Published By Gaia Association 2014

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Holistic Feasibility Study of a National Scale-up Programme for Ethanol Cook stoves and Ethanol Micro Distilleries (EMDs) in Ethiopia

Feasibility study of EMDs: Market, Financial and Economic Analyses

December 2014

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.

This Ethanol Micro Distillery and Ethanol Cookstoves Market, Financial and Economic Feasibility Study Report 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.

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Stands for
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CRGE	Ethiopia's Climate-Resilient Green Economy
CSA	Central Statistical Authority
DFID	Department for International Development, UK
EIRR	Economic Internal Rate of Return
EMD(s)	Ethanol Micro Distillery(ies)
ENPV	Economic Net Present Value
ETB	Ethiopian Birr
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
GHG	Greenhouse gases
GTP	Growth and Transformation Plan
Ha/ha	Hectare
HH(s)	Household(s)
IPCC	Intergovernmental Panel on Climate Change
MoFED	Ministry of Finance and Economic Development
MoWIE	Ministry of Water, Irrigation and Energy
SCIP	Strategic Climate Institutions Programme

CURRENCY EQUIVALENTS

Exchange Rate Date: December 30, 2014
Currency Unit = Ethiopian Birr (ETB)
1 USD = 20.0987 ETB
1 ETB =0.0498 USD
Source: http://www.nbe.gov.et/market/dailyexchange.html

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. Owing to rapidly growing population, fuelwood and charcoal use has been growing steadily and has directly led to increased deforestation. It is estimated that between 1990 and 2000, the Country lost an average of 140,900 hectares of forest per year. With decline in biomass resource availability, households' costs of energy acquisition has steadily increased and eroded household welfare

2. 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. In order to address these limitations, Gaia Association 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); and Project Gaia Inc., has initiated the present "Holistic Feasibility Study of a National Scale-up Programme for Ethanol Cook Stoves and Ethanol Micro Distilleries (EMDs) in Ethiopia". The Project is financed by DFID's Strategic Climate Institutions Programme (SCIP).

3. The main objective of the Holistic Feasibility Study of a National Scale-up Programme for Ethanol Cook Stoves and Ethanol Micro Distilleries (EMDs) is 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.

4. This report analyses the market for ethanol production and assess the financial and economic feasibility of different scales of micro-distillery plants using various alternative feedstock scenarios including molasses, sugarcane, and a mix of other feedstock: sweet sorghum stalk, sweet potato, cactus and cassava.

5. The report is structured as follows. Section 2 analyses the market for ethanol production. It looks at various production and plant scenarios for ethanol production and estimates of demand for ethanol for cooking. This is followed by Section 3 which presents the financial analysis. This includes estimates of the financial impact of ethanol for cooking Programme on households and feasibility of ethanol micro-distilleries using different feedstock option: molasses, sugarcane, and a mix of sweet sorghum stalk, sweet potato, cactus and cassava.

6. Section 4 provides economic analysis –incorporates wider benefits including valuation of avoided energy-related deforestation and GHG emission reductions and carbon revenue opportunities. Finally, Section 5 summarizes some of the conclusions and recommendations.

2. Market Analysis

2.1. Demand Analysis

2.1.1. Household Cooking Fuels and Stoves

7. Ethiopia is endowed with diverse energy resources. These include biomass, hydropower, solar, wind, geothermal, coal and natural gas. Despite the presence of considerable energy resources, the Country has one of the least developed energy sector in the world.

8. In 2007, approximately 89% of the total final energy consumption was derived from bio-energy sources[1] (see Figure 1). Firewood and charcoal combined accounted for 74% percent and agricultural residues (dung and crop residues) for 15% percent. Petroleum and electricity play a less important role in the national energy supply system. Their share in total consumption is 11% (8% petroleum fuels and 3% electricity).

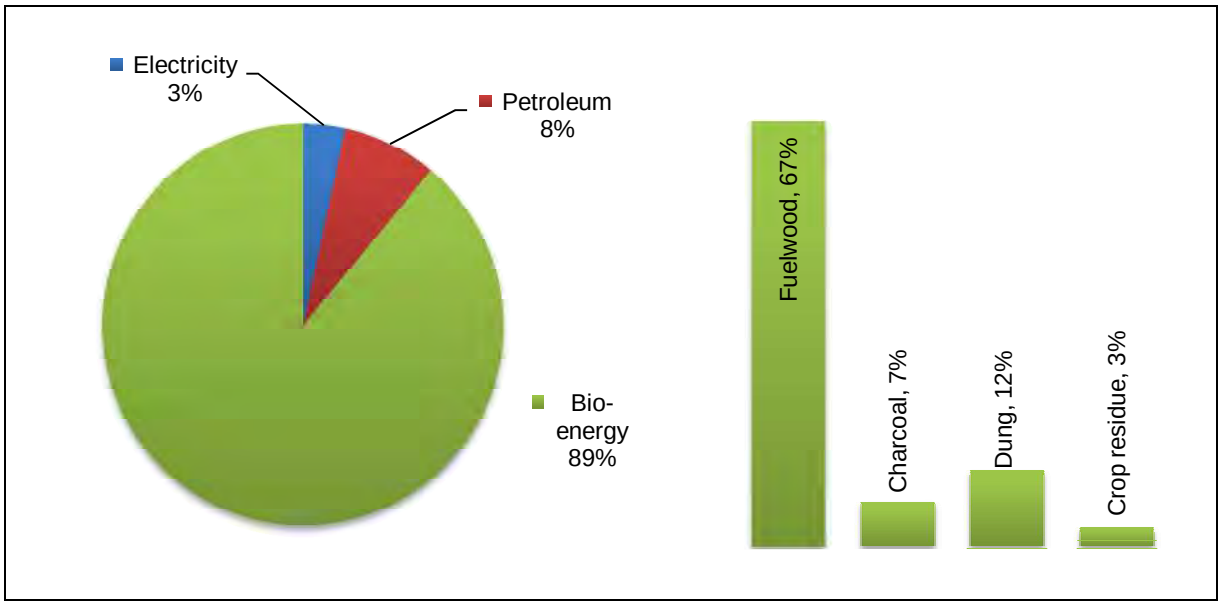

Figure 1. Energy Consumption by Fuel Type

9. According to a recent survey by the Central Statistics Agency (CSA), 96% of Ethiopian households (15.5 million households in 2011) used biomass fuels as their main sources for cooking. At country level, about 81.4 percent of the households use firewood, around 11.5 percent cook with leaves/dung cakes and only 2.4 percent use kerosene for cooking. The majority of rural households use firewood (84.4 percent) and few of them (12.7 percent) use leaves/dung cakes (see Figure 2).

[1] MoWIE (2013)

10. The use of modern source of cooking fuel such as butane gas, electricity and kerosene for cooking is uncommon in the rural areas (0.4 percent). Use of kerosene in urban areas stands at 13.8% following firewood (65.4%), charcoal (7.7%), electricity (2.4%) and leaves (5.3%) are also used rarely by urban households. On the other hand, only 0.2% of the households in rural areas are observed to use charcoal for cooking. In the previous surveys, however, no household was reported to use charcoal as source of cooking fuel.

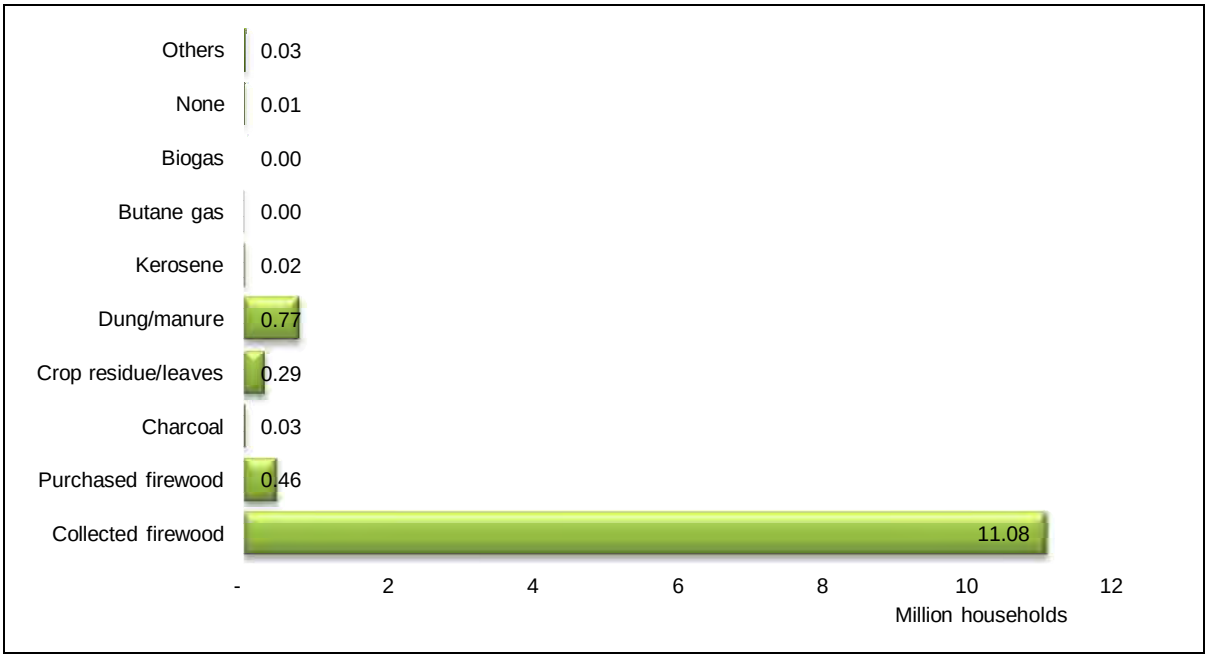

Figure 2. Distribution of Households by Cooking Fuel use in Ethiopia, 2011 (CSA, 2012)

2.1.2. Trends in Fuel Substitution

11. Cooking fuels use in the urban and rural areas change quite frequently due to changes in prices and availability of fuels. In rural areas, the percentage of households who reported firewood as their primary cooking fuel has increased from 76% in 1996 to over 90% in 2011 (see Figure 3). The increase in the number of households who use firewood is accompanied with a decline in the proportion of households who reported branches, leaves and twigs (BLT) and agricultural residues (crop residues and dung) as primary cooking fuel (from 19.1% in 1996 to 8.4% in 2011).

12. In urban areas, a significant change has taken place between 1996 and 2011 where the number of households who reported kerosene as their primary cooking fuel has declined, from 21.5% to 4.9% (see Figure 4). Households that would have used kerosene as their primary cooking fuel have switched to other fuels mainly charcoal. The proportion of households who reported charcoal as their primary fuel increased 8.3% to 17.5% during the same period. Such a shift towards a less convenient and efficient fuel suggests price may have been the main driver.

13. The key energy issues in the domestic sector are the widening gap between sustainable supply and demand for biomass fuels; adverse environmental impact of household energy use at the indoor, local and global scale; and relatively high proportion of household income spend on energy for cooking.

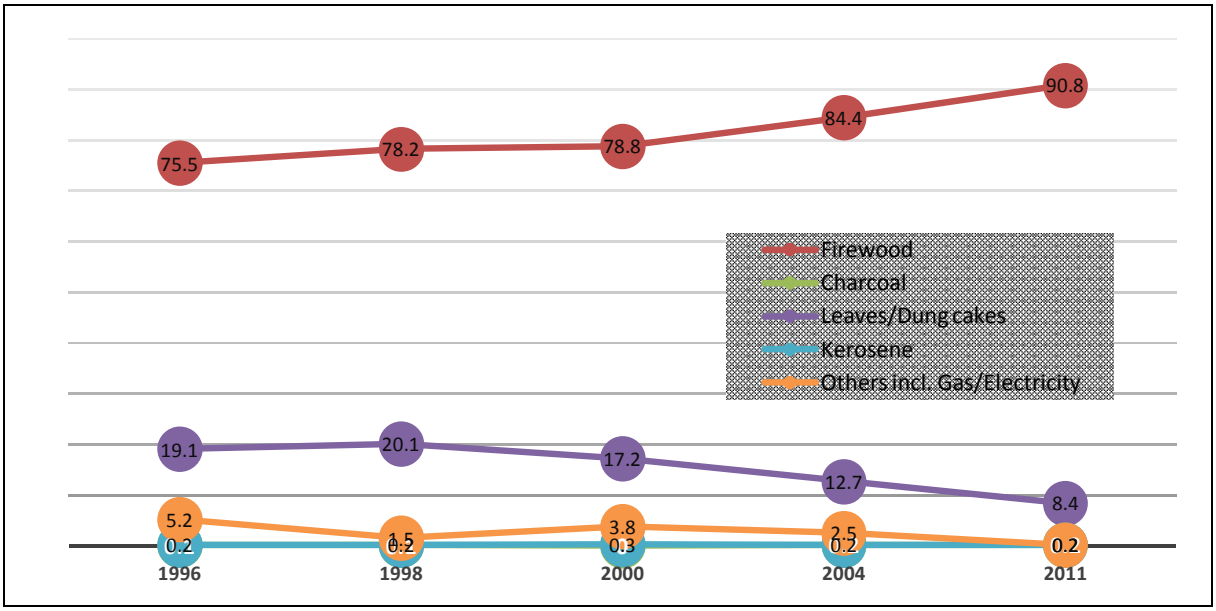

Figure 3. Distribution of RURAL Households by Main Type of Cooking Fuel (1996-2011)

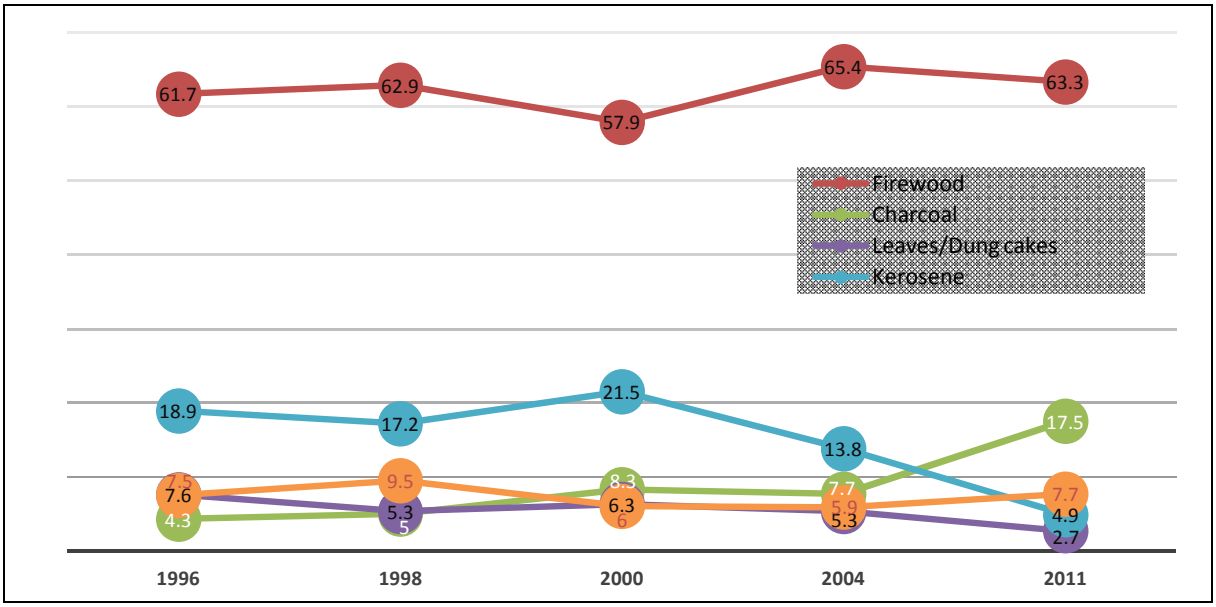

Figure 4. Distribution of URBAN Households by Main Type of Cooking Fuel (1996-2011)

2.1.3. Relative Costs of Various Types of household Cooking

14. Energy use by households is for baking (*Injera*, bread etc.) and cooking (making sauce, tea, coffee, and other type of cooking). The comparative costs are based on useful energy demand for cooking.

