

# 1. Introduction

The development programs of Ethiopia entail full participation of the population and benefiting the population phase by phase. On the other hand, the Government has developed Agriculture Development Led Industrialization (ADLI) Strategy which supports the country to eradicate poverty and it is at the stage of its implementation. Based on the umbrella of this development strategy all sector development programs are at operational stage for the full implementation of the strategy.

The Government of Ethiopia has developed wide range of development program on the promotion and expansion of power sector and electricity service. Accordingly there are projects on going on power development, transmission and distribution. On the other hand the search on oil exploration and studies has been done and today this activity is strengthened. The purpose of oil exploration is to use fuel for the transport service and transport service will enhance the economic development of the nation. Realizing these factors for the last 15 years the Ethiopian Federal Democratic Republic of Ethiopia (EFDRE) has given high priority for infrastructure development.

The development of the infrastructure coupled with the high national income has exacerbated the demand for fuel. In addition to transport, fuel is important for industry, agriculture, households and societal service. Ethiopia imports fuel on average at the expense of 768 USD per annum and this covers 77 % of the total export earnings. The demand for fuel will increase when the economic growth of the nation increases.

In order to ensure the country's continued development program and the national fuel security, it is important to increase fuel utilization and substituting the demand by locally produces fuels such as biofuel. This document "*The Ethiopian Biofuel Development and Utilization Strategy*" is targeted for supply of fuels from locally produced biofuel and *the objective of the strategy is to ensure the production of biofuel without affecting food self sufficiency, import substitution and improve balance of payment*. And biofuel is defined as follows:

**Biofuel:** It is defined as liquid fuels produced from biomass; it excludes treatments of solid biomass as a source of energy. It focuses on ethanol and biodiesel based fuels on current available or near commercially developed technologies. The two most important biofuel are ethanol and biodiesel.

**Ethanol:** Ethanol is manufactured from microbial conversion of biomass materials through fermentation. Ethanol contains 35 percent oxygen. The production process consists of conversion of biomass to fermentable sugars, fermentation of sugars to ethanol, and the separation and purification of the ethanol. Fermentation initially produces ethanol, and separation and purification of ethanol. Fermentation initially produces ethanol containing a substantial amount of water. Distillation removes the majority of water to yield about 95 percent purity ethanol, the balance being water. This mixture is called *hydrous* ethanol. If the remaining water is removed in a further process, the ethanol is called *anhydrous* ethanol and suitable for blending into gasoline. Ethanol is “denatured” prior to leaving the plant to make it unfit for human consumption by addition of small amount of products such as gasoline.

**Biodiesel:** Biodiesel production, oil is extracted from oil seeds by mechanical crushing or solvent extraction. Byproduct is a protein – rich residue cake that can be used for animal feed. Oil is filtered, washed, decanted dried, and heated. It is reacted with methanol in the presence of base catalyst (typically caustic soda potash) at 50 °C in a process called *transesterification*. The biodiesel is purified by washing with warm water. For trouble – free operation in diesel engines biodiesel must be free of glycerin, catalyst, alcohol and free fatty acids.

Biodiesel fuels are oxygenated organic compounds- methyl or ethyl esters-derived from a variety of renewable sources such as vegetable oil, animal fat, and cooking oil. The oxygen contained in biodiesel makes it unstable and requires stabilization to avoid storage problems.

## **Competitiveness of Biofuel**

The development of biofuel has a benefit from the point of environmental protection and escalation of fuel price.

The major crops for biodiesel feedstock are *Jatropha curcas*, castor crop and palm tree.

### **i. *Jatropha curcas***

The *Jatropha* plant is growing at different areas of Ethiopia. It grows mainly in dry area and also it grows in mid and high altitude. *Jatropha curcas* yield varies from one agro-ecology to another agro ecology with different climatic conditions. For example; one of the highest oil yielding *Jatropha* variety, *Jatropha curcas*, can be grown in arid climates (rainfall as low as 200mm, mean temperatures of 20-25 degrees Celsius) and marginal soils to produce 1000 kg of oil per hectare (ha). A wide range of productivity estimates are currently given for the plant starting from 5 ton to 12 ton of seed per ha. Production of 5 tons of seed per ha can be expected for the plant in good soils and rainfall (900-1200mm).

In Ethiopia *Jatropha curcas* plantation may be produced at cheaper cost than other countries.

In Ethiopia *Jatropha* and castor oil cost is estimated from 0.45 to 0.76 USD per liter but in Germany it is sold for 1.3 USD. If the oil is transported to Germany the cost of transportation is estimated 0.575 to 0.885 USD. Therefore, export of *Jatropha* or castor oil to Europe is competitive in terms of cost.

*Jatropha curcas* oil production in arid area is estimated higher and it bears 22% better earnings than the edible oil production.

