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Financial and Economic Analysis of Ethanol Production from Sugar Molasses: A Case Study of an Integrated Sugar Plant in Ethiopia

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Abstract

The Search for and development of alternative sources of energy and its efficient use is increasing with mounting scarcity of petroleum fuels. Long dependence on fossil fuels particularly for the transport sector made life vulnerable to erratic price and supply changes. As a result interest to produce and use Biofuels as an alternative source of energy increased worldwide. Ethiopia has already started production and use of ethanol with the aim of partially offsetting impact of petroleum products import on balance of payment. The initiative as well as enforcement of the national bio fuel sector has to be checked for viability with respect to different requirements including financial and economic performances. This study, as part of the caution, employed cost benefit analysis technique to assess the financial and economic performance of Ethanol production at Finchaa Sugar Factory, a state owned enterprise in Ethiopia. The comparative advantage position in ethanol production from molasses was assessed using Domestic Resource Cost (DRC) method of project appraisal. The Finchaa Sugar Factory Ethanol Plant has an installed capacity of 450 hectolitres of pure alcohol per day. Calculations of Net Present Value and Internal Rate of Return of the project indicated that the production of ethanol from molasses was economically viable. In comparative advantage assessment, estimated DRC figure of 9.70 ETB was less than the shadow exchange rate (ETB 11.58/USD) signifying production cost was less than import value. Real value added through ethanol production over project period was 175 million in Ethiopian Birr. In conclusion study findings demonstrated financial and economical viability of ethanol production from sugar molasses.

Keywords: Ethanol, Economic analysis, Financial analysis, Internal rate of return, Net present value

Introduction

With increasing scarcity and environmental concern of fossil fuels, the prominence to look for alternative sources and uses of energy is growing. Besides the search for alternative sources, strive for higher efficiency in consumption as well as production of energy sources in order to save energy and also attain less emission for environmental safety. This encouraged the development and use of fuel saving technologies. On the other side, countries with less or no energy resources can resort to depend on world market supply and thus allowing use of resources in the production of other goods in which they have comparative advantage. It's also believed that quality of energy services drives broader economic productivity apart from the physical availability of energy per se. The use of more flexible energy forms (fuels and electricity) contributes to increased factor productivity through enhancing the discovery, development and use of new process, new equipment, new systems of production, and new industrial locations (schurr 1984 cited in Toman and Jemelkova 2002).

Per capita energy consumption for Ethiopia is the lowest within the low income countries and the progress over time is relatively stagnant or experience negative growth for some years **(Table 1).** Current energy supply is less diverse with both production and consumption processes involving low efficiency. Biomass especially wood produced and also used in traditional way is the major energy source in the country. For instance energy requirement estimates by Cecelski (1984) indicates cooking one kg of *injera* needs about 62,500 kJ of energy which exceeds forty times the energy required to bake the same quantity of chapatti or twenty times the energy required to boil one kg of rice.

Ethiopia, though endowed with a considerable level and variety of energy resources (**Table** 2); its common national modern energy is limited to electrical, mostly from hydro sources. Even within the hydro based electrical energy supply, it is not more than 3% of the national hydropower potential that is exploited so far (MME, 2010).

Table 1. Per Capita Energy Consumption in Kg Oil Equivalent (Kgoe)

	Year			
Region / country	**1965***	**1990**	**2000**	**2005**
North America		7,686.3	8,157.9	7,942.9
Europe		4,080.4	3,580.8	3,773.4
Germany		4,481.2	4,175.3	4,187.0
Kenya	86.1	533.0	490.0	503.0
Ethiopia	6.3	296.0	291.0	304.0
Low Income Countries		431.5	457.3	491.8
World	1115.8	1,668.0	1,657.0	1,778.0

Sources: World Resources Institute (2007); * Aman (1969, 21), Kg coal equivalent (kgce) converted to kg oil equivalent (kgoe) with a conversion factor 1 kgce = 0.7 kgoe.