15. The results of the relative cooking cost analysis, summarized in Table 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). Household expenditure on charcoal and LPG will be ETB263/month and ETB 389/month, respectively.

16. 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.

Table 1. Relative Costs of Cooking on a useful energy basis (October 2014 prices Addis Ababa)

Fuel Type Fuel Unit	Firewood kg	Charcoal kg	Kerosene Litre	LPG kg	Electricity kWh	Ethanol Litre
Price of fuel ETB/unit	1	8.7	16	43.8	0.567	13.99
Energy content of fuel, MJ/unit	15	29	35.3	45.2	3.6	24
Price of stove, ETB	0	70	90	450	450	1035
Life of stove, years	0	4	5	10	10	10
Efficiency of stove, %	10	25	42	55	60	60
Useful energy, MJ/unit	1.5	7.3	14.8	24.9	2.2	14.4
Annualized capital cost, CRF@10%)	-	22.1	23.7	73.2	73.2	168.4
Fuel cost, ETB/year	1,740	3,132	2,816	4,598	685	2,535
Total Expenditure, ETB/year	1,740	3,154	2,840	4,671	758	2,704
Total Expenditure, ETB/month	145	263	237	389	63	225
Index Firewood = 1	1.00	1.81	1.63	2.68	0.43	1.55
Rank	2	5	4	6	1	3

2.1.4. Households Preferences Fuels and Stoves

17. User preferences for household fuels were investigated and from the household energy survey, it was found 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 (see Table 2).

18. The household energy survey conducted as part of this Study indicated 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.

19. 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.

Table 2. Fuel and Stove Characteristics Sought by Households

92% of Households are interested in a new cooking stove ***Properties sought in a new domestic cooking stove:***	Kerosene with wick stove	Charcoal with improved	Fuelwood on three-stone fire	LPG	Electricity - burner	Ethanol CC stove
a) Fuel cost	M	M	H	L	H	M
b) Durability	M	M	M	L	H	H
c) Cheap stove	H	H	H	M	M	L
d) Cleanness and convenience	L	L	L	H	H	H
e) Safety	L	L	L	M	H	H
f) Speed of cooking	L	L	L	H	M	H

Note: H=High, M=Medium, L=Low
Source: Household energy survey, Gaia Association (2014).

2.1.5. Demand for Ethanol for Cooking

20. 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.

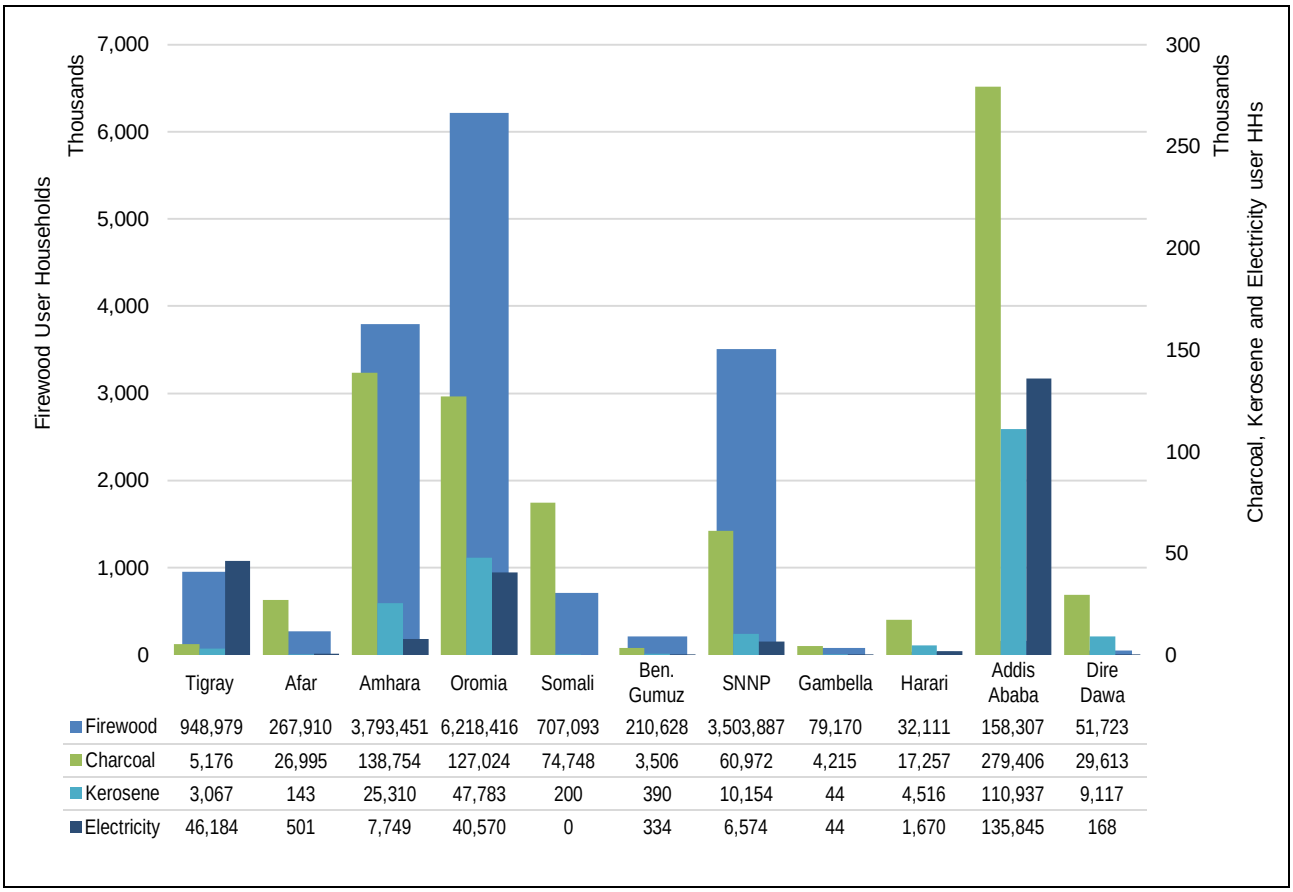

Figure 5. Estimated Number of Households by Type of Main Cooking Fuel

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

a. 100% percent of urban and rural households using kerosene will shift to ethanol. Currently an estimated 211,661 households (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 households currently using charcoal will shift to ethanol. The number of households using charcoal as a primary cooking fuel is estimated at 767,666 (urban 727,452 or 95%; and rural 40,214 or 5%) are using kerosene for cooking;

c. One-third of the urban and 50% of the rural households who purchase firewood will shift to ethanol. It is estimated that currently about 16 million households (2.8 million urban or 17% and 13.2 million rural or 83%) are using firewood as a primary cooking fuel and that 71% and 4% of urban and rural households purchase firewood, in their respective orders. Thus, 23.4% of urban and 2% of rural households are assumed to use ethanol instead of purchased firewood.

22. Based on the above assumptions, the numbers of households substituting fuelwood, charcoal and kerosene for ethanol are shown in Table 3. A total of 1.7 million households (1.4 million urban and 0.3 million rural) will shift to ethanol.

Table 3. Estimated Number of Urban and Households Shifting to Ethanol

	% of HHs Substituting Ethanol		No. of HHs Substituting Ethanol		Urban and Rural HHs Substituting Ethanol	
Fuel Substituted	Urban	Rural	Urban	Rural	Number	%
Firewood	23%	2%	633,653	263,462	897,115	52%
Charcoal	75%	50%	561,950	16,675	578,625	34%
Kerosene	100%	100%	210,598	24,650	235,248	14%
Total			1,406,201	304,787	1,710,988	100%
%			82%	18%		

23. The estimated demand for ethanol for substitution of kerosene, charcoal and firewood are presented in Table 4. The total estimated potential demand for ethanol could be as high as 300 million litres of which 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.

Table 4. Demand for Ethanol for cooking by type of fuel displaced (2014)

	Ethanol fuel (Million litres)			
Fuel Displaced	Urban	Rural	Total	%
Firewood	94.4	49.4	143.8	47%
Charcoal	68.8	0.9	69.6	23%
Kerosene	85.7	10.0	95.7	31%
Total	248.8	60.3	309.1	100%
%	80%	20%	100%	

24. 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 as summarized in Figure 6.

25. 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), envisaged increasing ethanol production from around 27 million litres in 2014 to 340 million litres in 2029 and to 350million litres in 2020. 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.

26. 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 7).

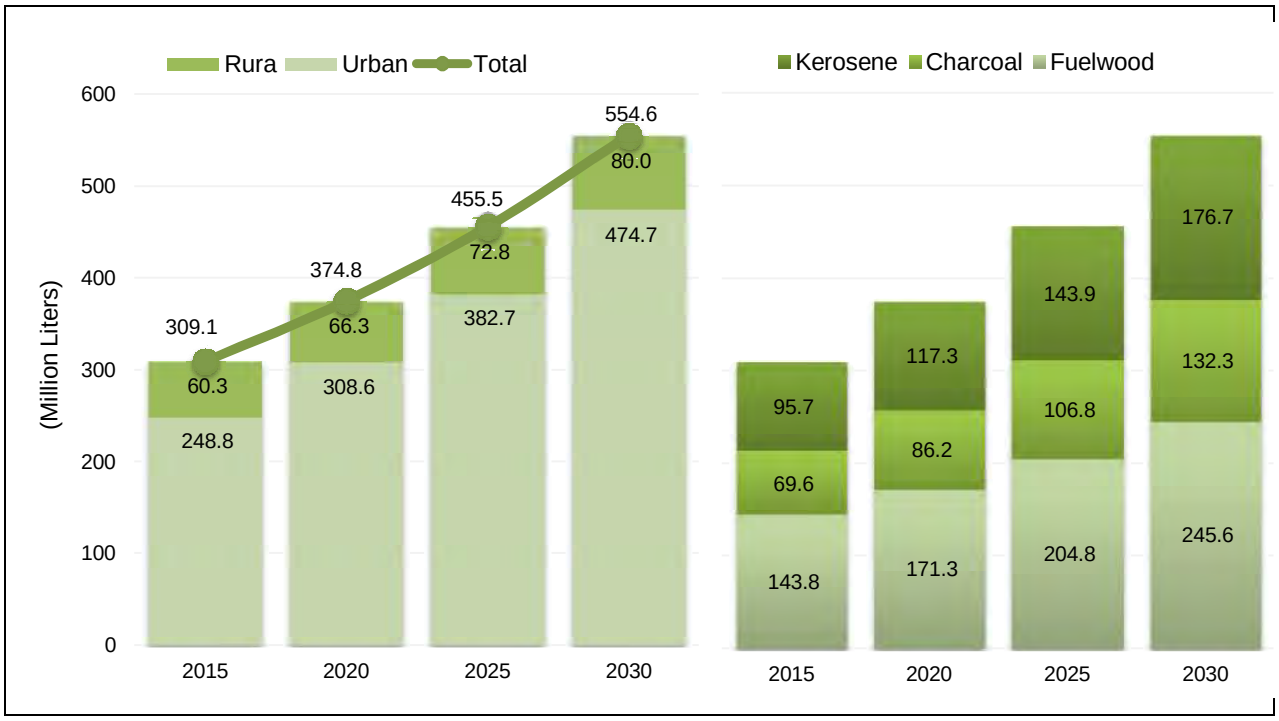

Figure 6. Demand for Ethanol for Cooking by Rural and Urban and by Types of Fuels Substituted

