsewhere. Because of the refusal or reluctance of government to sanction the production of beverage alcohol at the Zanzibar Sugar Factory, this easy and often lucrative market is precluded. Other potential markets are fuel blending in petrol, export sales, and industrial use. Fuel blending is technically challenging, expensive, and the current

supply is too small to make it feasible for Zanzibar. Moreover, Zanzibar's gasoline-fueled vehicles may not have ethanol-compliant motors (only new vehicles will be ethanol-compliant). The export market is not very desirable because the value of the ethanol is lost to the local economy. Moreover, the value of the ethanol for export may be low because cheap ethanol is available from large-scale producers elsewhere (such as India)[12]. This leaves industrial markets (such as solvents and perfume) and ethanol fuel for stoves, which are apparently the markets favored by the Zanzibar Sugar Factory. Each of these markets will probably pay a better price than any other market but beverage, which has been ruled out. Therefore, industrial use and fuel use for stoves are favored.

Fuel ethanol is an easy, non-technical market to supply. The ethanol is cheaply and effectively denatured at the plant, making it unfit for any use but fuel. The distillery is designed to produce very high quality ethanol (extra neutral), which provides a premium stove fuel (very low in aldehydes and fusel oils). The ethanol will be produced cheaply, leaving plenty of room for the producer's and the distributor's margins.

There are supply chain opportunities that will bring jobs and incomes to Zanzibar. An ethanol supply chain is potentially similar to a kerosene supply chain. It could piggyback on a petroleum fuel business supply chain, or it could be built separately, with hub-and-spoke distribution by very small entrepreneurs (village or neighborhood certified fuel sellers). If the Zanzibar Sugar Factory decides to sell and distribute its fuel directly, the supply chain could be short with few steps between factory and retail point-of-sale. This will make the supply chain economical. The high-value, dense urban market of Stone Town is not far away from the Sugar Factory gates and by targeting distribution outlets, the market can be geographically concentrated. If more ethanol can be produced and/or sourced to meet the needs of the entire island, this would not be an extensive supply chain to build. It could all be built from the factory, which has generous space, buildings and storage.

Ethanol is a new fuel, yet to be introduced to Zanzibar—although ethanol is used as a chafing dish fuel in many of its hotels and restaurants[13]. But Zanzibar has seen the introduction of new fuels before. The Government of Zanzibar has successfully introduced domestic biogas technologies to the island. Despite the fact that biogas technology requires significant investment in digester construction, handling and management, and that it has been introduced into low-income rural settings, the Government of Zanzibar has recently managed to disseminate over a dozen units[14]. This experience should provide encouragement for the dissemination of ethanol stoves. Ethanol fuel appears already to be price-competitive. The initial investment in the ethanol stove is less than half the cost of a single-burner gas stove. With arrangement of financing for installment purchase of the stove, and the opportunity cross-subsidization of the stove in the fuel, or use of carbon finance, strong market uptake of ethanol stoves could be expected in a short time.

A proven, tested ethanol stove, which has been shown to be safe, efficient and well-appreciated by consumers, already exists and is commercially available in African markets. This is the CleanCook stove manufactured by Dometic AB, a Swedish company[15]. Following a global technology search, Project Gaia Research Studies (now Project Gaia, Inc.) selected this stove and began testing it in Africa in 2001. In 2004 to 2006, the Shell Foundation funded pilot studies with this stove in Ethiopia and Brazil. In 2007 to 2010 the USEPA funded testing and commercialization activities with this stove in Nigeria and Ethiopia. In 2009, Novozymes, a Danish company, selected this stove for a project in Mozambique, where the stove is now commercially available. It is manufactured in Durban, South Africa, from whence it comes duty-

[12] Typical commodity prices for ethanol today are in the range of 0.50 to 0.60 USD/lt. or Tzs 800 to 1000.

[13] Gelfuel stoves were promoted in Tanzania more than a decade ago by the Millennium Gelfuel Project and probably have come to Zanzibar. The Moto Poa stove is an example. Gelling ethanol represents an expense added to the fuel cost that does not add fuel value, compromising combustion efficiency and stove functionality.

[14] Global Climate Adaptation Partnership, The Economics of Climate Change in Zanzibar, Technical Report (Final), UKAID, DFID, 2012. See also http://www.biogas-tanzania.org/.