Table 2: Energy Resources Potential of Ethiopia

Resource	Unit	Exploitable reserve	Percent exploited
Hydropower	MW	30 - 45,000	< 3%
Solar/day	KWh/m^2	4-6	~0%
Wind: Power	GW	100	~0%
Speed	m/s	> 6	
Geothermal	MW	5000	~0%
Wood	Million tons	1120	50%
Agricultural waste	Million tons	15-20	30%
Natural gas	Billion m^3	113	0%
Coal	Million tons	300	0%
Oil shale	Million tons	253	0%

Source: Ministry of Mines and Energy, 2010. Energy Information Administration and Development Follow-up

With increasing pressure on balance of payment due to petroleum products import and environmental problems associated with fuel wood consumption, the country couldn't afford to stay away from making Biofuels part of national energy sources. For the period April to June 2010, expenditure related to fuel import accounted for 18% of total import spending. However, fuel import consumed more than 55% of export earnings of the period (CSA, 2010). As a result, Government formulated a policy "The Ethiopian Biofuel Development and Utilization Strategy" to tackle the problem. The policy which took effect in 2007 seeks to support and therefore increase the supply of renewable fuels from local sources. In order to enforce the demand side, Government enacted a regulation to blend ethanol with gasoline at rates of 5% ethanol in 2007 and then gradually increase to 10% for the years to come (MME, 2007).

Despite the decisive role of energy, expanding access to modern economically competitive energy services has remained a big challenge for developing regions, especially in the poorest countries. In Ethiopia the major local energy source, biomass representing mainly wood from decreasing forest areas, is already at stake by itself and posed ecological problems in effect. Collecting firewood from forests has remained the traditional energy source especially in the rural areas. Nevertheless, collecting firewood has become more and more difficult and time consuming as well as more expensive for urban households. For the period 1991 – 2002, prices of gasoline and fuel wood showed a record increase of 300% and 185% respectively (Mebratu & Tamire, 2002).

Environmental concern is another reason to shift from fossil to renewable energy sources. In 2005, the global greenhouse emission was 44 Gt (Giga ton) CO_2-equivalent where energy related emission contributed 61% (IEA, 2008). The same report indicated that greenhouse emission related to fossil fuel production and consumption was 28 Gt in 2006 and projected to grow by 45% in 2030. In Ethiopia, dependence on fuel wood for energy supply is causing severe environmental problems and thus on its services. World Bank (1984) report indicates fuel wood use in Ethiopia had reached 2.5 times the level of sustainable supply estimated based on the existing tree coverage of the period. In addition to fuel wood need, forests are cleared to make available new areas for residence requirement and agricultural production to feed the growing population. Under this circumstance, deforestation rate is estimated to be 150,000 – 200,000 hectares annually (EFAP, 1994).

The prevailing energy condition of Ethiopia, more than 90% sourced from biomass and about half of export earnings spent on fuel import, remains a major challenge for the country's development aspirations. In developing alternative sources, Ethanol from sugar producing plants is seen to have the major potential. In a study to evaluate the impact of using ethanol with Clean Cook stove, Hassen (2006) had reported an improvement in the economic and social condition through reduced time for fuel wood searching, healthy in-door environment, reduced cutting of trees, and reduced risk associated with fuel wood collection. Based on this research findings, the tendency to produce ethanol has been given an increased attention at national level. From the status quo, Biofuels sector in the country is new and expanding. Therefore, as part of the required cautions for possible foreseeable impacts, this study generally assesses the viability of ethanol production from sugar molasses with the following specific objectives:

1. To calculate cost of ethanol production from sugar molasses
2. To assess the financial and the economic viability of ethanol production from sugar molasses
3. To assess the comparative advantage in ethanol production for fuel purpose

Methodology and Data

Study Unit, Data Types and Sources

Finchaa Sugar Factory (FSF) is state owned sugar producing enterprise located 350 km west of Addis Ababa in Oromiya Regional State. FSF is the only sugar and ethanol integrated factory in Ethiopia which started its operation in 1998/99. The ethanol plant has an installed capacity of producing nine million litres of ethanol per annum.