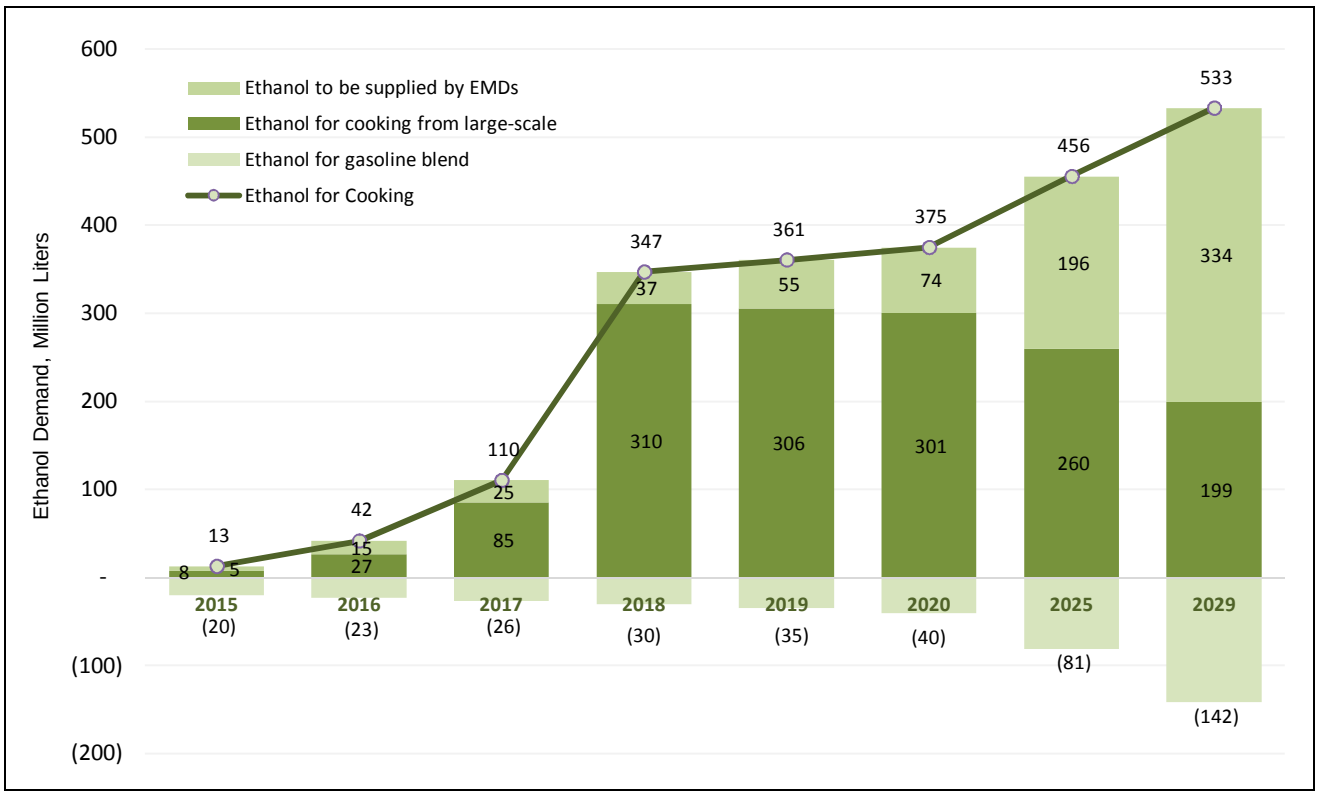

Figure 7. Projected Ethanol Demand and Supply

3. Financial Analysis

3.1. Financial Impact on Households

27. The ethanol for cooking programme will bring substantial financial benefits to ethanol user households. Based on the relative costs of cooking, discussed previously, 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.

28. 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 (see Table 5).

Table 5. Estimates of Household Expenditure Savings from Using Ethanol

	Year							
No. of Households ('000)	**1**	**2**	**3**	**4**	**5**	**6**	**10**	**15**
Urban								
Fuelwood				721.0	752.8	785.9	974.7	1,157.9
Charcoal				639.4	667.6	696.9	864.4	1,026.8
Kerosene	31.4	102.0	229.5	239.6	250.2	261.2	323.9	384.8
Total - Urban	**31.4**	**102.0**	**229.5**	**1,600.1**	**1,670.5**	**1,744.0**	**2,163.0**	**2,569.5**
Rural								
Fuelwood				278.8	284.1	289.5	318.0	342.9
Charcoal				17.6	18.0	18.3	20.1	21.7
Kerosene			25.6	26.1	26.6	27.1	29.8	32.1
Total - Rural			**25.6**	**322.5**	**328.6**	**334.9**	**367.9**	**396.7**
Urban and Rural	**31.4**	**102.0**	**255.1**	**1,922.6**	**1,999.1**	**2,078.9**	**2,530.9**	**2,966.2**
Savings, ETB million								
Urban Households								
Fuelwood								
Charcoal				287.7	300.4	313.6	389.0	462.1
Kerosene	4.3	13.9	31.2	32.6	34.0	35.5	44.1	52.3
Total - Urban	**4.3**	**13.9**	**31.2**	**320.3**	**334.4**	**349.1**	**433.0**	**514.4**
Rural Households								
Fuelwood								
Charcoal				7.9	8.1	8.2	9.1	9.8
Kerosene			3.5	3.5	3.6	3.7	4.0	4.4
Total - Rural			**3.5**	**11.5**	**11.7**	**11.9**	**13.1**	**14.1**
Total expenditure savings	4.3	13.9	34.7	331.8	346.1	361.1	446.1	528.5
NPV @10.23%, ETB Millions	**2,185**							

3.2. Financial Analysis of Ethanol Micro-distilleries

29. A Cost Benefit Analysis (CBA) approach was used for the financial analysis. The analysis is conducted based on market prices, discounting net benefits over a specific time horizon and testing financial viability indicators for sensitivities to key parameters.

30. The principal indicator applied is the net financial present value (FNPV). The FNPV is derived by subtracting the sum of the present value (PV) of a cash flow of costs from the sum of the PV of a cash flow of revenues. The difference between discounted revenues and discounted costs gives the FNPV. In order for a project to be considered financially viable, the FNPV must have a positive value as this indicates that the overall

benefits outweigh the overall costs of the project over time. Additional viability indicator provided is the financial Internal Rate of Return (FIRR). The IRR is the discount rate at which present values of both benefits and costs are equal. Projects should have FIRR greater than the discount rate to be considered viable.

31. The financial analysis of the micro-distilleries are conducted over a 15-year time horizon, both used a discount rate of 10.23%. All fixed assets will be replaced at the end of their expected economic lives based on their respective depreciation rates. A straight-line depreciation method is adopted for computing annual deprecation charges.

3.2.1. Investment Costs and Financing Sources

32. The initial investment costs for the various ethanol micro-distillery plant scenarios is summarized in Table 6. The investment cost ranges between ETB 1.7 million for the 150 litres/day distillery plant to almost ETB 30 million for the relatively larger plant (5000 litres/day). The investment cost includes plant and machinery, land lease cost, civil works, buildings and office equipment and furniture, vehicle and working capital requirements.

33. The sources of finance will be equity capital and long-term loans. It is assumed that the envisaged the projects will be capitalized by its owners in an equivalent to 30% and 70% through a long-term loan. It is further assumed that interest rate on the long-term loan would be 10.23% percent per annum and will be repaid over ten years.

Table 6. Estimated Initial Investment Costs of EMDs ETB (million)

	Production Scenarios- EMD Capacity (Litres/day)						
Item	150	800	1000	1600	2400	3200	5000
Land lease cost	0.03	0.08	0.10	0.25	0.30	0.40	0.50
Civil works, buildings, office furniture	0.38	1.00	1.25	2.50	5.25	7.00	8.75
Plant Machinery and commissioning	1.11	3.93	4.92	6.46	8.85	10.97	17.06
Vehicle and other fixed assets	-	-	-	0.75	0.75	1.50	2.25
Pre-operative expenses	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Working Capital	0.20	0.30	0.30	0.40	0.50	0.50	0.50
Total	1.72	5.32	6.58	10.37	15.66	20.38	29.07
Financing source (%):							
Equity	30%						
Loan	70%						
Interest rate	10.23%						

3.2.2. Financial Analysis Results

34. The financial analysis was conducted for alternative plant and production scenarios. The analysis considered seven ethanol micro-distillery plants, producing 150 to 5000 litres per day. Three production scenarios, outlined previously, were used for the financial analysis of ethanol micro-distilleries, as follows:

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

35. The results of the financial assessments of the various plant and production scenarios are summarized in Table 7 and Figure 8. A complete set of financial statements are provided in Annex A.

36. 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%%.

37. On the other hand, 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.

Table 7. Summary of Financial Analysis Results

Production Scenario	Project Worth	Plant Scenario EMD Capacity (litres/day)						
		150	800	1000	1600	2400	3200	5000
Scenario 1: Molasses (100%)	FNPV at 8.5%	(1.3)	1.5	2.1	5.3	9.3	13.4	23.7
	FNPV at 10.23%	(1.3)	0.8	1.2	3.7	6.7	9.9	18.2
	FNPV at 12.5%	(1.3)	0.1	0.3	2.0	4.0	6.2	12.3
	FIRR	-9.9%	12.9%	13.5%	16.2%	17.4%	18.2%	20.2%
Scenario 2: Sugarcane (100%)	FNPV at 8.5%	(2.8)	(6.6)	(8.0)	(10.7)	(14.8)	(18.9)	(26.5)
	FNPV at 10.23%	(2.7)	(6.3)	(7.7)	(10.5)	(14.6)	(18.7)	(26.3)
	FNPV at 12.5%	(2.5)	(6.0)	(7.4)	(10.2)	(14.3)	(18.3)	(25.9)
	FIRR	#NUM!	#NUM!	#NUM!	-21.2%	-15.0%	-14.6%	-12.8%
Scenario 3: Mixed Feedstock (100%)	FNPV at 8.5%	(3.2)	(8.6)	(10.5)	(14.9)	(21.0)	(27.0)	(39.5)
	FNPV at 10.23%	(3.0)	(8.1)	(9.9)	(14.2)	(20.1)	(25.9)	(37.8)
	FNPV at 12.5%	(2.7)	(7.6)	(9.3)	(13.3)	(19.0)	(24.6)	(35.8)
	FIRR	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

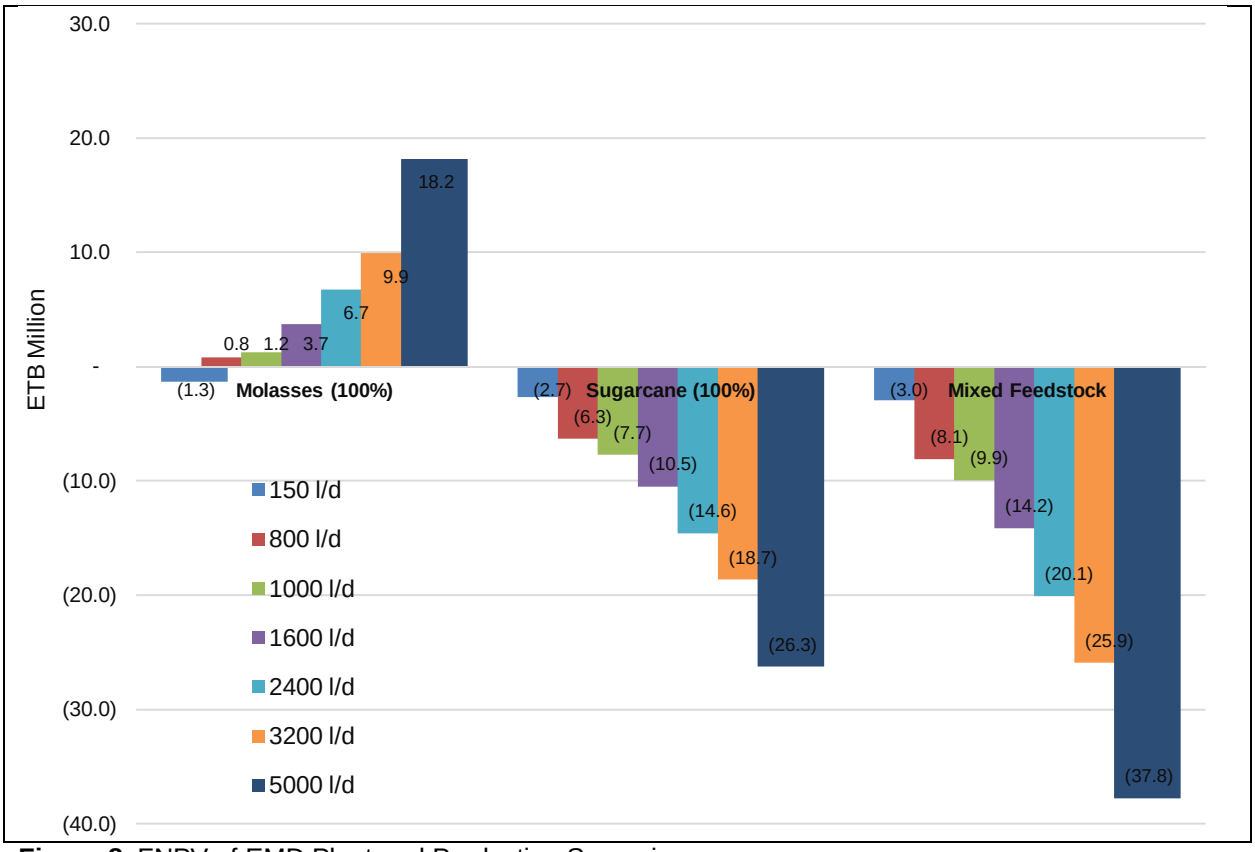

Figure 8. FNPV of EMD Plant and Production Scenarios

3.2.3. Sensitivity Analyses

38. Sensitivity analysis was done to determine the profitability of ethanol production with regard to changes in two key parameters: (a) price of ethanol and (b) purchase price of feedstock. The analysis was done by fixing the prices of feedstock and changing the price of ethanol and vice versa.

39. The 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 (see Table 8).

40. 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.