[15] See Dometic AB at http://www.dometic.com/enie/International/Site/CleanCook-Alcohol-Fueled-Stoves/.

free to Mozambique. Some 38,000 stoves are now in use in Maputo and Matola with an average market absorption rate of more than 1,000 stoves per month during the last year[16]. Charcoal is the fuel being displaced. As this stove is now successful in several African countries with similar socio-economic conditions to Zanzibar, it is likely that this stove would also be accepted in Zanzibar. Using the same core burner technology, Dometic will adapt the stove body and pot supports to the needs of the local market.

Ethanol fuel and stove sales and distribution could be expected to have significant economic, social and environmental benefits for Zanzibar. These include the saving of scarce foreign exchange through the substitution of imported gas and paraffin for locally produced fuel, improvement in respiratory health of families who switch from wood, charcoal and kerosene to clean-burning ethanol fuel, and demand reduction on the island's woody biomass resources. Earning of foreign exchange from the sale of Certified Emission Reductions (CERs), with the displacement of wood and charcoal by ethanol, a low carbon fuel, is also significant. The revenue from these CERs would presumably be reinvested in scaling up ethanol stoves throughout Zanzibar.

Challenges to use of ethanol as cooking fuel in Zanzibar

Even though ethanol is clean burning and has notable virtues as a household fuel (low toxicity, miscibility in water, biodegradability, etc.), the dissemination of ethanol cooking fuel will not be without challenges.

Since the distillery will initially produce 6,000 liters per day (LPD) and with improvements 10,000 LPD, this will supply up to but not more than 20,000 households with fuel. If the ethanol stove and fuel are popular on the island, there could be a potential demand across 200,000 households, representing the need for a ten-fold scale-up. Thus, the Sugar Factory may need to develop a fuel scale-up strategy. Fuel supply may not be able to be met only with local production and therefore would require the importing of ethanol fuel. Currently importing ethanol fuel from India, priced competitively, is possible[17], but this may not be the case in the future. The Government would have to permit fuel importation and would undoubtedly tax it. A scale-up strategy would require a commitment by government for it to be achieved.

In some government and policy circles, there may remain opposition to producing ethanol for fuel, because of the fear that this could be diverted to undesirable and prohibited beverage use. A very clear line must be maintained between ethanol as fuel and ethanol as beverage. It must be clearly understood that the two are entirely distinct products, with no overlap. Ethanol fuel must be denatured at point of production.

The initial seemingly high cost of the ethanol stove could be a deterrent to quick adoption of the fuel by households. Unlike, paraffin and charcoal stoves, the ethanol stove is sturdy enough to last up to 10 years or more. Appropriate financing methods with extended payments should be developed to strengthen consumers' purchasing power, so as to promote quick uptake of stoves.

"Copycat" products, both stoves and fuel, will come into the market. It would be important for the Government of Zanzibar to properly regulate the ethanol stoves coming into the market, and to regulate ethanol fuel. The Zanzibar Sugar Factory is likely to develop the new stove and fuel business properly, but others coming into the market may not do so.

[16] Email exchange with Ms. Thelma Venichand of CleanStar Mozambique 9-24-13 and 3-20-14. See also: www.ndzilo.com, "*A Nova Forma de Cozinhar*."

[17] Major new ethanol capacity has recently come on line in Zimbabwe, Kenya and Madagascar, with more in the region promised.

4 Stakeholders' Assessment

Government organizations

Preliminary consultation has been made with several relevant government offices/stakeholders to introduce the idea of developing ethanol as a household fuel in Zanzibar and to ascertain if such action would be in line with the government's policy direction.

Several government ministries and departments, including the Federal Planning Commission and the Office of the Second Vice President, were contacted during this scoping study. Please see the list of contacted organizations and persons in the annex. Due to the limited time available for the scoping visit in Zanzibar, it was not possible to visit all relevant ministries, such as the Ministry of Agriculture and Forestry. Each of the offices and the officials visited indicated that the ethanol stove project is supported by their respective sector policies and programs. The executive director of the Planning Commission, a cross-cutting agency, emphasized this—that an ethanol stove program would harmonize well with Zanzibar's plans and objectives towards ensuring environmental sustainability and provision of safe, clean and affordable energy to its citizens. All offices interviewed also indicated that the stove project should be considered a sensible add-on to the support they had already lent to the re-opening of the Zanzibar Sugar Factory.