## **Benefit of *Jatropha curcas* production in farmers' holdings**

Three *Jatropha* plants can be planted within one row in one meter interval then within two rows six plants can be planted. On average in one farm holding<sup>1</sup> about 1200 trees can be planted and as fence also from 300 to 600 *Jatropha* plants can be planted. Hence at least 2000kg *Jatropha* or castor seeds can be easily produced. About 40% of the seed weight is oil. Therefore about 800litres of oil can be produced from one farmer's holdings. Accordingly farmers can use the oil for different purposes and they may sell it for biodiesel producing companies as result they can benefit.

On the other hand, Ethiopia on average imports about 1 billion liters petrol diesels. With the participation of 1.25 million farmers in biodiesel production program the import of 1 billion liters of petrol diesel can be substituted with biodiesel. At the same time by involving biodiesel producing companies the production will be in excess of local consumption and this will be a good commodity for export.

## **Byproduct of biodiesel**

The production of biodiesel leaves huge amount of byproducts, glycerol and seed cakes. One liter of biodiesel will leave 2kgs of seed cakes and this can be used for fertilizer and energy production.

For example: In Canada the cost of a liter of glycerol was 1.5 USD but the cost of 1 liter of biodiesel was 0.503 USD. Therefore the benefit out of the byproduct shouldn't be ignored.

## **ii. Castor crop**

Castor crop is growing in different localities in Ethiopia and it is indigenous plant. Suitable condition for castor crop growing zone is between 1600 and 2600 m.a.s.l and the rainfall distribution between 600 and 700mm with warm and dry climatic condition. The yield is estimated between 260 and 1250 kgs per hectare.

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<sup>1</sup> The farmers holdings is assumed to be on average 1 hectare and 0.025 ha is considered as extra land for other purposes and this can be used for biofuel growing

### **iii. Palm tree**

Palm tree grows 10 degree south and north of equator. The suitable temperature is between 22 and 32<sup>0</sup> C and 2000 mm rainfall is suitable for palm tree. In one hectare about 150 palm trees can be planted and from 5000 to 30000 lts of oils can be collected.

## **2. BIOFUEL STRATEGY FORMULATION NEEDS**

Bio-fuel demand in the world is rising, because of its many uses. Currently the increase of fuel prices is challenging economic developments, especially in countries which are registering accelerated economic development. Fuel demand is getting higher while the supply is getting less. Political and social unrest in some oil producing countries also contribute to the escalation and destabilization of oil prices in the world. The oil price increase, which is the result of the mismatch between demand and supply, is becoming the barrier for stable and sustainable economic development for many countries, particularly for the developing world.

On the other hand, since it is believed that fossil fuel use is the main cause for atmospheric air pollution and earth warming, international effort is being exerted to minimize the use of fossil fuels and to substitute by renewable energy sources. Accordingly, minimizing the consumption of petroleum fuels including hydrocarbons, undertaking energy conservation measures and renewable energy development activities have gained international focus and many countries are engaged in the implementation of the activities.

Because of the reasons noted above, energy use of countries is guided by the general direction of energy conservation and renewable energy source utilization. Under this general direction, wide range of development and research works on bio-fuels to use them as an alternative or substitute fuel for transport, rural industries and rural electrification is being carried out. Nowadays, bio-fuel use, in Brazil ( at large scale), North America and Europe, Africa including countries like Malawi, Mali, Kenya, Zambia

and other developing and developed countries is already started and the utilization is expected to grow in the forthcoming years.

The imbalance between fossil fuel demand and supply and the unstable price has confronted the sustainability of the economic growth it has brought negative impact on the import and export trade balance of the country.

Ethiopia has high labor force, land potential and suitable climate for the development of bio-fuels. Bio-fuel can help the country to reduce imported fuel demand and meet the national consumption. Even, the country has the potential to supply to the international market at large scale and thereby strengthen its international finance and technical cooperation.

Due to the existing fossil fuel constraint or shortage realities and so as to meet the demands by undertaking accelerate bio-fuel development activities in the country; it has become necessary to formulate a bio-fuel strategy which focuses mainly on:

- Arresting/withstanding the challenges of unexpected fossil fuel price increase, save foreign earnings and produce foreign currency by exploiting and availing alternative energy sources for the country;
- Enhancing rural development, industrial and service sectors by providing support and creating employment opportunities;
- Supporting soil and water conservation programs;
- Implementing environmental protection programs and measures.

### **3. STATUS OF BIO-FUEL DEVELOPMENT IN ETHIOPIA AND INTERNATIONAL OPPORTUNITIES**

The economic development policy objective of the Federal Democratic Government of Ethiopia has four features. Firstly, its goal and rationale is based on bringing/securing

rapid economic development. As the result of the economic development or gain it provides opportunity to the society or population to be the most beneficiary. The third feature is based on the strengthening of economic integration and improvement of the scale of the integration in a sustainable manner. The other feature of the policy objective focuses on building free market economy. Bio-fuel development strategy and direction formulation is, therefore, among the energy development efforts being carried out for meeting the national economic development objective.