The study uses quantitative data representing both primary and secondary types. Data on inputs such as labour, chemicals (yeast, anti-foam, DAP, sulphuric acid), utilities (electricity, water, steam) and service inputs were collected from records of the enterprise. Information regarding the national potential in energy production, import and prices of fossil fuels, and policy information were obtained from offices namely Ministry of Mines and Energy, Ethiopian Petroleum Enterprise, and Sugar Development Agency. Parameters for estimating economic values (eg....?) were taken from the national economic parameters estimates by the Ministry of Finance and Economic Development.

Method of Analysis

In order to assess the economic and financial performance, cost benefit analysis method was selected. Measures of project worth with decision criteria Net Present Value and Internal Rate of Return are used to meet the objectives. Domestic resource cost way of project evaluation was (is) also employed to assess comparative advantage in ethanol production. Calculating cost of production supplements identification and valuation of inputs in the project.

Cost of Ethanol Production

Cost of ethanol production comprises cost positions for feedstock, capital, operating and maintenance. Depending on feedstock used and production process employed, gains from co-products are also included in cost estimation. In most instances feedstock cost accounts for a major share of production cost. In Brazil, leading in ethanol technology from sugar cane, more than 50% of production cost goes to feedstock (Henniges and Zeddies, 2007).

In assessing the performance of an ongoing project, investment cost is the outlay that had been incurred in the past. Therefore, the undertaken analyses and results given in this study refer only to the remaining project period. Project period from the beginning as well as remaining project years as considered in this study is shown in Figure 1.

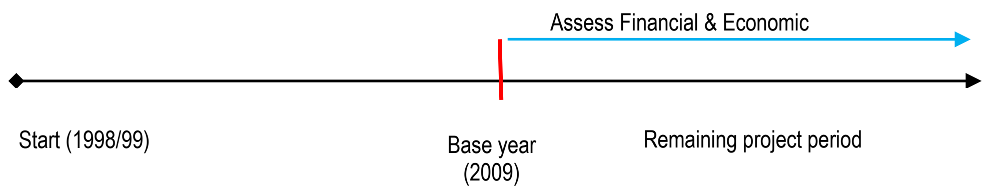

Figure 1. Time Path for Project Decision

Annuity formula given in Equation (1) is selected to compute the capital cost in the project over the remaining period.

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] \quad (1)$$

A - Annual payments (ETB per year)
P - Present worth of initial investment cost (ETB)
i - Annual interest rate in %
n - Project period in years

Average interest rate (i) of 11% estimated based on annual interest rate data from National Bank of Ethiopia (NBE) for the period June 1999 to June 2009.

Operating and maintenance costs include spending for labour, utilities and consumables, repairs and maintenance, taxes, insurance and administrative expenses. For outsourced inputs, actual expenditures on those items represent their cost at financial prices. Ethanol production from sugar molasses by FSF has co-products vinasse and carbon dioxide. Vinasse, a liquid leftover after alcohol is removed, contains high levels of nutrients such as nitrogen, potassium, phosphate, sucrose, and yeast which can be applied to cropland as a fertilizer (Shapouri *et al.* 2006). In Vinasse valuation, **Table** 3 gives details on the nutrient composition of vinasse and nutrients requirement of sugar cane cultivation at the project site. Purchase prices of the chemical nutrients are used in savings calculation.