Zanzibar Electricity Corporation

Electricity in Zanzibar has been subsidized but the Government is now removing the subsidies in a phased approach. ZECO made its first tariff revision in November 2013. There will be two subsequent revisions, which will be completed by January 2015. Currently, the household life-line tariff, at a monthly consumption rate not exceeding 50 KWh, is Tzs 66 per kWh. Consumption above 50 kWh per month falls into a higher tariff category with a charge of Tzs 400 per kWh. Use of electricity for cooking easily makes a household fall in categories above the life-line tariff. This will make additional households that were able to cook with electricity shift towards low grade fuels such as paraffin and biomass. The Government of Zanzibar is cognizant of the need for alternative cooking fuels for households to offset this potential shift.

Zanzibar Sugar Factory

The Zanzibar Sugar Factory seems to enjoy very good support in government. This was obvious from our conversations with the factory administration and with government officials. The factory has now started operation and both sugar and molasses are being produced at the plant. The ethanol distillery was in the final stage of the rehabilitation process during our scoping visit and we were informed that it would commence ethanol production soon. The factory already has new or renovated storage facilities for molasses and ethanol. The rehabilitation work is being performed by seasoned Indian engineers with extensive experience in Africa, both in rehabilitations and new construction. The engineering company was recently involved with the commissioning of the new Metahara distillery and the rehabilitation of the Finchaa distillery in Ethiopia. Coincidently, the engineers knew the CleanCook stove because they were introduced to it at the Metahara distillery, where several are in use[18].

[18] The distillery rehabilitation team is led by Mr. Krishan Kumar Sharma of Integrated Casetech Consultants (P) Ltd. This consultancy is owned by Simbhaoli Sugars of New Delhi and Uttar Pradesh. Simbhaoli describes itself as "India's largest integrated sugar refinery," pioneering "innovations in sugar refining . . . high value, niche products (specialty sugars) and clean energy (ethanol)." See http://www.simbhaolisugars.com/contact-us.aspx.

The Sugar Factory has approximately 2,500 acres of sugar cane under production now, with another 1,500-acre farm available for production. An out-grower scheme could be added, allowing for significant expansion, as well as for the opportunity of small farmers to participate in the production of sugar cane.

The plant was built in the early 1970s by a Chinese company, run successfully for more than a decade, closed, and then reopened again in the last decade. It was repaired and modernized at that time and was operated for a few more years. It is being thoroughly rehabilitated now and the management states that it will be producing by July of this year[19]. It has a capacity of 6,000 liters per day, and can be pushed to 10,000 liters per day. It has an extensive front end fermentation line and is designed to run in a continuous process (24 hours per day).

Although built over 40 years ago, the major components of the distillery appear to be in good condition and the pipes, valves, pumps, tanks and distillation columns are being repaired, rehabilitated and where necessary replaced. Mr. Krishan Kumar reported to us that it is a well-designed and built distillery that produces Extra Neutral Alcohol (ENA), which means ethanol stripped of lighter and heavier impurities, namely ketones and aldehydes and amyl alcohols, otherwise known as fusel oil. This is essential for the use of ethanol in perfume making and pharmaceuticals (and other chemical and industrial uses) and a plus for ethanol as a stove fuel, since the cleaner the ethanol, the less likely there will be any soot or smell associated with its use in a stove.

The distillation unit is built with a mixing column, a rectification column and a purification column. The impurities such as the fusel oils are extracted from the rectification column and may be sold as their own chemical product. The distillery will make 96% ethanol and could eventually be equipped to make 98% ethanol.

We also learned that that a number of improvements are being added to the distillery to boost energy and process efficiency, including improvements in the fermentation system that will reduce contamination and increase alcohol production, and better heat transfer throughout the process, from back end to front end (when alcohol vapor is cooled to liquid ethanol, the heat may be recycled for use in sterilizing the mash and heating the fermenters). Moreover, the heat comes to the distillation unit as steam from the sugar factory, so this energy input is essentially free to the distillery and there is ample supply. The sugar factory provides three important inputs to the distillery: steam, molasses and electric power. The distillery will be semi-automated and will require about 10 people to operate.

Our conclusion is that the distillery will produce high quality ethanol economically. Since the key inputs are coming from the sugar factory, the ethanol is essentially "value added" and "energy added." Of the top four cost inputs—feedstock, heat, labor and power—three are coming from the sugar operation for free or for an assigned internal cost. These will allow the distillery to produce ethanol cheaply. With previous trial productions, the plant sold its ethanol at Tzs 1,500 per liter. Although it is difficult to estimate the cost of the ethanol without knowing the internal costs assigned to the molasses, steam and power, it is reasonable to bracket the actual cost of the ethanol between 0.30 and 0.55 USD/lt.