Table 8. Sensitivity of FNPV on Price of Ethanol **Million ETB**

Production Scenario	Ethanol Price Birr/litre	Plant Scenario Litres/day						
		150	800	1000	1600	2400	3200	5000
Scenario 1 – Molasses (100%)	7.56	(2.16)	(3.63)	(4.32)	(5.18)	(6.58)	(7.84)	(9.57)
	8.51	(1.88)	(2.15)	(2.47)	(2.22)	(2.14)	(1.92)	(0.32)
	9.45	(1.61)	(0.67)	(0.62)	0.75	2.30	4.00	8.93
	10.40	**(1.33)**	**0.81**	**1.24**	**3.71**	**6.74**	**9.92**	**18.19**
	11.34	(1.05)	2.29	3.09	6.67	11.18	15.84	27.44
	12.29	(0.77)	3.77	4.94	9.63	15.62	21.76	36.69
	13.23	(0.50)	5.25	6.79	12.59	20.06	27.68	45.94
	14.18	(0.22)	6.73	8.64	15.55	24.51	33.61	55.20
	15.12	0.06	8.21	10.49	18.51	28.95	39.53	64.45
Scenario 2 – Sugarcane (100%)	7.56	(3.49)	(10.75)	(13.25)	(54.04)	(27.89)	(36.42)	(54.01)
	8.51	(3.21)	(9.27)	(11.40)	(44.79)	(23.45)	(30.49)	(44.76)
	9.45	(2.93)	(7.79)	(9.55)	(35.53)	(19.01)	(24.57)	(35.50)
	10.40	**(2.66)**	**(6.31)**	**(7.70)**	**(26.28)**	**(14.57)**	**(18.65)**	**(26.25)**
	11.34	(2.38)	(4.83)	(5.85)	(17.03)	(10.13)	(12.73)	(17.00)
	12.29	(2.10)	(3.35)	(4.00)	(7.78)	(5.68)	(6.81)	(7.75)
	13.23	(1.82)	(1.87)	(2.15)	1.48	(1.24)	(0.89)	1.51
	14.18	(1.54)	(0.39)	(0.30)	10.73	3.20	5.03	10.76
	15.12	(1.27)	1.09	1.55	19.98	7.64	10.96	20.01
Scenario 3 - Mixed feedstock	7.56	(3.80)	(12.55)	(15.47)	(23.06)	(33.43)	(43.66)	(65.55)
	8.51	(3.52)	(11.07)	(13.62)	(20.10)	(28.99)	(37.74)	(56.30)
	9.45	(3.24)	(9.59)	(11.77)	(17.13)	(24.55)	(31.82)	(47.04)
	10.40	**(2.97)**	**(8.11)**	**(9.92)**	**(14.17)**	**(20.10)**	**(25.89)**	**(37.79)**
	11.34	(2.69)	(6.63)	(8.07)	(11.21)	(15.66)	(19.97)	(28.54)
	12.29	(2.41)	(5.15)	(6.22)	(8.25)	(11.22)	(14.05)	(19.29)
	13.23	(2.13)	(3.67)	(4.37)	(5.29)	(6.78)	(8.13)	(10.03)
	14.18	(1.86)	(2.19)	(2.52)	(2.33)	(2.34)	(2.21)	(0.78)
	15.12	(1.58)	(0.71)	(0.67)	0.63	2.10	3.71	8.47

41. A further analysis was conducted to determine the impact of the prices of feedstock on the financial viability of ethanol production using micro-distilleries. The prices of alternative feedstock was obtained from different sources including the Central Statistics Agency's producer and retail price surveys, market survey conducted as part of this Study, Sugar Corporation and Factories, and the Wonji Sugarcane Farmers Cooperative Society (WSFCS). The price of molasses offered by the Sugar Factory was ETB 70.00 per quintal (inclusive of 15% Value Added Tax (VAT)) and the wholesale price of sugarcane by the WSFCS to the Wonji Sugar Factory was ETB50.00 per quintal.

42. Molasses and sugarcane were assumed to be available over the full year (for 330 per year). However, the other alternative feedstock (sweet sorghum stalk, sweet potato, cactus and cassava) are not generally available over this time-frame, and therefore a mix of these is assumed to be used.

43. The sensitivity analysis was run for different feedstock price scenarios to identify the price point the various distillery plant schemes become financially viable (i.e. starts producing a positive FNPV), which is summarized in Table 9. It can be seen that the feedstock price has a significant impact on the viability of the distillery plants. For example, 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.

Table 9. Sensitivity of FNPV on Price of Feedstock Million ETB

Production Scenario	Feedstock price (ETB/kg)	EMD Plant Scenario						
		150 l/d	800 l/d	1000 l/d	1600 l/d	2400 l/d	3200 l/d	5000 l/d
Scenario 1 – Molasses (100%)	0.43	(1.11)	1.95	2.67	5.99	10.17	14.50	25.34
	0.49	(1.19)	1.57	2.19	5.23	9.03	12.97	22.95
	0.55	(1.26)	1.19	1.71	4.47	7.88	11.45	20.57
	0.61	(1.33)	0.81	1.24	3.71	6.74	9.92	18.19
	0.67	(1.40)	0.43	0.76	2.94	5.60	8.39	15.80
	0.73	(1.47)	0.05	0.28	2.18	4.45	6.87	13.42
	0.79	(1.54)	(0.33)	(0.19)	1.42	3.31	5.34	11.04
Scenario 2 – Sugarcane (100%)	0.35	(2.04)	(3.02)	(3.59)	(5.72)	(5.72)	(5.50)	(5.70)
	0.40	(2.24)	(4.12)	(4.96)	(12.58)	(12.58)	(9.88)	(12.55)
	0.45	(2.45)	(5.22)	(6.33)	(19.43)	(19.43)	(14.27)	(19.40)
	0.50	(2.66)	(6.31)	(7.70)	(26.28)	(26.28)	(18.65)	(26.25)
	0.55	(2.86)	(7.41)	(9.07)	(33.13)	(33.13)	(23.04)	(33.10)
	0.60	(3.07)	(8.50)	(10.44)	(39.99)	(39.99)	(27.42)	(39.96)
	0.65	(3.27)	(9.60)	(11.81)	(46.84)	(46.84)	(31.81)	(46.81)
Scenario 3 - Mixed feedstock	6.65	(2.13)	(3.65)	(4.34)	(5.25)	(6.72)	(8.05)	(9.91)
	7.60	(2.41)	(5.13)	(6.20)	(8.23)	(11.18)	(14.00)	(19.20)
	8.55	(2.69)	(6.62)	(8.06)	(11.20)	(15.64)	(19.95)	(28.50)
	9.50	(2.97)	(8.11)	(9.92)	(14.17)	(20.10)	(25.89)	(37.79)
	10.44	(3.25)	(9.59)	(11.78)	(17.15)	(24.57)	(31.84)	(47.09)
	11.39	(3.52)	(11.08)	(13.64)	(20.12)	(29.03)	(37.79)	(56.38)
	12.34	(3.80)	(12.57)	(15.49)	(23.10)	(33.49)	(43.74)	(65.67)

4. Economic Analysis

4.1. Assumptions and Scope of the Economic Analysis

44. 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.

45. 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 CO_2 emissions reductions and estimated carbon revenue. Other economic impacts are foreign exchange saving due to displacing imported kerosene as well as jobs created.

46. The financial/market prices are converted into economic values, using the following conversion factors[2]:

Construction	0.623
Imported machinery	0.92
Skilled labour	0.76
Unskilled Labour Formal	0.31
Social Discount Rate:	10.23%

4.2. Results of the Economic Analysis

4.2.1. Valuation of Avoided Deforestation

47. 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.

48. 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/ha[3]. Assuming that fuelwood and charcoal are derived from non-sustainable forests, the avoided deforestation over the 15 year period will be 441 thousand hectares.

[2] MoFED (2008).
[3] FAO (2000).

49. The economic value of the avoided deforestation, summarized in Table 10, is estimated based on avoided tonnes of CO_2 equivalent calculated based on carbon density of 18 tonne/ha multiplied by 3.67 to convert to tonnes of CO_2 equivalent. It is estimated that over 15-years, about 29 million tCO_2e will be avoided. Based on an average price of ETB100/tCO_2e (US$5/ tCO_2e), the economic benefit at a discount rate of 10.23% will be ETB 1,168 million.

Table 10. Estimated Value of Avoided Deforestation

	Year							
	1	2	3	4	5	6	10	15
1. Wood substituted with ethanol								
Fuelwood, '000 tonnes	-	-	-	1,533	1,588	1,645	1,897	2,273
Charcoal, '000 tonnes	-	-	-	157	164	171	203	252
Charcoal FW Equivalent, '000 tonnes [a]	-	-	-	684	713	745	884	1,095
Total, thousand tonnes	-	-	-	2,216	2,301	2,389	2,780	3,368
2. Avoided Deforestation, '000 ha [b]	-	-	-	30	31	32	37	45
3. tCO2e, million [c]	-	-	-	1.95	2.03	2.10	2.45	2.97
4. Value of Avoided deforestation, ETB Million [d]	-	-	-	195	203	210	245	297
5. PV (@ 10.23%), ETB Million	1,168							

Notes:

[a] Based on wood to charcoal conversion efficiency of 23%

[b] Based on fuelwood yield of 75/tonnes/ha

[c] Based on estimated carbon density of 18 tonne/ha multiplied by 3.67 to convert to tonnes of CO2 equivalent

[d] Based on ETB 100 (orUSD5) per tCO2e

4.2.2. GHG Emission Reduction and Carbon Revenue

50. With respect to greenhouse gas emissions, over a period of 15 years, 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.

Table 11. GHG Emission Reduction and Carbon Revenue

	Year							
	1	2	3	4	5	6	10	15
Emission reduction:								
Fuelwood, '000 tCO_2e				2,479	2,567	2,660	3,179	3,675
Charcoal, '000 tCO_2e				1,551	1,619	1,689	2,093	2,484
Kerosene, '000 tCO_2e	232	242	252	262	273	285	349	412
Total reduction, '000 tCO_2e	232	242	252	4,292	4,459	4,634	5,621	6,571
Carbon revenue,'000 US$ #	1,162	1,210	1,260	21,460	22,297	23,169	28,106	32,854
Transaction Costs, '000 US$								
Baseline determination & monitoring plan	40							
Validation	20							
Due Diligence	120							
Annual certification	20	20	20	20	20	20	20	20
Transaction Costs, '000 US$	200	20	20	20	20	20	20	20
Net Carbon Revenue, '000 US$	962	1,190	1,240	21,440	22,277	23,149	28,086	32,834
PV of Net Revenue, US$ million @	**131.5**							

Notes:
* At US$0.65 per litre of kerosene
@ The Present values are at discount rate of 10.23%
# Carbon sales revenue is based on US$5/ tCO_2e

4.2.3. Economic Viability of Micro –Distilleries

51. Table 12 presents the range of 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 described previously The ENPVs incorporate the avoided deforestation valued in terms of avoided tCO_2e emissions as well as GHG emission reduction (see Figure 9).

Table 12. 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%

52. 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.

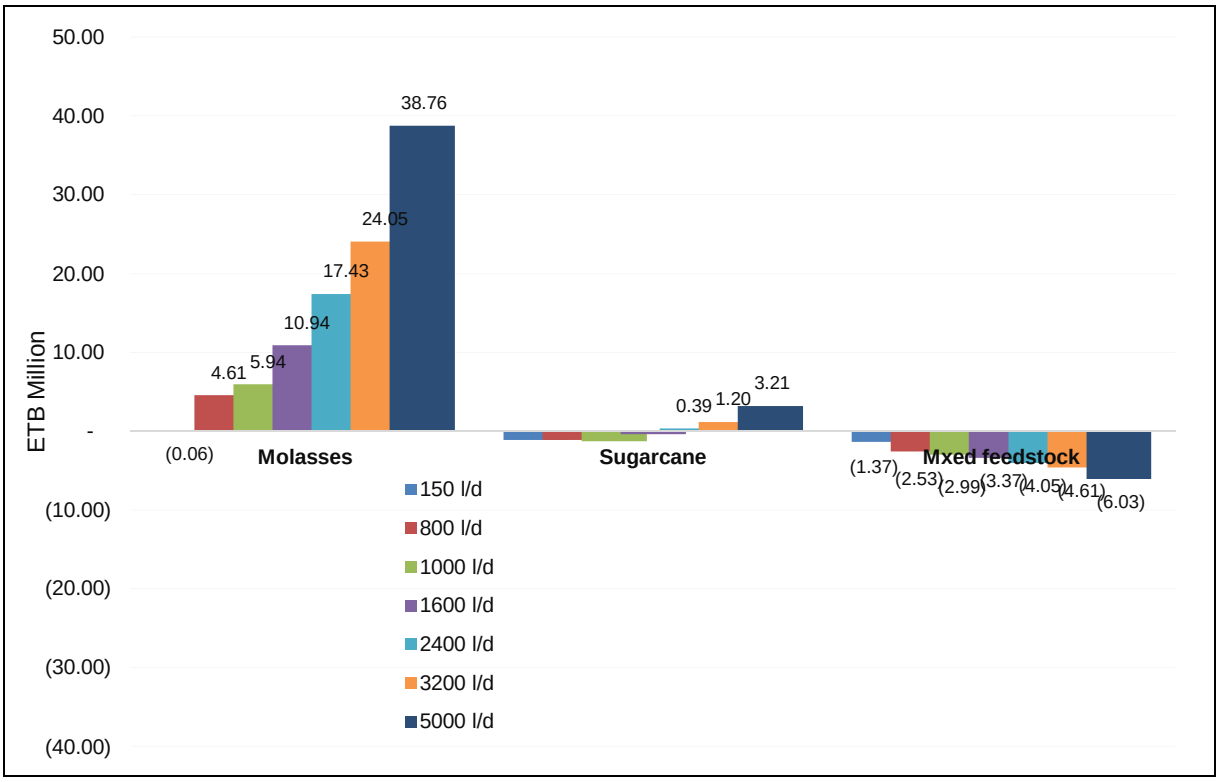

Figure 9. ENPV of EMD Plant and Production Scenarios

53. 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.

54. 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.

4.2.4. Sensitivity Analysis

55. As is the case with the financial analysis, sensitivity analysis was done to determine the economic viability of ethanol micro-distilleries with regard to changes in ethanol and feedstock prices. The analysis was done by fixing the prices of feedstock and changing the price of ethanol and vice versa.

56. The sensitivity analyses indicate that the economic viability of the distillery plant and production scenarios are highly sensitive to changes in the prices of ethanol. A range of factory gate prices were analysed from the ETB 7.56/litre and $15.12/litre (Figure 10).

57. 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.