Table 3: Vinasse Nutrient Composition and Cane Fertilizer Requirement at Project Site

Description	Fertilizers		
	N	P_2O_5	K_2O
Fertilizer needs For one hectare (kg)	90	50	200
Availability of Vinasse In one ton of molasses (kg) (in 2.78 m^3 of Vinasse)	8	1.5	40
Cost of fertilizer per ton (ETB)	5,883.90	8,390.90	(a)3,334.40

Source: SOFRECO, 2004

(a) Price for potassium is adapted from SOFRECO,2004

Accordingly, per unit cost of ethanol production is given by Equation (2) below.

$$C_E = C_F + C_{OM} + C_I + C_{RP} - C_{CP} \quad (2)$$

C_E - Ethanol production Cost per litre

C_F - Feedstock cost per litre

C_{OM} - Operating and maintenance cost per litre

C_I - Investment cost per litre

C_{RP} - Risk premium per litre

C_{CP} - Value of co-product per litre

Cost benefit analysis method

Cost-benefit analysis (CBA) is a quantitative analytical tool used to find out how resources are allocated more efficiently. In an increasingly complex and challenging fiscal and economic environment, CBA serves the purpose of securing optimal use of resources through providing management information for sound decision. In applying the cost-benefit analysis technique, Net Present Value (NPV) and Internal Rate of Return (IRR) are the two decision criteria selected in this study.

i. Net Present Value (NPV)

NPV measures the absolute welfare

gain over the whole project life (Belli *et al.*, 1998). It is determined using the mathematical expression given in Equation (3) below.

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} = \sum_{t=1}^{n} \frac{NB_t}{(1+r)^t} \quad (3)$$

B_t - Benefit during year t
C_t - Cost during year t
r - Discount rate in percent
t -Time in years
NB_t - Net benefit in year t
n - Project period in years
(Gittinger, 1982: 361)

For a cash flow of year 't', at first it is normal to eliminate inflation and then actualize cash flows without inflation. Mathematically;

$$\frac{NB_t / (1+i)^t}{(1+r)^t} = \frac{NB_t}{(1+r)^t \ (1+i)^t} \quad (4)$$

Where:
NB_t - Net benefit in year t
i - Annual inflation rate (%)
r - Annual nominal interest rate (%)
t - Time in year

For both financial and economic objectives, underlying rule for NPV as a decision criterion in CBA is to accept projects that have a positive NPV while projects with negative NPV are not feasible. *Ceteris paribus*, the decision maker accepts a project with the largest NPV when there are several mutually exclusive alternatives. NPV is a preferred criterion if one has to select from mutually exclusive projects (Gittinger, 1982).

ii. Internal Rate of Return (IRR)

Internal Rate of Return (IRR) is a financial analysis procedure followed to assess the viability of projects. IRR is easier to understand than NPV or other discounted cash flow analysis measures and often used to explain and justify investment decisions. Mathematical representation of IRR:

$$\sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} = 0 \ \leftrightarrow \ \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} = \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} \quad (5)$$

In the expression above (Equation 5) 'i' represents the Internal Rate of Return (IRR). Other symbols used in the IRR formula are defined in the same way as in the NPV Equation (3). The decision rule for IRR depends on the desired rate of return. IRR of a project greater than the desired rate of return shows that the project is feasible; otherwise, alternatives will have greater return (Gittinger, 1982). For both criteria constant price across years is assumed.

Domestic resource cost

In order to address the objective of comparative economic performance and possible savings/earnings that can be generated through ethanol project, domestic resource cost (DRC) based project evaluation is employed. Ford and White (1984) defined DRC as measure of the cost of producing one dollar worth commodity from domestic resources. In this particular case, DRC is calculated using Equation 6 given below.

$$\text{Domestic resource cost} = \frac{\text{Present worth of domestic currency cost of realizing foreign exchange saving}}{\text{Present worth of net foreign exchange saving}} \quad (6)$$