5 Strategic actions for promoting use of ethanol as a clean cooking fuel

The Government of Zanzibar has expressed its desire to support domestic production and use of ethanol for cooking. We learned during discussions with government officials that the household energy sector has been accorded a sense of urgency and should be prioritized. Well-formulated government policies and programs are now to be made real with concrete actions and strategies to implement them. Government and non-government stakeholders alike should be brought together to realize the policy goals. The

[19] Interview with Mr. Vicky Patel, Business Development Manager, VP Group, Zanzibar Sugar Factory, 2-18-14.

following are suggested actions for government organizations, development partners and the private sector, starting with the Department of Energy, perhaps, for introducing ethanol as a cooking fuel in Zanzibar.

Department of Energy of the Ministry of Lands, Housing, Water and Energy

Awareness and market development

- Collaborate with development partners for promotion of the ethanol stove, beginning in Zanzibar City.
    - ✓ Department of Energy and GoZ to work with development partners such as UNIDO, the Zanzibar Sugar Factory and qualified technical partners to promote ethanol fuel for household cooking in Zanzibar. Designate a "champion" in government to drive the process forward.
    - ✓ Request from UNIDO assistance to coalesce the technical partners.
    - ✓ Carry out a pilot study in 150 to 200 households to ensure that the stove is well-suited to cooking needs in Zanzibar and that all issues are identified.
    - ✓ Engage with technical partners to address technical issues (stove design, fuel preparation and quality, supply chain issues, empirical studies, etc.). Establish working standards and norms that will assure the quality of the study and set the program on the right trajectory.
    - ✓ Take the opportunity of the pilot study to gather not only empirical data on performance but also economic and market data. This will lay the groundwork for a commercial roll-out of fuel and stove following the pilot study.
    - ✓ Import the pilot study stoves as "seed stoves." Thereafter, encourage private enterprise to import and grow the number of stoves in the market. For example, Zanzibar Sugar Factory or a business of its creation could import and supply the stove to the market with its fuel. Or, a separate business could enter into a fuel off-take agreement with the Sugar Factory and start the stove and fuel business.
    - ✓ Design and execute the pilot study in an "entrepreneurial" manner. After an initial trial period, sell the ethanol fuel to the participants in the study. At the conclusion of the study, do not give but sell the stoves to the participants. Test price points for both stove and fuel.
    - ✓ Begin promotion in Zanzibar Urban District (population 223,000, 25% of the island's population)[20]. Promotion should initially focus on the highest and second highest income groups and commercial users, those using gas, paraffin and charcoal. Promote the stove for its safety, efficiency, economical operation, and high quality.
    - ✓ Encourage business planning during the course of the pilot study.

- Conduct demonstrations of the stove in other locations in Zanzibar following and informed by results from the initial assessments in the pilot study.

- Ensure that there is a sufficient supply of ethanol to fuel the stoves during the pilot study.

Financial incentives

- Work with the appropriate government institutions (i.e. Ministry of Finance and Ministry of Trade, Industry and Marketing) to lower or waive taxes on ethanol fuel and the stove. Ideally any import duties, excise taxes and VAT would be waived during the pilot study, including on imported stoves. The ultimate benefit to the economy and to the public good will justify this.
- Tax holidays should be viewed as temporary. However tax policy on the fuel and stove should be designed to nurture the project as it grows.

[20] National Bureau of Statistics, Tanzania. See: http://www.nbs.go.tz/.

Carbon finance

- Begin to develop carbon finance during the pilot study with the objective that a carbon finance program could be launched with the commercial launch. This is important for reasons of establishing additionality.

Global Environment Facility, GEF

- The GEF is an appropriate mechanism for financing technology transfer and scaling up of a stove and fuel business in Zanzibar. Under the right conditions, it may also fund ethanol fuel production capacity expansion. The Department of Energy with UNIDO and the technical partners should prepare a Project Identification Form or PIF as a planning exercise in the early stages of the project.

  The GEF invests million annually in energy efficiency, renewable energy, emerging low-carbon energy-generating technologies, cost-effective short-term response measures and sustainable urban transport. Under GEF-5 (2010-2014), funding for climate change mitigation programs has expanded to approximately $1.4 billion. The GEF's climate change strategy embraces technology transfer as a priority. Today, the GEF is supporting technology transfer activities in almost 100 developing countries. Tanzania is a GEF country. The GEF's Tanzanian Operational Focal Point is Dr. Julius Ningu, Director of Environment in the Vice President's Office, Dar Es Salaam. Contacts are: Tel: + 255 22 211 8416, + 255 767 733-904, + 255 22 212-5297, + 255 22 211 3867 and email: jkningu@yahoo.com[21].