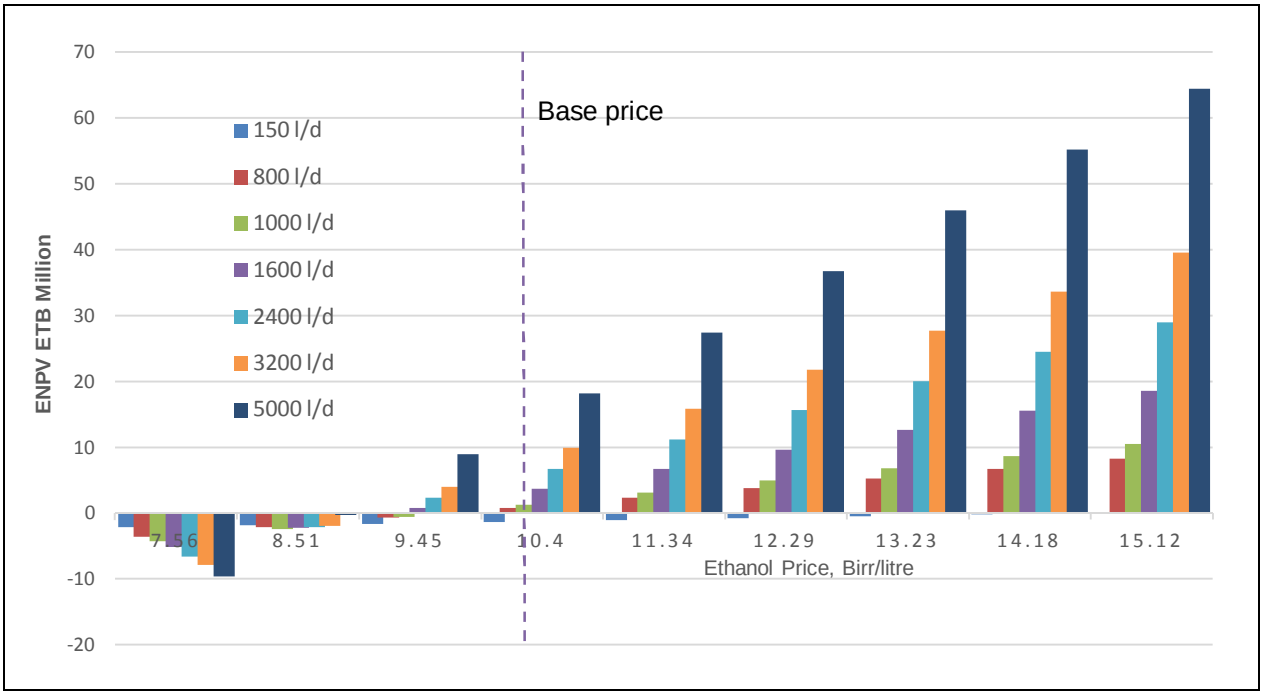

Figure 10. Sensitivity of ENPV Molassess micro-distilleries to Ethanol Prices

58. On the other hand, 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. Similarly, 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.

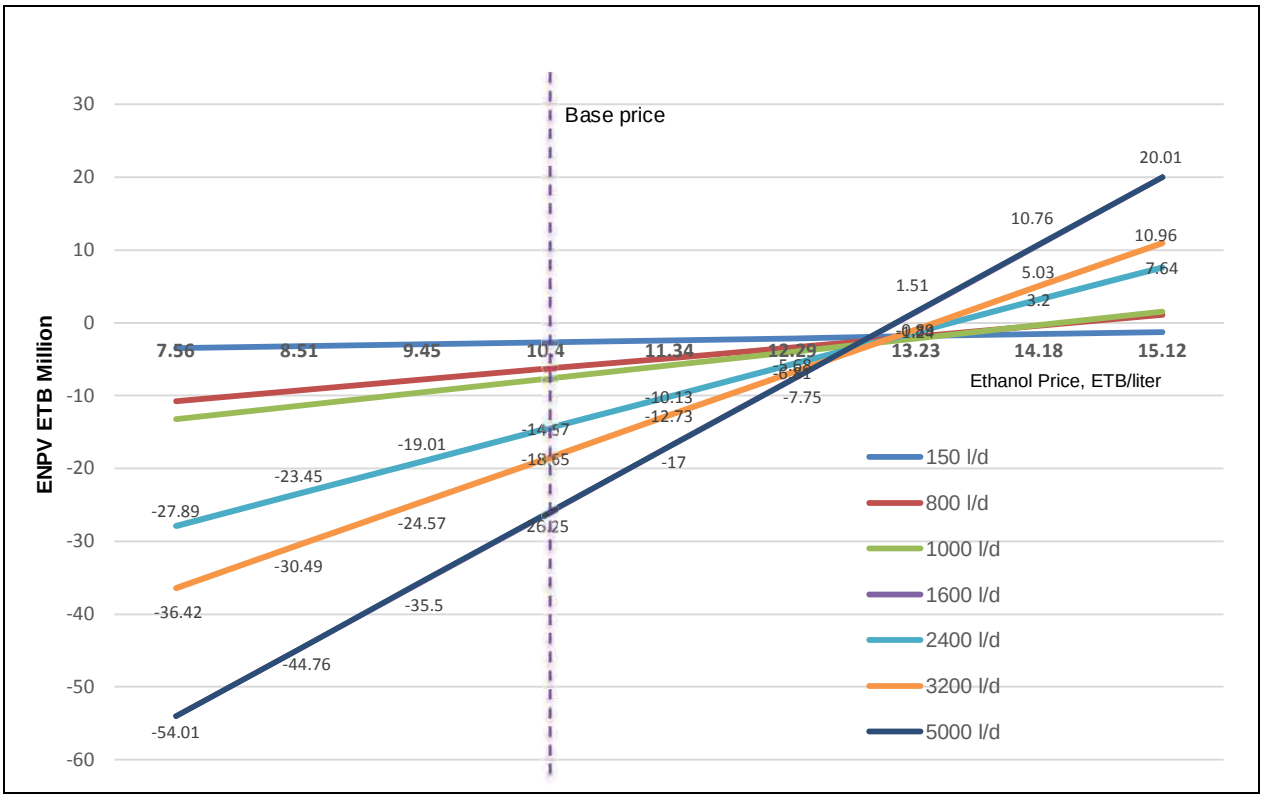

Figure 11. Sensitivity of ENPV Sugarcane Micro Distilleries to Ethanol Prices

4.2.5. Foreign Exchange Savings

59. 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.

60. The present value of the foreign exchange saving on kerosene import (net of foreign exchange requirements for the importation of ethanol micro-distilleries machinery and equipment and vehicles and at a discount rate of 10.23% will be US$ 440 million (see Table 13).

Table 13. Impact on Foreign Exchange from Kerosene Import Substitution

	Year							
	1	2	3	4	5	6	10	15
Kerosene Import Substitution								
Kerosene displaced in million litres	12.4	40.3	100.8	105.0	109.4	113.9	139.8	164.7
Ethanol required in million litres	12.8	41.5	103.8	108.1	112.6	117.3	143.9	169.6
Foreign exchange saved, US$ million *	8.1	26.2	65.5	68.2	71.1	74.0	90.8	107.1
Foreign exchange requirement for ethanol plant, US$ million	6.2	13.8	30.0	2.1	2.2	2.3	2.8	3.3
Net Foreign Exch. Saving , US$ million	1.9	12.4	35.5	66.2	68.9	71.8	88.1	103.8
PV of Net saving in million US$	**440.0**							

Notes:
* At US$0.65 per litre of kerosene

4.2.6. Impact on Employment Creation

61. 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 (see Table 14). This is estimated by multiplying the number of EMDs by 17 people per plant.

62. 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.

Table 14. Employment Generation Potential of EMDs

		Year								
		1	2	3	4	5	6	7	10	15
1.	Ethanol to be supply by EMDs, Cumulative million Litres	5	15	25	37	55	74	95	196	334
2.	EMDs plants of 1000 litres/day capacity required to meet the projected supply, Number	15	45	76	111	166	225	288	593	1,012
3.	EMD plants added each year, Number	15	30	30	35	55	59	63	85	118
4.	Jobs created each year, Number	258	515	515	597	939	1,004	1,075	1,445	2,013
5.	Jobs created, Cumulative Number	258	773	1,288	1,885	2,824	3,828	4,903	10,080	17,201

5. Conclusions and Recommendations

5.1. Conclusions

a) Although the dominant current consumption of ethanol in Ethiopia is for transport as gasoline-blend, the experiences over the last ten years has shown demonstrated that there is strong acceptance of ethanol as a sustainable cooking fuel. 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.

b) 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.

c) 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. Changes with regard to the prices of feedstock have a strong effect on the viability of ethanol production using micro-distilleries. On the other hand, ethanol production using mixed feedstock is not financially viable. Even with an increase of 150% of the price of ethanol, the FNPVs of the distillery plants using mixed feedstock will still be negative.

d) The sensitivity analysis demonstrates that 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.

e) Ethanol for cooking programme in Ethiopia offers substantial economic benefits. The economic analysis demonstrates an ethanol for cooking programme will bring significant benefits. There will be a positive impact on household's income resulting from expenditure saving on cooking energy. The programme will have a positive impact on forest cover. By substituting 33 million tonnes of fuelwood equivalent, the ethanol for cooking Programme will allow saving 441 thousand hectares from deforestation. With respect to greenhouse gas emissions, over a period of 15 years, 65 million tCO_2e will be avoided, with the potential to generate more than US$130 million at market price of US$5/$tCO_2e$ and a discount rate of 10.23%.

5.2. Recommendations

63. Based on the findings of the present study, it is recommended that:

a) National Ethanol Programme - the Government needs 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. Uncertainty about long-term availability of ethanol in large volumes has also inhibited potential new entrants (such as petroleum companies) from entering the market. Supply uncertainties have seriously undermined the market development. In initial stages, the Government need to prioritise sufficient ethanol fuel for cooking in order to ensure sustained supply of ethanol for cooking;

d) Rationalize ethanol pricing relative to alternatives: the Government should rationalize its ethanol pricing based on the economic, social and environmental valuation of all benefits and costs of using ethanol and alternative cooking fuels. Also, differential pricing of ethanol fuel for gasoline-blend and for cooking are under implementation.

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. 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.

g) Comprehensive consumer information and marketing campaigns. The public is not aware of the existence of ethanol as a potential alternative cooking fuel. Very few households in Addis Ababa use ethanol for cooking. The Government should support the private sector in public awareness campaigns.

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Projected Financial Statements

EMD Capacity	150 Liters/day							
Feedstock	Molasses (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		360,270	386,003	437,470	437,470	463,204	488,937	488,937
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		360,270	386,003	437,470	437,470	463,204	488,937	488,937
Investment								
Land lease	25,000							
Civil works, buildings, Office Furniture	375,000							
Plant Machinery and commissioning	1,111,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			55,319	50,739	45,690	40,124		
Repayment of Long-term Loan			44,777	49,357	54,406	59,972		
Expenses								
Labor								
Skilled labor		89,692	89,692	89,692	89,692	89,692	89,692	89,692
Unskilled labor		53,548	53,548	53,548	53,548	53,548	53,548	53,548
Feedstock cost								
Molasses		84,365	90,391	102,443	102,443	108,470	114,496	114,496
Sugar cane								
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		84,365	90,391	102,443	102,443	108,470	114,496	114,496
Chemicals		29,094	31,173	35,329	35,329	37,407	39,485	39,485
Power		4,920	5,272	5,975	5,975	6,326	6,678	6,678
Water		12,994	13,922	15,778	15,778	16,706	17,634	17,634
Packaging		866	928	1,052	1,052	1,114	1,176	1,176
Repair and Maintenance		11,112	11,112	11,112	11,112	11,112	22,224	44,448
General and Admin Expenses		48,180	48,180	48,180	48,180	48,180	48,180	48,180
Total cost	1,521,191	334,772	444,313	463,205	463,205	472,650	393,112	415,336
Net benefits	(1,521,191)	25,498	(58,310)	(25,734)	(25,734)	(9,447)	95,825	73,602

Project Worth

NPV at 8.5%	Birr	(1,327,970)
NPV at 10.23%	Birr	(1,328,988)
NPV at 12.5%	Birr	(1,323,491)
IRR on Equity		-9.9%

EMD Capacity	800 Liters/day							
Feedstock	Molasses (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		1,921,438	2,058,683	2,333,175	2,333,175	2,470,420	2,607,666	2,607,666
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		1,921,438	2,058,683	2,333,175	2,333,175	2,470,420	2,607,666	2,607,666
Investment								
Land lease	75,000							
Civil works, buildings, Office Furniture	1,000,000							
Plant Machinery and commissioning	3,931,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			170,864	156,715	141,120	123,929		
Repayment of Long-term Loan			138,300	152,448	168,044	185,235		
Expenses								
Labor								
Skilled labor		222,440	222,440	222,440	222,440	222,440	222,440	222,440
Unskilled labor		112,560	112,560	112,560	112,560	112,560	112,560	112,560
Feedstock cost								
Molasses		449,948	482,087	546,365	546,365	578,504	610,643	610,643
Sugar cane								
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		449,948	482,087	546,365	546,365	578,504	610,643	610,643
Chemicals		155,170	166,253	188,420	188,420	199,504	210,588	210,588
Power		26,242	28,116	31,865	31,865	33,739	35,614	35,614
Water		69,300	74,250	84,150	84,150	89,100	94,050	94,050
Packaging		4,620	4,950	5,610	5,610	5,940	6,270	6,270
Repair and Maintenance		39,312	39,312	39,312	39,312	39,312	78,624	157,248
General and Admin Expenses		119,880	119,880	119,880	119,880	119,880	119,880	119,880
Total cost	5,016,191	1,199,471	1,559,012	1,659,766	1,659,766	1,710,143	1,490,668	1,569,292
Net benefits	(5,016,191)	721,967	499,672	673,409	673,409	760,277	1,116,997	1,038,374

Project Worth

NPV at 8.5%	Birr	1,477,210
NPV at 10.23%	Birr	809,779
NPV at 12.5%	Birr	109,053
IRR on Equity	12.9%	