DRC determined in this way represents the cost in the domestic currency required to earn a unit of foreign exchange through the project (Gittinger, 1982). Domestic resource cost method gives more insight on the use of resources and the values of outputs of a given sector or economy. Equation (6) excluding the time dimension as used by Ruiz (2003) and adapted to ethanol project can be rewritten as:

$$DRC = \frac{DC_e}{VA_e} = \frac{\sum_h R_{he} S_h}{P_e} \qquad (7)$$

DRC - Domestic resource cost
DC_e - Domestic cost of production
VA_e - Value added at international prices
R_{he} - Requirement of factor 'h'
S_h - Shadow price of factor 'h' and
P_e - Border price of Ethanol

The ratio in Equation 7 relates the cost of producing a unit of ethanol with the value of ethanol at international prices. In this case, DRC can be defined as a measure of the cost of saving (earning) a unit foreign exchange by means of an import substitution or export promotion policy. When production of certain goods by the project may require imported inputs, Equation (7) is rewritten as shown in Equation (8) in order to incorporate imported inputs.

$$DRC_e = \frac{\sum_h r_{he} s_h}{p_e - \sum_j mj \times p_j} \qquad (8)$$

mj - Imported unit of input *j* in a unit of ethanol produced
p_j - Border price of input *j*

Simplification of the expression in the denominator of Equation (8) represents the net foreign exchange that can be earned or saved by the project. The numerator gives domestic real cost of production or the real value added generated by the project. DRC figure is compared with official exchange rate or shadow exchange rate in order to decide if home production is cheaper compared to its import. If the DRC is greater than the shadow exchange rate, it means that it would cost more to produce a unit foreign currency worth product through a project in which case it is preferable to import. Shadow exchange rate (SER) determined using the expression given in Equation (9).

$$SER = \frac{OER}{SCF} \qquad (9)$$

SER - Shadow exchange rate
OER - Official exchange rate
SCF - Standard conversion factor

Determining economic values

In evaluating the net impact of public sector projects on welfare, Dreze and Stern defined shadow prices as 'the social opportunity costs of the resources used (and correspondingly for outputs generated)' (Derze and Stern, 1990: 2). Adjusting the market price of any good or service to make it more closely represent the opportunity cost to the society is known as shadow pricing. This may involve the use of conversion factors (CF) defined as:

$$CF_i = \frac{shadow\ price\ of\ item\ in\ question\ (SP_i)}{market\ price\ of\ an\ item\ (MP_i)}$$

a. Traded goods

Economic price for traded goods is estimated based on opportunity cost of those goods. Because the socially relevant opportunity of traded goods is the gains from trade of that good, opportunity cost of traded goods is defined by their border price (Macarthur, 1997). Following the standard conversion factor approach, economic prices of traded items in the project are estimated using the foreign exchange paid for imports and received for exports including insurance, freight and cost of transportation and marketing to the point of consideration.

b. Non-tradable goods

When specific conversion factors are available and these factors incorporate the adjustments for non-traded goods distortions, opportunity cost, and distribution weights, the market price need only be multiplied by the specific conversion factor to reach at economic values (Little & Mirrlees, 1974). This approached is followed to estimate economic prices for non-tradable items in ethanol project.

Table 4. Conversion Factors

Factors	Conversion factor (World price numeraire)	Conversion factor (Domestic price numeraire)
Domestic resources	0.90	1.00
Unskilled labour Rural Formal	0.31	0.36
Skilled labour	0.76	0.84
Utilities	1.557	1.73
Fertilizer	0.99	1.095
Construction - buildings	0.55	0.61
Standard Conversion Factor	0.90	1.00

Source: Ministry of Finance and Economic Development (MoFED), 2008

Technical assumptions and important notes in the study

Finchaa sugar factory has an installed capacity of crushing 450 TCD (tonnes of sugar cane per day). Ethanol plant with an installed capacity of producing 450 hectolitres of pure alcohol (hlPA) per day is linked to the sugar plant allowing for the major input supply. Though the installed capacity of the plant is 9 million litres of pure alcohol per year, actual production slowly reached seven million in 2009 production season. In this study, therefore, the actual production level 7 million litres was used for year one of assumed project period and 450hlPA/day capacity from second year on. Ethanol production by FSF project is fuel grade and this quality is considered in the valuation and the corresponding analyses.