6 Relevant follow-up actions—recommendations for next step

The scoping study identified that there is a high demand for alternative clean cooking fuels that would help alleviate the burden on the biomass resource base in Zanzibar. It was also learned that prices of cooking fuels, including traditional fuels, in Zanzibar are high. It is the intention of the Government of Zanzibar to ensure a sustainable and affordable supply of energy to its citizens. Ethanol is a locally produced fuel, which, with proper policy support, could be a solution to at least partly address the household cooking energy problem faced by Zanzibar. Government sector policies are supportive of promoting ethanol as a household fuel. To achieve a scaled dissemination of ethanol fuel for households, several things must be done to identify proper implementation strategies. Conducting a stove pilot study within a commercial or semi-commercial setting would logically be the first step.

The Zanzibar Sugar Factory has indicated its support for this pilot study. The Sugar Factory will be producing batches or test runs of ethanol. This ethanol could be used for the pilot study. If necessary, the ethanol could be supplemented with drums of ethanol shipped from India, denatured and colored to specification. The stoves would be provided to pre-selected homes on loan with a coupon or purchase strategy at the end of the pilot. After an introductory period, ethanol fuel would be sold to the homes. Commercial price points, among other study objectives, would be tested. A pilot study of up to 200 stoves assessed over 60 to 90 days would be easy and affordable to execute. This study would include a household energy baseline survey, a post intervention study with regular visits to the households, electively some indoor air quality monitoring, price point studies, and consumer assessment feedback, individually and through focus groups. The fuel distribution system set up to support these pilot study stoves would be studied for the lessons it could provide to a commercial supply chain. Components of the pilot study include:

[21] See: http://www.thegef.org/gef/whatisgef.

Baseline household cooking energy and supply

A baseline assessment to map the households cooking energy supply and demand pattern should be conducted prior to any promotion of ethanol fuel and ethanol stoves. The baseline information not only sets the benchmark against which to measure achievements of the new fuel and stove but also provides basic data about each household. This baseline will also serve as a baseline for a carbon finance program.

Feasibility assessment for ethanol use as household cooking fuel

A preliminary assessment of the cost of cooking with various fuels and stoves during the scoping study indicated that ethanol is already price-competitive with all fuels but firewood. However, a proper feasibility assessment that includes the cost of production of ethanol, the price build-up for the fuel and the stove during distribution, and comparative advantages of the fuel vis-à-vis other fuels, should be conducted. Potential ethanol fuel distribution channels should be studied and recommended. The feasibility assessment should also look into other supply options for ethanol including the use of alternative feedstocks in production and opportunities for importing ethanol to boost supply. Carbon financing should also be studied as part of the financing mechanism for wide scale adoption of the ethanol stoves.

Acceptability assessment for ethanol use as household fuel

Experience in several other African countries, including nearby Mozambique, suggests that ethanol as a household fuel will be well-accepted. However, each country has its own distinct socio-economic conditions, culture, value systems and markets that may affect how the fuel is accepted. An acceptability assessment survey should be conducted in the study households to gauge the level of interest in using ethanol for cooking, its appropriateness for use in preparing local foods, the performance of the stove and the willingness of the households to buy the fuel. It is only following this assessment that further planning for the promotion of ethanol should begin.

After successful completion of these assessments and the pilot study, promotional and awareness raising activities can begin to encourage the scale up of ethanol fuel and cookstoves in Zanzibar.

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Annex: List of persons contacted

#	Organization visited	Person Contacted	Position
1	The First Vice President's Office, Department of Environment	Mr. Sheha Mjaja Juma	Director
2	Ministry of Lands, Housing, Water and Energy	Mr. Ali Khalil Mirza	Principal Secretary
3	Ministry of Trade, Industry and Marketing	Mr. Saleh S. Hamad Mr. Hussien M. Khalid Dr. Abdulla R. Abdulla Mr. Siddik Jumma Khamis	Director Representative to the Director Expert Expert
4	The Second Vice President's Office	Mr. Abdulla Ali Abdulla	Private Secretary of the Second Vice President
5	Ministry of Finance	Mr. Juma Ameir Hafidh	Deputy Principal Secretary, Ministry of Finance
6	Zanzibar Planning Commission	Ms. Amina Kh. Shaaban	Executive Secretary
7	Zanzibar Sugar Factory	Mr. Vicky Patel	Business Development Manager, Vegpro (K) Limited, VP Corporate
8	Zanzibar Electric Corporation (ZECO)	Sales Department	