EMD Capacity	1,000 Liters/day							
Feedstock	Molasses (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		2,401,797	2,573,354	2,916,468	2,916,468	3,088,025	3,259,582	3,259,582
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		2,401,797	2,573,354	2,916,468	2,916,468	3,088,025	3,259,582	3,259,582
Investment								
Land lease	100,000							
Civil works, buildings, Office Furniture	1,250,000							
Plant Machinery and commissioning	4,916,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			211,360	193,859	174,567	153,302		
Repayment of Long-term Loan			171,079	188,580	207,872	229,137		
Expenses								
Labor								
Skilled labor		248,683	248,683	248,683	248,683	248,683	248,683	248,683
Unskilled labor		144,397	144,397	144,397	144,397	144,397	144,397	144,397
Feedstock cost								
Molasses		562,435	602,609	682,957	682,957	723,130	763,304	763,304
Sugar cane								
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		562,435	602,609	682,957	682,957	723,130	763,304	763,304
Chemicals		193,962	207,817	235,526	235,526	249,380	263,234	263,234
Power		32,802	35,145	39,831	39,831	42,174	44,517	44,517
Water		86,625	92,813	105,188	105,188	111,375	117,563	117,563
Packaging		5,775	6,188	7,013	7,013	7,425	7,838	7,838
Repair and Maintenance		49,162	49,162	49,162	49,162	49,162	98,324	196,648
General and Admin Expenses		144,505	144,505	144,505	144,505	144,505	144,505	144,505
Total cost	6,276,191	1,468,346	1,913,756	2,039,699	2,039,699	2,102,670	1,832,364	1,930,688
Net benefits	(6,276,191)	933,452	659,598	876,769	876,769	985,355	1,427,218	1,328,894

Project Worth

NPV at 8.5%	Birr	2,097,312
NPV at 10.23%	Birr	1,235,255
NPV at 12.5%	Birr	329,144
IRR on Equity		13.5%

EMD Capacity	1,600 Liters/day							
Feedstock	Molasses (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		3,842,876	4,117,367	4,666,349	4,666,349	4,940,840	5,215,331	5,215,331
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		3,842,876	4,117,367	4,666,349	4,666,349	4,940,840	5,215,331	5,215,331
Investment								
Land lease	250,000							
Civil works, buildings, Office Furniture	2,500,000							
Plant Machinery and commissioning	6,461,191							
Vehicle and other fixed assets	750,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			333,332	305,731	275,307	241,770		
Repayment of Long-term Loan			269,805	297,407	327,831	361,368		
Expenses								
Labor								
Skilled labor		288,223	288,223	288,223	288,223	288,223	288,223	288,223
Unskilled labor		176,137	176,137	176,137	176,137	176,137	176,137	176,137
Feedstock cost								
Molasses		899,896	964,174	1,092,730	1,092,730	1,157,009	1,221,287	1,221,287
Sugar cane								
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		899,896	964,174	1,092,730	1,092,730	1,157,009	1,221,287	1,221,287
Chemicals		310,340	332,507	376,841	376,841	399,008	421,175	421,175
Power		52,483	56,232	63,730	63,730	67,478	71,227	71,227
Water		138,600	148,500	168,300	168,300	178,200	188,100	188,100
Packaging		9,240	9,900	11,220	11,220	11,880	12,540	12,540
Repair and Maintenance		64,612	64,612	64,612	64,612	64,612	129,224	258,448
General and Admin Expenses		183,130	183,130	183,130	183,130	183,130	183,130	183,130
Total cost	9,971,191	2,122,660	2,826,552	3,028,061	3,028,061	3,128,815	2,691,043	2,820,267
Net benefits	(9,971,191)	1,720,216	1,290,815	1,638,289	1,638,289	1,812,026	2,524,289	2,395,065

Project Worth

NPV at 8.5%	Birr	5,299,517
NPV at 10.23%	Birr	3,706,533
NPV at 12.5%	Birr	2,025,601
IRR on Equity	16.2%	

EMD Capacity	2,400 Liters/day							
Feedstock	Molasses (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		5,764,314	6,176,050	6,999,524	6,999,524	7,411,261	7,822,997	7,822,997
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		5,764,314	6,176,050	6,999,524	6,999,524	7,411,261	7,822,997	7,822,997
Investment								
Land lease	300,000							
Civil works, buildings, Office Furniture	5,250,000							
Plant Machinery and commissioning	8,851,191							
Vehicle and other fixed assets	750,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			503,354	461,675	415,731	365,088		
Repayment of Long-term Loan			407,424	449,104	495,047	545,690		
Expenses								
Labor								
Skilled labor		331,754	331,754	331,754	331,754	331,754	331,754	331,754
Unskilled labor		207,846	207,846	207,846	207,846	207,846	207,846	207,846
Feedstock cost								
Molasses		1,349,843	1,446,261	1,639,096	1,639,096	1,735,513	1,831,930	1,831,930
Sugar cane								
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		1,349,843	1,446,261	1,639,096	1,639,096	1,735,513	1,831,930	1,831,930
Chemicals		465,509	498,760	565,261	565,261	598,512	631,763	631,763
Power		78,725	84,348	95,594	95,594	101,218	106,841	106,841
Water		207,900	222,750	252,450	252,450	267,300	282,150	282,150
Packaging		13,860	14,850	16,830	16,830	17,820	18,810	18,810
Repair and Maintenance		88,512	88,512	88,512	88,512	88,512	177,024	354,048
General and Admin Expenses		242,880	242,880	242,880	242,880	242,880	242,880	242,880
Total cost	15,161,191	2,986,829	4,048,739	4,351,002	4,351,002	4,502,133	3,830,998	4,008,021
Net benefits	(15,161,191)	2,777,484	2,127,311	2,648,522	2,648,522	2,909,128	3,992,000	3,814,976

Project Worth

NPV at 8.5%	Birr	9,301,617
NPV at 10.23%	Birr	6,740,912
NPV at 12.5%	Birr	4,035,071
IRR on Equity	17.4%	

EMD Capacity	3,200 Liters/day							
Feedstock	Molasses (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		7,685,752	8,234,734	9,332,698	9,332,698	9,881,681	10,430,663	10,430,663
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		7,685,752	8,234,734	9,332,698	9,332,698	9,881,681	10,430,663	10,430,663
Investment								
Land lease	400,000							
Civil works, buildings, Office Furniture	7,000,000							
Plant Machinery and commissioning	10,973,191							
Vehicle and other fixed assets	1,500,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			655,120	600,874	541,078	475,166		
Repayment of Long-term Loan			530,267	584,513	644,309	710,221		
Expenses								
Labor								
Skilled labor		385,599	385,599	385,599	385,599	385,599	385,599	385,599
Unskilled labor		303,161	303,161	303,161	303,161	303,161	303,161	303,161
Feedstock cost								
Molasses		1,799,791	1,928,348	2,185,461	2,185,461	2,314,017	2,442,574	2,442,574
Sugar cane								
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		1,799,791	1,928,348	2,185,461	2,185,461	2,314,017	2,442,574	2,442,574
Chemicals		620,679	665,013	753,682	753,682	798,016	842,350	842,350
Power		104,966	112,464	127,459	127,459	134,957	142,454	142,454
Water		277,200	297,000	336,600	336,600	356,400	376,200	376,200
Packaging		18,480	19,800	22,440	22,440	23,760	25,080	25,080
Repair and Maintenance		109,732	109,732	109,732	109,732	109,732	219,464	438,928
General and Admin Expenses		295,930	295,930	295,930	295,930	295,930	295,930	295,930
Total cost	19,883,191	3,915,539	5,302,434	5,705,451	5,705,451	5,906,959	5,032,812	5,252,276
Net benefits	(19,883,191)	3,770,213	2,932,300	3,627,248	3,627,248	3,974,722	5,397,851	5,178,387

Project Worth

NPV at 8.5%	Birr	13,418,705
NPV at 10.23%	Birr	9,920,140
NPV at 12.5%	Birr	6,219,981
IRR on Equity	18.2%	

EMD Capacity	5,000 Liters/day							
Feedstock	Molasses (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		12,008,987	12,866,772	14,582,341	14,582,341	15,440,126	16,297,911	16,297,911
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		12,008,987	12,866,772	14,582,341	14,582,341	15,440,126	16,297,911	16,297,911
Investment								
Land lease	500,000							
Civil works, buildings, Office Furniture	8,750,000							
Plant Machinery and commissioning	17,059,941							
Vehicle and other fixed assets	2,250,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			934,315	856,950	771,671	677,668		
Repayment of Long-term Loan			756,252	833,616	918,895	1,012,898		
Expenses								
Labor								
Skilled labor		656,295	656,295	656,295	656,295	656,295	656,295	656,295
Unskilled labor		477,305	477,305	477,305	477,305	477,305	477,305	477,305
Feedstock cost								
Molasses		2,812,174	3,013,043	3,414,783	3,414,783	3,615,652	3,816,522	3,816,522
Sugar cane								
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		2,812,174	3,013,043	3,414,783	3,414,783	3,615,652	3,816,522	3,816,522
Chemicals		969,811	1,039,084	1,177,628	1,177,628	1,246,900	1,316,172	1,316,172
Power		164,010	175,725	199,155	199,155	210,870	222,585	222,585
Water		433,125	464,063	525,938	525,938	556,875	587,813	587,813
Packaging		28,875	30,938	35,063	35,063	37,125	39,188	39,188
Repair and Maintenance		170,599	170,599	170,599	170,599	170,599	341,199	682,398
General and Admin Expenses		448,099	448,099	448,099	448,099	448,099	448,099	448,099
Total cost	28,569,941	6,160,293	8,165,716	8,795,430	8,795,430	9,110,286	7,905,177	8,246,375
Net benefits	(28,569,941)	5,848,694	4,701,056	5,786,912	5,786,912	6,329,840	8,392,734	8,051,536

Project Worth

NPV at 8.5%	Birr	23,725,441
NPV at 10.23%	Birr	18,186,885
NPV at 12.5%	Birr	12,316,948
IRR on Equity	20.2%	

EMD Capacity	150 Liters/day							
Feedstock	Sugarcane (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		360,270	386,003	437,470	437,470	463,204	488,937	488,937
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		360,270	386,003	437,470	437,470	463,204	488,937	488,937
Investment								
Land lease	25,000							
Civil works, buildings, Office Furniture	375,000							
Plant Machinery and commissioning	1,111,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			55,319	50,739	45,690	40,124		
Repayment of Long-term Loan			44,777	49,357	54,406	59,972		
Expenses								
Labor								
Skilled labor		89,692	89,692	89,692	89,692	89,692	89,692	89,692
Unskilled labor		53,548	53,548	53,548	53,548	53,548	53,548	53,548
Feedstock cost								
Molasses								
Sugar cane		242,550	259,875	294,525	294,525	311,850	329,175	329,175
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		242,550	259,875	294,525	294,525	311,850	329,175	329,175
Chemicals		29,094	31,173	35,329	35,329	37,407	39,485	39,485
Power		4,920	5,272	5,975	5,975	6,326	6,678	6,678
Water		12,994	13,922	15,778	15,778	16,706	17,634	17,634
Packaging		866	928	1,052	1,052	1,114	1,176	1,176
Repair and Maintenance		11,112	11,112	11,112	11,112	11,112	22,224	33,336
Other production cost		58,987	62,406	69,245	69,245	72,665	87,197	98,308
General and Admin Expenses		48,180	48,180	48,180	48,180	48,180	48,180	48,180
Total cost	1,521,191	492,956	613,797	655,286	655,286	676,031	607,791	618,903
Net benefit	(1,521,191)	(132,687)	(227,794)	(217,816)	(217,816)	(212,827)	(118,854)	(129,966)

Project Worth

NPV at 8.5%	Birr	(2,825,189)
NPV at 10.23%	Birr	(2,655,282)
NPV at 12.5%	Birr	(2,464,835)
IRR on Equity	#NUM!	

EMD Capacity	800 Liters/day							
Feedstock	Sugarcane (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		1,921,438	2,058,683	2,333,175	2,333,175	2,470,420	2,607,666	2,607,666
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		1,921,438	2,058,683	2,333,175	2,333,175	2,470,420	2,607,666	2,607,666
Investment								
Land lease	75,000							
Civil works, buildings, Office Furniture	1,000,000							
Plant Machinery and commissioning	3,931,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			170,864	156,715	141,120	123,929		
Repayment of Long-term Loan			138,300	152,448	168,044	185,235		
Expenses								
Labor								
Skilled labor		220,448	220,448	220,448	220,448	220,448	220,448	220,448
Unskilled labor		111,552	111,552	111,552	111,552	111,552	111,552	111,552
Feedstock cost								
Molasses								
Sugar cane		1,293,600	1,386,000	1,570,800	1,570,800	1,663,200	1,755,600	1,755,600
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		1,293,600	1,386,000	1,570,800	1,570,800	1,663,200	1,755,600	1,755,600
Chemicals		155,170	166,253	188,420	188,420	199,504	210,588	210,588
Power		26,242	28,116	31,865	31,865	33,739	35,614	35,614
Water		69,300	74,250	84,150	84,150	89,100	94,050	94,050
Packaging		4,620	4,950	5,610	5,610	5,940	6,270	6,270
Repair and Maintenance		39,312	39,312	39,312	39,312	39,312	78,624	157,248
Other production cost		294,643	312,881	349,357	349,357	367,595	425,145	503,769
General and Admin Expenses		118,680	118,680	118,680	118,680	118,680	118,680	118,680
Total cost	5,016,191	2,038,923	2,458,725	2,680,001	2,680,001	2,790,639	2,631,425	2,710,049
Net benefit	(5,016,191)	(117,485)	(400,041)	(346,826)	(346,826)	(320,218)	(23,759)	(102,383)

Project Worth

NPV at 8.5%	Birr	(6,571,012)
NPV at 10.23%	Birr	(6,311,685)
NPV at 12.5%	Birr	(6,011,110)
IRR on Equity		#NUM!