Table 5. Feedstock and Technical Assumptions

Description	Assumption/given
Feedstock	Molasses
Ethanol yield (litre/ton of molasses)*	278
Plant type	Single-feedstock & integrated to sugar processing plant
Location	Finchaa in East Wellega, Ethiopia
Capacity	450 hlPA/day
Number of operating days per year	200
Project period	10 years
Base year	2009
Exchange rate	ETB 10.4205 /USD (June 2009)
Market	Addis Ababa

* Estimated based on data from feasibility study document by SOFRECO, 2004

Results and Discussion

Financial analysis

Capital cost including machinery and buildings plus capitalized value of land was ETB 44.22 million. Feedstock cost was ETB 426 per ton including transport charge to project site. Total operating and other costs of the project amount to ETB 6.34 million in 2009 prices. Production multiplied by weighted price of ethanol (ETB 5.91 per litre estimated from 2009 selling price) and remaining value from buildings give project benefit ETB 4.12 million.

Financial Cost of Production

Production cost was calculated and summary of the result showing the respective contribution of each cost item is presented in **Table** 6.

Table 6: Summary of Financial Cost of Production

	Capacity	Actual production in 2009 (7million litres)			Installed capacity (9 million litres)	
Nr.	Cost Item	Total (000' ETB)	Per litre (ETB)	Contribution (%)	Per litre (ETB)	Contribution (%)
1	Capital	7,145.91	1.02	29	0.79	25
2	Feedstock	10,726.62	1.53	44	1.53	49
3	Operating costs	4,986.07	0.71	21	0.68	21
4	Other costs	1,352.93	0.19	6	0.15	5
5	Total Cost	24,211.52	3.46	100	3.15	100
6	Cost including tax *		4.60		4.19	
7	Cost at market **		4.71		4.30	

* Excise tax is 33% of production cost

** Cost at market includes tax and transport charge (project site to Addis Ababa-market) ETB 0.11 per litre

From actual activities of the plant in 2009, production cost calculated was ETB 3.46 per litre. Risk premium included under other costs category was ETB 0.03 per litre representing 1% of unit cost of production. For the period January to May 2009, quantity weighted price of ethanol at market was ETB 5.91 per litre which is higher than cost at market. Production cost falls by more than 9% for a shift in production capacity from 7 to 9 million litres (See Table VI). Per unit production cost is dominated by feedstock cost at both capacities. The share of operating cost declined from ETB 0.71 to 0.68 in absolute terms for a shift to full capacity utilization. Given the constant price assumption, decline in operating cost contribution was due to labour cost which doesn't change with production under existing requirement.

Financial performance of the project

Calculated Financial NPV of the project was ETB 110.30 million. The result tells that enterprise's earning over the whole project period would be ETB 110 million given that assumption about costs, benefits, and parameters holds throughout project period. Hence, indicated by NPV criteria, ethanol production from molasses is feasible from the enterprise's perspective.

IRR was 160% estimated by interpolation. The rate is higher than the real interest rate (4%). Hence, the project was found feasible with the IRR criteria too. However, conclusions based on both financial measures calculated here are valid only from view point of the enterprise. More figures on financial NPV and IRR at various plant capacities are given in **Table** 7.

Table 7: Summary of the Financial Analysis Results

Capacity (litres)	Financial Criteria	Financial Analysis Results
7 million*	NPV (in million ETB)	80.04
	IRR (%)	122
8 million	NPV (in million ETB)	95.17
	IRR (%)	141
9 million	NPV (in million ETB)	110.30
	IRR (%)	160

* Actual production reached during the base year

Economic Analysis

Economic value of capital items for the remaining years was ETB 35.98 million. Cost for molasses and operating items (labour, consumables and utilities) and other items for year one of project study period was ETB 22.70 million. Project benefit was ETB 28.24 million for year one of project period and ETB 38.58 for project's last period (tenth year) including remaining value of buildings and land.