EMD Capacity	1,000 Liters/day							
Feedstock	Sugarcane (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		2,401,797	2,573,354	2,916,468	2,916,468	3,088,025	3,259,582	3,259,582
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		2,401,797	2,573,354	2,916,468	2,916,468	3,088,025	3,259,582	3,259,582
Investment								
Land lease	100,000							
Civil works, buildings, Office Furniture	1,250,000							
Plant Machinery and commissioning	4,916,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			211,360	193,859	174,567	153,302		
Repayment of Long-term Loan			171,079	188,580	207,872	229,137		
Expenses								
Labor								
Skilled labor		266,674	266,674	266,674	266,674	266,674	266,674	266,674
Unskilled labor		127,366	127,366	127,366	127,366	127,366	127,366	127,366
Feedstock cost								
Molasses								
Sugar cane		1,617,000	1,732,500	1,963,500	1,963,500	2,079,000	2,194,500	2,194,500
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		1,617,000	1,732,500	1,963,500	1,963,500	2,079,000	2,194,500	2,194,500
Chemicals		193,962	207,817	235,526	235,526	249,380	263,234	263,234
Power		32,802	35,145	39,831	39,831	42,174	44,517	44,517
Water		86,625	92,813	105,188	105,188	111,375	117,563	117,563
Packaging		5,775	6,188	7,013	7,013	7,425	7,838	7,838
Repair and Maintenance		49,162	49,162	49,162	49,162	49,162	98,324	196,648
Other production cost		368,326	391,124	436,719	436,719	459,516	531,475	629,799
General and Admin Expenses		143,305	143,305	143,305	143,305	143,305	143,305	143,305
Total cost	6,276,191	2,522,671	3,043,408	3,320,002	3,320,002	3,458,300	3,263,320	3,361,644
Net benefit	(6,276,191)	(120,874)	(470,053)	(403,534)	(403,534)	(370,275)	(3,738)	(102,062)

Project Worth

NPV at 8.5%	Birr	(8,001,310)
NPV at 10.23%	Birr	(7,700,696)
NPV at 12.5%	Birr	(7,350,600)
IRR on Equity	#NUM!	

EMD Capacity	1,600 Liters/day							
Feedstock	Sugarcane (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		3,842,876	4,117,367	4,666,349	4,666,349	4,940,840	5,215,331	5,215,331
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		3,842,876	4,117,367	4,666,349	4,666,349	4,940,840	5,215,331	5,215,331
Investment								
Land lease	250,000							
Civil works, buildings, Office Furniture	2,500,000							
Plant Machinery and commissioning	6,461,191							
Vehicle and other fixed assets	750,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			333,332	305,731	275,307	241,770		
Repayment of Long-term Loan			269,805	297,407	327,831	361,368		
Expenses								
Labor								
Skilled labor		286,361	286,361	286,361	286,361	286,361	286,361	286,361
Unskilled labor		174,999	174,999	174,999	174,999	174,999	174,999	174,999
Feedstock cost								
Molasses								
Sugar cane		2,587,200	2,772,000	3,141,600	3,141,600	3,326,400	3,511,200	3,511,200
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		2,587,200	2,772,000	3,141,600	3,141,600	3,326,400	3,511,200	3,511,200
Chemicals		310,340	332,507	376,841	376,841	399,008	421,175	421,175
Power		52,483	56,232	63,730	63,730	67,478	71,227	71,227
Water		138,600	148,500	168,300	168,300	178,200	188,100	188,100
Packaging		9,240	9,900	11,220	11,220	11,880	12,540	12,540
Repair and Maintenance		64,612	64,612	64,612	64,612	64,612	129,224	193,836
Other production cost		575,275	611,751	684,702	684,702	721,178	822,266	886,878
General and Admin Expenses		181,930	181,930	181,930	181,930	181,930	181,930	181,930
Total cost	9,971,191	3,805,764	4,630,178	5,072,730	5,072,730	5,294,006	4,976,756	5,041,368
Net benefit	(9,971,191)	37,111	(512,811)	(406,381)	(406,381)	(353,166)	238,575	173,964

Project Worth

NPV at 8.5%	Birr (10,725,283)
NPV at 10.23%	Birr (10,481,594)
NPV at 12.5%	Birr (10,176,516)
IRR on Equity	-21.2%

EMD Capacity	2,400 Liters/day							
Feedstock	Sugarcane (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		5,764,314	6,176,050	6,999,524	6,999,524	7,411,261	7,822,997	7,822,997
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		5,764,314	6,176,050	6,999,524	6,999,524	7,411,261	7,822,997	7,822,997
Investment								
Land lease	300,000							
Civil works, buildings, Office Furniture	5,250,000							
Plant Machinery and commissioning	8,851,191							
Vehicle and other fixed assets	750,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			503,354	461,675	415,731	365,088		
Repayment of Long-term Loan			407,424	449,104	495,047	545,690		
Expenses								
Labor								
Skilled labor		329,910	329,910	329,910	329,910	329,910	329,910	329,910
Unskilled labor		206,690	206,690	206,690	206,690	206,690	206,690	206,690
Feedstock cost								
Molasses								
Sugar cane		3,880,800	4,158,000	4,712,400	4,712,400	4,989,600	5,266,800	5,266,800
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		3,880,800	4,158,000	4,712,400	4,712,400	4,989,600	5,266,800	5,266,800
Chemicals		465,509	498,760	565,261	565,261	598,512	631,763	631,763
Power		78,725	84,348	95,594	95,594	101,218	106,841	106,841
Water		207,900	222,750	252,450	252,450	267,300	282,150	282,150
Packaging		13,860	14,850	16,830	16,830	17,820	18,810	18,810
Repair and Maintenance		88,512	88,512	88,512	88,512	88,512	177,024	265,536
Other production cost		854,506	909,220	1,018,648	1,018,648	1,073,362	1,216,587	1,305,099
General and Admin Expenses		241,680	241,680	241,680	241,680	241,680	241,680	241,680
Total cost	15,161,191	5,513,586	6,756,278	7,420,106	7,420,106	7,752,020	7,261,667	7,350,179
Net benefit	(15,161,191)	250,728	(580,228)	(420,582)	(420,582)	(340,759)	561,330	472,818

Project Worth

NPV at 8.5%	Birr (14,765,159)
NPV at 10.23%	Birr (14,566,432)
NPV at 12.5%	Birr (14,288,679)
IRR on Equity	-15.0%

EMD Capacity	3,200 Liters/day							
Feedstock	Sugarcane (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		7,685,752	8,234,734	9,332,698	9,332,698	9,881,681	10,430,663	10,430,663
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		7,685,752	8,234,734	9,332,698	9,332,698	9,881,681	10,430,663	10,430,663
Investment								
Land lease	400,000							
Civil works, buildings, Office Furniture	7,000,000							
Plant Machinery and commissioning	10,973,191							
Vehicle and other fixed assets	1,500,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			655,120	600,874	541,078	475,166		
Repayment of Long-term Loan			530,267	584,513	644,309	710,221		
Expenses								
Labor								
Skilled labor		383,920	383,920	383,920	383,920	383,920	383,920	383,920
Unskilled labor		301,840	301,840	301,840	301,840	301,840	301,840	301,840
Feedstock cost								
Molasses								
Sugar cane		5,174,400	5,544,000	6,283,200	6,283,200	6,652,800	7,022,400	7,022,400
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		5,174,400	5,544,000	6,283,200	6,283,200	6,652,800	7,022,400	7,022,400
Chemicals		620,679	665,013	753,682	753,682	798,016	842,350	842,350
Power		104,966	112,464	127,459	127,459	134,957	142,454	142,454
Water		277,200	297,000	336,600	336,600	356,400	376,200	376,200
Packaging		18,480	19,800	22,440	22,440	23,760	25,080	25,080
Repair and Maintenance		109,732	109,732	109,732	109,732	109,732	219,464	438,928
Other production cost		1,131,058	1,204,009	1,349,913	1,349,913	1,422,865	1,605,549	1,825,012
General and Admin Expenses		294,730	294,730	294,730	294,730	294,730	294,730	294,730
Total cost	19,883,191	7,285,947	8,913,886	9,798,990	9,798,990	10,241,542	9,608,438	9,827,902
Net benefit	(19,883,191)	399,804	(679,152)	(466,291)	(466,291)	(359,861)	822,225	602,761

Project Worth

NPV at 8.5%	Birr (18,870,619)
NPV at 10.23%	Birr (18,651,530)
NPV at 12.5%	Birr (18,334,962)
IRR on Equity	-14.6%

EMD Capacity	5,000 Liters/day							
Feedstock	Sugarcane (100%)							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		12,008,987	12,866,772	14,582,341	14,582,341	15,440,126	16,297,911	16,297,911
By-products								
Deforestation avoided								
Carbon-finance								
Total benefits		12,008,987	12,866,772	14,582,341	14,582,341	15,440,126	16,297,911	16,297,911
Investment								
Land lease	500,000							
Civil works, buildings, Office Furniture	8,750,000							
Plant Machinery and commissioning	17,059,941							
Vehicle and other fixed assets	2,250,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			934,315	856,950	771,671	677,668		
Repayment of Long-term Loan			756,252	833,616	918,895	1,012,898		
Expenses								
Labor								
Skilled labor		654,558	654,558	654,558	654,558	654,558	654,558	654,558
Unskilled labor		476,042	476,042	476,042	476,042	476,042	476,042	476,042
Feedstock cost								
Molasses								
Sugar cane		8,085,000	8,662,500	9,817,500	9,817,500	10,395,000	10,972,500	10,972,500
Sweet Sorghum stalk								
Sweet potato								
Cactus								
Cassava								
Total feedstock cost		8,085,000	8,662,500	9,817,500	9,817,500	10,395,000	10,972,500	10,972,500
Chemicals		969,811	1,039,084	1,177,628	1,177,628	1,246,900	1,316,172	1,316,172
Power		164,010	175,725	199,155	199,155	210,870	222,585	222,585
Water		433,125	464,063	525,938	525,938	556,875	587,813	587,813
Packaging		28,875	30,938	35,063	35,063	37,125	39,188	39,188
Repair and Maintenance		170,599	170,599	170,599	170,599	170,599	341,199	511,798
Other production cost		1,766,421	1,880,408	2,108,382	2,108,382	2,222,370	2,506,956	2,677,556
General and Admin Expenses		446,899	446,899	446,899	446,899	446,899	446,899	446,899
Total cost	28,569,941	11,428,919	13,810,972	15,193,947	15,193,947	15,885,434	15,056,955	15,227,554
Net benefit	(28,569,941)	580,068	(944,201)	(611,606)	(611,606)	(445,308)	1,240,956	1,070,357

Project Worth

NPV at 8.5%	Birr (26,470,668)
NPV at 10.23%	Birr (26,252,217)
NPV at 12.5%	Birr (25,897,808)
IRR on Equity	-12.8%

EMD Capacity	150 Liters/day							
Feedstock type	Mixed Feedstock							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		360,270	386,003	437,470	437,470	463,204	488,937	488,937
By-products		49,763	53,318	60,427	60,427	63,982	67,536	67,536
Deforestation avoided								
Carbon-finance								
Total benefits		410,033	439,321	497,897	497,897	527,185	556,473	556,473
Investment								
Land lease	25,000							
Civil works, buildings, Office Furniture	375,000							
Plant Machinery and commissioning	1,111,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			55,319	50,739	45,690	40,124		
Repayment of Long-term Loan			44,777	49,357	54,406	59,972		
Expenses								
Labor								
Skilled labor		89,692	89,692	89,692	89,692	89,692	89,692	89,692
Unskilled labor		53,548	53,548	53,548	53,548	53,548	53,548	53,548
Feedstock cost								
Molasses								
Sugar cane								
Sweet Sorghum stalk		20,790	22,275	25,245	25,245	26,730	28,215	28,215
Sweet potato		147,956	158,524	179,660	179,660	190,229	200,797	200,797
Cactus		103,950	111,375	126,225	126,225	133,650	141,075	141,075
Cassava		56,306	60,328	68,372	68,372	72,394	76,416	76,416
Total feedstock cost		329,002	352,502	399,502	399,502	423,002	446,502	446,502
Chemicals		29,094	31,173	35,329	35,329	37,407	39,485	39,485
Power		4,920	5,272	5,975	5,975	6,326	6,678	6,678
Water		12,994	13,922	15,778	15,778	16,706	17,634	17,634
Packaging		866	928	1,052	1,052	1,114	1,176	1,176
Repair and Maintenance		11,112	11,112	11,112	11,112	11,112	22,224	33,336
Other production costs		58,987	62,406	69,245	69,245	72,665	87,197	98,308
General and Admin Expenses		48,180	48,180	48,180	48,180	48,180	48,180	48,180
Total Costs	1,521,191	579,408	706,424	760,263	760,263	787,183	725,119	736,231
Net benefits	(1,521,191)	(169,375)	(267,103)	(262,366)	(262,366)	(259,998)	(168,645)	(179,757)

Project Worth

NPV at 8.5%	Birr	(3,176,584)
NPV at 10.23%	Birr	(2,966,220)
NPV at 12.5%	Birr	(2,732,062)
IRR on Equity	#NUM!	

EMD Capacity	800 Liters/day							
Feedstock type	Mixed Feedstock							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		1,921,438	2,058,683	2,333,175	2,333,175	2,470,420	2,607,666	2,607,666
By-products		243,243	260,618	295,367	295,367	312,741	330,116	330,116
Deforestation avoided								
Carbon-finance								
Total benefits		2,164,681	2,319,301	2,628,541	2,628,541	2,783,161	2,937,781	2,937,781
Investment								
Land lease	75,000							
Civil works, buildings, Office Furniture	1,000,000							
Plant Machinery and commissioning	3,931,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			170,864	156,715	141,120	123,929		
Repayment of Long-term Loan			138,300	152,448	168,044	185,235		
Expenses								
Labor								
Skilled labor		220,448	220,448	220,448	220,448	220,448	220,448	220,448
Unskilled labor		111,552	111,552	111,552	111,552	111,552	111,552	111,552
Feedstock cost								
Molasses								
Sugar cane								
Sweet Sorghum stalk		110,880	118,800	134,640	134,640	142,560	150,480	150,480
Sweet potato		789,096	845,460	958,188	958,188	1,014,552	1,070,916	1,070,916
Cactus		554,400	594,000	673,200	673,200	712,800	752,400	752,400
Cassava		300,300	321,750	364,650	364,650	386,100	407,550	407,550
Total feedstock cost		1,754,676	1,880,010	2,130,678	2,130,678	2,256,012	2,381,346	2,381,346
Chemicals		155,170	166,253	188,420	188,420	199,504	210,588	210,588
Power		26,242	28,116	31,865	31,865	33,739	35,614	35,614
Water		69,300	74,250	84,150	84,150	89,100	94,050	94,050
Packaging		4,620	4,950	5,610	5,610	5,940	6,270	6,270
Repair and Maintenance		39,312	39,312	39,312	39,312	39,312	78,624	117,936
Other production costs		294,643	312,881	349,357	349,357	367,595	425,145	464,457
General and Admin Expenses		118,680	118,680	118,680	118,680	118,680	118,680	118,680
Total Costs	5,016,191	2,499,999	2,952,735	3,239,879	3,239,879	3,383,451	3,257,171	3,296,483
Net benefits	(5,016,191)	(335,318)	(633,434)	(611,338)	(611,338)	(600,289)	(319,390)	(358,701)

Project Worth

NPV at 8.5%	Birr	(8,594,233)
NPV at 10.23%	Birr	(8,107,103)
NPV at 12.5%	Birr	(7,559,430)
IRR on Equity	#NUM!	

EMD Capacity	1,000 Liters/day							
Feedstock type	Mixed Feedstock							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		2,401,797	2,573,354	2,916,468	2,916,468	3,088,025	3,259,582	3,259,582
By-products		304,054	325,772	369,208	369,208	390,926	412,644	412,644
Deforestation avoided								
Carbon-finance								
Total benefits		2,705,851	2,899,126	3,285,676	3,285,676	3,478,951	3,672,227	3,672,227
Investment								
Land lease	100,000							
Civil works, buildings, Office Furniture	1,250,000							
Plant Machinery and commissioning	4,916,191							
Vehicle and other fixed assets								
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			211,360	193,859	174,567	153,302		
Repayment of Long-term Loan			171,079	188,580	207,872	229,137		
Expenses								
Labor								
Skilled labor		246,785	246,785	246,785	246,785	246,785	246,785	246,785
Unskilled labor		143,295	143,295	143,295	143,295	143,295	143,295	143,295
Feedstock cost								
Molasses								
Sugar cane								
Sweet Sorghum stalk		138,600	148,500	168,300	168,300	178,200	188,100	188,100
Sweet potato		986,370	1,056,825	1,197,735	1,197,735	1,268,190	1,338,645	1,338,645
Cactus		693,000	742,500	841,500	841,500	891,000	940,500	940,500
Cassava		375,375	402,188	455,813	455,813	482,625	509,438	509,438
Total feedstock cost		2,193,345	2,350,013	2,663,348	2,663,348	2,820,015	2,976,683	2,976,683
Chemicals		193,962	207,817	235,526	235,526	249,380	263,234	263,234
Power		32,802	35,145	39,831	39,831	42,174	44,517	44,517
Water		86,625	92,813	105,188	105,188	111,375	117,563	117,563
Packaging		5,775	6,188	7,013	7,013	7,425	7,838	7,838
Repair and Maintenance		49,162	49,162	49,162	49,162	49,162	98,324	147,486
Other production costs		368,326	391,124	436,719	436,719	459,516	531,475	580,637
General and Admin Expenses		143,305	143,305	143,305	143,305	143,305	143,305	143,305
Total Costs	6,276,191	3,095,056	3,656,960	4,015,890	4,015,890	4,195,355	4,041,543	4,090,704
Net benefits	(6,276,191)	(389,205)	(757,834)	(730,214)	(730,214)	(716,403)	(369,316)	(418,478)

Project Worth

NPV at 8.5%	Birr (10,499,993)
NPV at 10.23%	Birr (9,917,970)
NPV at 12.5%	Birr (9,262,630)
IRR on Equity	#NUM!

EMD Capacity	1,600 Liters/day							
Feedstock type	Mixed Feedstock							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		3,842,876	4,117,367	4,666,349	4,666,349	4,940,840	5,215,331	5,215,331
By-products		486,486	521,235	590,733	590,733	625,482	660,231	660,231
Deforestation avoided								
Carbon-finance								
Total benefits		4,329,362	4,638,602	5,257,082	5,257,082	5,566,322	5,875,562	5,875,562
Investment								
Land lease	250,000							
Civil works, buildings, Office Furniture	2,500,000							
Plant Machinery and commissioning	6,461,191							
Vehicle and other fixed assets	750,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			333,332	305,731	275,307	241,770		
Repayment of Long-term Loan			269,805	297,407	327,831	361,368		
Expenses								
Labor								
Skilled labor		286,361	286,361	286,361	286,361	286,361	286,361	286,361
Unskilled labor		174,999	174,999	174,999	174,999	174,999	174,999	174,999
Feedstock cost								
Molasses								
Sugar cane								
Sweet Sorghum stalk		221,760	237,600	269,280	269,280	285,120	300,960	300,960
Sweet potato		1,578,192	1,690,920	1,916,376	1,916,376	2,029,104	2,141,832	2,141,832
Cactus		1,108,800	1,188,000	1,346,400	1,346,400	1,425,600	1,504,800	1,504,800
Cassava		600,600	643,500	729,300	729,300	772,200	815,100	815,100
Total feedstock cost		3,509,352	3,760,020	4,261,356	4,261,356	4,512,024	4,762,692	4,762,692
Chemicals		310,340	332,507	376,841	376,841	399,008	421,175	421,175
Power		52,483	56,232	63,730	63,730	67,478	71,227	71,227
Water		138,600	148,500	168,300	168,300	178,200	188,100	188,100
Packaging		9,240	9,900	11,220	11,220	11,880	12,540	12,540
Repair and Maintenance		64,612	64,612	64,612	64,612	64,612	129,224	193,836
Other production costs		575,275	611,751	684,702	684,702	721,178	822,266	886,878
General and Admin Expenses		181,930	181,930	181,930	181,930	181,930	181,930	181,930
Total Costs	9,971,191	4,727,916	5,618,198	6,192,486	6,192,486	6,479,630	6,228,248	6,292,860
Net benefits	(9,971,191)	(398,555)	(979,596)	(935,404)	(935,404)	(913,308)	(352,686)	(417,297)

Project Worth

NPV at 8.5%	Birr (14,898,023)
NPV at 10.23%	Birr (14,173,923)
NPV at 12.5%	Birr (13,349,786)
IRR on Equity	#NUM!

EMD Capacity	2,400 Liters/day							
Feedstock type	Mixed Feedstock							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		5,764,314	6,176,050	6,999,524	6,999,524	7,411,261	7,822,997	7,822,997
By-products		729,729	781,853	886,100	886,100	938,223	990,347	990,347
Deforestation avoided								
Carbon-finance								
Total benefits		6,494,043	6,957,903	7,885,623	7,885,623	8,349,484	8,813,344	8,813,344
Investment								
Land lease	300,000							
Civil works, buildings, Office Furniture	5,250,000							
Plant Machinery and commissioning	8,851,191							
Vehicle and other fixed assets	750,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			503,354	461,675	415,731	365,088		
Repayment of Long-term Loan			407,424	449,104	495,047	545,690		
Expenses								
Labor								
Skilled labor		329,910	329,910	329,910	329,910	329,910	329,910	329,910
Unskilled labor		206,690	206,690	206,690	206,690	206,690	206,690	206,690
Feedstock cost								
Molasses								
Sugar cane								
Sweet Sorghum stalk		332,640	356,400	403,920	403,920	427,680	451,440	451,440
Sweet potato		2,367,288	2,536,380	2,874,564	2,874,564	3,043,656	3,212,748	3,212,748
Cactus		1,663,200	1,782,000	2,019,600	2,019,600	2,138,400	2,257,200	2,257,200
Cassava		900,900	965,250	1,093,950	1,093,950	1,158,300	1,222,650	1,222,650
Total feedstock cost		5,264,028	5,640,030	6,392,034	6,392,034	6,768,036	7,144,038	7,144,038
Chemicals		465,509	498,760	565,261	565,261	598,512	631,763	631,763
Power		78,725	84,348	95,594	95,594	101,218	106,841	106,841
Water		207,900	222,750	252,450	252,450	267,300	282,150	282,150
Packaging		13,860	14,850	16,830	16,830	17,820	18,810	18,810
Repair and Maintenance		88,512	88,512	88,512	88,512	88,512	177,024	265,536
Other production costs		854,506	909,220	1,018,648	1,018,648	1,073,362	1,216,587	1,305,099
General and Admin Expenses		241,680	241,680	241,680	241,680	241,680	241,680	241,680
Total Costs	15,161,191	6,896,814	8,238,308	9,099,740	9,099,740	9,530,456	9,138,905	9,227,417
Net benefits	(15,161,191)	(402,771)	(1,280,405)	(1,214,117)	(1,214,117)	(1,180,972)	(325,561)	(414,073)

Project Worth

NPV at 8.5%	Birr (21,024,269)
NPV at 10.23%	Birr (20,104,926)
NPV at 12.5%	Birr (19,048,583)
IRR on Equity	#NUM!

EMD Capacity	3,200 Liters/day							
Feedstock type	Mixed Feedstock							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		7,685,752	8,234,734	9,332,698	9,332,698	9,881,681	10,430,663	10,430,663
By-products		972,972	1,042,470	1,181,466	1,181,466	1,250,964	1,320,462	1,320,462
Deforestation avoided								
Carbon-finance								
Total benefits		8,658,724	9,277,204	10,514,164	10,514,164	11,132,645	11,751,125	11,751,125
Investment								
Land lease	400,000							
Civil works, buildings, Office Furniture	7,000,000							
Plant Machinery and commissioning	10,973,191							
Vehicle and other fixed assets	1,500,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			655,120	600,874	541,078	475,166		
Repayment of Long-term Loan			530,267	584,513	644,309	710,221		
Expenses								
Labor								
Skilled labor		383,920	383,920	383,920	383,920	383,920	383,920	383,920
Unskilled labor		301,840	301,840	301,840	301,840	301,840	301,840	301,840
Feedstock cost								
Molasses								
Sugar cane								
Sweet Sorghum stalk		443,520	475,200	538,560	538,560	570,240	601,920	601,920
Sweet potato		3,156,384	3,381,840	3,832,752	3,832,752	4,058,208	4,283,664	4,283,664
Cactus		2,217,600	2,376,000	2,692,800	2,692,800	2,851,200	3,009,600	3,009,600
Cassava		1,201,200	1,287,000	1,458,600	1,458,600	1,544,400	1,630,200	1,630,200
Total feedstock cost		7,018,704	7,520,040	8,522,712	8,522,712	9,024,048	9,525,384	9,525,384
Chemicals		620,679	665,013	753,682	753,682	798,016	842,350	842,350
Power		104,966	112,464	127,459	127,459	134,957	142,454	142,454
Water		277,200	297,000	336,600	336,600	356,400	376,200	376,200
Packaging		18,480	19,800	22,440	22,440	23,760	25,080	25,080
Repair and Maintenance		109,732	109,732	109,732	109,732	109,732	219,464	329,196
Other production costs		1,131,058	1,204,009	1,349,913	1,349,913	1,422,865	1,605,549	1,715,281
General and Admin Expenses		294,730	294,730	294,730	294,730	294,730	294,730	294,730
Total Costs	19,883,191	9,130,251	10,889,926	12,038,502	12,038,502	12,612,790	12,111,422	12,221,154
Net benefits	(19,883,191)	(471,528)	(1,612,722)	(1,524,337)	(1,524,337)	(1,480,145)	(360,297)	(470,029)

Project Worth

NPV at 8.5%	Birr (27,039,832)
NPV at 10.23%	Birr (25,894,539)
NPV at 12.5%	Birr (24,574,553)
IRR on Equity	#NUM!

EMD Capacity	5,000 Liters/day							
Feedstock type	Mixed Feedstock							
	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10	Year 15
Revenue								
Ethanol sales		12,008,987	12,866,772	14,582,341	14,582,341	15,440,126	16,297,911	16,297,911
By-products		1,520,269	1,628,859	1,846,041	1,846,041	1,954,631	2,063,222	2,063,222
Deforestation avoided								
Carbon-finance								
Total benefits		13,529,256	14,495,631	16,428,382	16,428,382	17,394,757	18,361,133	18,361,133
Investment								
Land lease	500,000							
Civil works, buildings, Office Furniture	8,750,000							
Plant Machinery and commissioning	17,059,941							
Vehicle and other fixed assets	2,250,000							
Pre-operative expenses	10,000							
Increase/decrease in inventories								
Increase/decrease in inventories								
Interest payment on long-term loan			934,315	856,950	771,671	677,668		
Repayment of Long-term Loan			756,252	833,616	918,895	1,012,898		
Expenses								
Labor								
Skilled labor		654,558	654,558	654,558	654,558	654,558	654,558	654,558
Unskilled labor		476,042	476,042	476,042	476,042	476,042	476,042	476,042
Feedstock cost								
Molasses								
Sugar cane								
Sweet Sorghum stalk		693,000	742,500	841,500	841,500	891,000	940,500	940,500
Sweet potato		4,931,850	5,284,125	5,988,675	5,988,675	6,340,950	6,693,225	6,693,225
Cactus		3,465,000	3,712,500	4,207,500	4,207,500	4,455,000	4,702,500	4,702,500
Cassava		1,876,875	2,010,938	2,279,063	2,279,063	2,413,125	2,547,188	2,547,188
Total feedstock cost		10,966,725	11,750,063	13,316,738	13,316,738	14,100,075	14,883,413	14,883,413
Chemicals		969,811	1,039,084	1,177,628	1,177,628	1,246,900	1,316,172	1,316,172
Power		164,010	175,725	199,155	199,155	210,870	222,585	222,585
Water		433,125	464,063	525,938	525,938	556,875	587,813	587,813
Packaging		28,875	30,938	35,063	35,063	37,125	39,188	39,188
Repair and Maintenance		170,599	170,599	170,599	170,599	170,599	341,199	511,798
Other production costs		1,766,421	1,880,408	2,108,382	2,108,382	2,222,370	2,506,956	2,677,556
General and Admin Expenses		446,899	446,899	446,899	446,899	446,899	446,899	446,899
Total Costs	28,569,941	14,310,644	16,898,535	18,693,184	18,693,184	19,590,509	18,967,867	19,138,467
Net benefits	(28,569,941)	(781,389)	(2,402,904)	(2,264,803)	(2,264,803)	(2,195,752)	(606,735)	(777,334)

Project Worth

NPV at 8.5%	Birr (39,510,481)
NPV at 10.23%	Birr (37,790,746)
NPV at 12.5%	Birr (35,814,275)
IRR on Equity	#NUM!

Collaborators

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