Economic Cost of Production

Besides the prices, including gains from vinasse in economic cost estimation makes the difference between the financial and economic cost. Summary of economic costs together with percentage share of each contributing item is presented in **Table** 8.

Table 8: Summary of Economic Cost of Production (in ETB)

Nr.	Capacity / Cost Item	Actual production in 2009 (7million litres) Total cost (000' ETB)	Cost/gain per litre (ETB)	Contribution (%)	Installed capacity (9 million litres) Cost/gain per litre (ETB)	Contribution (%)
1	Capital cost	5,911.39	0.84	21	0.66	17
2	Feedstock cost	16,416.01	2.35	57	2.35	61
3	Operating cost	5,440.95	0.78	19	0.75	20
4	Other costs	845.58	0.12	3	0.09	2
5	Total cost	28,613.92	4.09	100	3.85	100
6	Gain from co-product	3,753.32	0.54	13	0.54	14
7	Net cost	24,860.59	3.55	87	3.31	86
8	**Cost at market***		**3.66**		**3.42**	

* Cost at market includes transport charge (project site to market) which is ETB 0.11 per litre

At full capacity operation, calculated net economic cost was ETB 3.31 per litre which is less by 7% compared to production cost at actual production level already attained. After adjusting for spreading cost of vinasse use as a fertilizer, net gain was found to be ETB 0.54 per litre of ethanol produced. The gain from the co-product reduced cost of production by more than 14% at full capacity operation. At both capacities, feedstock accounted for more than 50% of the total cost. In this regard, ethanol production cost in Ethiopia seems to have similar relative per unit cost structure with other major producers such as Brazil.

i. Cost Comparison with other Countries

Ethanol is produced by a number of countries from different feedstock types. Taking into account the low capacity plant considered in this study, a lower capacity plant of selected countries was considered in order to allow better comparability among countries. Table 9 presents cost of ethanol production for different countries together with the feedstock used. For values not in USD exchange rates mentioned in the respective studies were used for conversion. The comparison shows that per unit production cost for Ethiopia was the lowest among the group and followed by Brazil and USA respectively.

Table 9: Cost Comparison with Other Countries Producing Ethanol

Country	Feedstock	Cost/unit given in the respective studies	Cost per litre (USD)
Ethiopia [(a)]	Molasses	ETB 3.42 /litre	0.21

Brazil [(b)]	sugar cane	EUR 20.01 /hl	0.24
USA [(b)]	Corn	USD 1.23 /gallon	0.33
Germany [(b)]	Wheat	EUR 51.43 /hl	0.62
Thailand [(c)]	Molasses	Baht 15.83 /litre	0.40

Note:

(a) Own calculation
(b) Henniges, O. & J.Zeddies, 2007
(c) Yoosin and Sorapipantana, 2007

Economic Performance of the Project

Economic NPV of ethanol project in 2009 prices was found ETB 12.64 million (USD 1.21 million) when all benefits and costs discounted at 10.23% discount rate for ten years. Calculated NPV indicated that project impact from society's view point was positive (i.e. benefits exceed costs). Hence, the decision criteria NPV shows project was feasible economically. Interpreted: present values of expected economic benefits exceed the present values of economic costs if project continued to completion. Estimated economic IRR of the project was 21% rounded to whole number. The estimated economic IRR was higher than opportunity cost of capital (10.23%) showing economic viability of project with IRR criterion too. For a better comprehension of project viability, more NPV and IRR figures (Table 10) were calculated at different capacities including actual production level reached during the base year.

Table 10: Summary of the Economic feasibility Analysis Results

Capacity in litres	Economic Criteria	Economic Analysis Results
7 million*	NPV (in million ETB)	1.90
	IRR (%)	12
8 million	NPV (in million ETB)	7.27
	IRR (%)	16
9 million	NPV (in million ETB)	12.64
	IRR (%)	21

* Actual production reached during the base year

From results given in Table 10, both economic criteria agree on the economic attractiveness of the project at the actual production which is below full capacity. As indicated by IRR and NPV values in the table, the project has a higher economic performance at a full capacity.

Comparative Advantage in Ethanol Production

To investigate whether domestic production of ethanol is preferred economically compared to import, comparative assessment conducted using DRC method.

Foreign Exchange Items

Foreign exchange items in the project appeared in both cost and benefit categories a possible case when some inputs are imported as indicated in the denominator part of Equation (8). The cost aspect of a foreign exchange arises from import of capital items like machinery and some of the chemicals (Anti-Foam, Yeast, and DAP). Summary of the foreign exchange component is shown in Table 11. Foreign exchange earning comes from ethanol sale and cost savings from reduced fertilizer import due to vinasse. Remaining values of capital items added to this component after converting them into USD at the official exchange rate (10.4205 ETB/USD) during the base year.

Table 11: Summary of Present Values of Foreign Exchange Component (000' USD)

Value Item	Cost (USD) (A)	Benefit (USD) (B)	Net benefit (USD) (B-A)
Capital	3,733.03		-3,733.03
Chemicals	139.94		-139.94
Ethanol		19,144.73	19,144.73
Saving from Vinasse		2,724.27	2,724.27
Remaining value of capital items*		82.21	82.21
Total	**3,872.97**	**21,951.21**	**18,078.24**

* Remaining value represents value of capital items with economic life longer than project study period.

Domestic Currency Cost Items

Domestic currency cost items include cost for capital items (land, and buildings), feedstock, consumables (chemicals produced locally), utilities, labour and other costs. Summary of domestic currency component items are given in Table 12 under general categories: capital, feedstock, operating cost and other cost.

Table 12: Summary of Present Values of Domestic Currency Component (000' ETB)

Cost Item	Cost of domestic factors (ETB)
Capital	7,258.31
feedstock	124,162.96
Operating costs*	38,734.89
Other costs**	5,197.75
Total	**175,353.92**

* Operating costs include costs for consumables, labour and utilities

** Other costs include maintenance, insurance and miscellaneous costs

Note: Figures in Table 11 and Table 12 are based on:

1. Full capacity (9 million litres per year) operation starting from year two of project period.
2. Constant price throughout project life
3. Discounted at 10.23% discount rate for 10 years

Using data presented in Table 11 and Table 12, DRC was estimated to be 9.70 (ETB/USD) using Equation 6. This implies that the cost of earning or saving one USD through ethanol project is 9.70 in Ethiopian Birr. For decision making, the DRC value was compared with the shadow exchange rate (11.5783 ETB/USD estimated using Equation 9). The domestic resource cost was found to be less than the shadow exchange rate (SER) indicating that cost of producing ethanol at home is less than import value. Hence, it was economically preferable to produce ethanol than importing. The real value added for the project was ETB 175 million (**Table 12**). Total net foreign exchange saving was also calculated USD 18.09 million (**Table** 11). Assuming similar production environment for all enterprises that can produce ethanol; based on this research findings and analysis, it suggest that the country has comparative advantage in ethanol production from sugar molasses.

Conclusion and Recommendation

Analyses results demonstrated ethanol production was viable financially as well as economically. Findings showed ethanol production by sugar integrated plant is economical; has potential to contribute to energy security through increasing supply and alternative sources. The result reinforces views that Biofuels production is more beneficial to countries with substantial land resource and suitable environment for feedstock production prompting further expansion of production. Hence, in Ethiopia with an enormously rural and agrarian population, the following points need further research: what use of fuel ethanol (household or transport) will better address the energy problem and associated impacts in the country; and the potential impact of Biofuels expansion on agricultural production and thus food security in the country.

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