### **3.1 DEVELOPMENT OF BIO-ETHANOL**

Ethiopia has three sugar real estate industries which are run and administered by Sugar Development Agency. These include, Fincha, Metehara and Wonji Shoa. Tendaho which is under construction and will be completed soon is the forth factory. Finch is producing 8 million liters of ethanol and the production potential will be increased in the future. The Metehara and Wonji are in preparation stage to produce ethanol shortly. In our country production of ethanol is expected to reach 35.1 million liter in 2002 Ethiopian fiscal year.

The Ministry of Water Resource studies indicate that the production of ethanol in the medium and long development term can grow to 1 billion liters. This amount can be produced, if integrated development activity is implemented in the identified 700,000 ha suitable land for sugar cane plantation. It should be noted that the 1 billion ethanol to be produced annually is nearly equivalent to 7 times of the current gasoline consumption of the country.

Table: Planed ethanol production by year and industry in m<sup>3</sup>.

Sugar Industry	1999 2006/07	2000 2007/08	2001 2008/09	2002 2009/10	2003 2010/11	2004 2011/12	2005 2012/13
Fincha	8,000	8,448	11,009	13,834	16,585	18,515	21,221
Metehara	---	---	7,311	11,700	11,700	28,183	35,527
Wonji	----	--	----	-----	---	15,428	20,728
Tendaho	-----	---	-----	9,602	24,428	38,205	50,689
<b>Total</b>	<b>8,000</b>	<b>8,448</b>	<b>18,320</b>	<b>35,136</b>	<b>52,713</b>	<b>100,331</b>	<b>128,165</b>

Source: Ethiopian Sugar Agency, July 1999 EFY

### 3.2 BIO-DIESEL DEVELOPMENT

Although production of bio-diesel is not yet started, various types of plant species which can be used for producing bio-diesel grow in the country. Favorable air condition and suitable soil type for bio-diesel development is available. *Jatropha*, which is very important feed-stock for bio-diesel grows in many parts of the country and used as a hedge and medicinal plant. Assessments, conducted in Amhara indicate that there are about 11 million wild and planted *Jatropha* plants in the Regional State. The plant grows in the Southern and other places and being used for many purposes as well. It has various names depending on the locations it grows. In some areas it is called ‘‘Ayderkie’’, which means Draught Resistant, and in some places it is called ‘‘Yedinber Shimagilie’’, which means Border Mediator since it is widely used as hedge.

Another plant which grows in many parts of Ethiopia and important feed-stock for producing bio-diesel is castor oil. Imported Palm tree seedlings are planted in 100 ha area in the Gambella Regional State for producing oil and soap around *Tepi Area*.

Ethiopia is endowed with natural resource suitable for bio-diesel development. In this regard, at national level, an estimated area of 23.3 million ha suitable land is available for development of bio-diesel. Regionally, the available land in million ha is : Oromia 17.2, Benishangul-Gumuz 3.1, Gambela 2.8, Somali 1.5, Amhara 1, Southern Nations Nationalities 0.05, Tigray 0.007. Statistical information for Afar and Hareri is not

available. It should be noted that there is information gap in some of the regions; nevertheless, the potential is expected to be higher than the available record.

Based on the Government development strategy local and foreign private investors have started growing plants for producing bio-diesel. Until recently, the progress shows that over 14 local and foreign investors are undertaking preparations for the development. Among these, about 5 investors already started implementation.

### **3.3 OTHER BENEFITS OF DEVELOPING BIO-FUEL**

The increase of air pollution from time to time has resulted in climate change, flooding and global warming in our planet and countries have set/establish mechanism for controlling these disasters .The Green House Gas (GHG) which is the major cause for climate change is mainly emitted from developed countries of industrial development activities. These countries known as annex-1 countries which have agreed to mitigate their emission potential to the year 1990 level until the year 2012. The non-annex countries are not obliged to implement the Kyoto protocol, carbon emission reduction, but are encouraged to develop and use renewable energy sources and get economic benefits by selling their carbon to the developed world. Therefore, Ethiopia can be benefited by developing bio-fuel, which meets and relevant to the clean development mechanism (CDM).

## **4. GOALS AND OBJECTIVES OF THE STRATEGY**

### **4.1 GOAL**

The goal of the strategy is to produce adequate bio-fuel energy from domestic resource for substituting imported petroleum products and to export excess products.

## **4.2 OBJECTIVES**

The general objectives are:

- Substituting mineral fuels by locally produced bio-fuels, in order to save and earn foreign exchange;
- Contributing to rural development through agricultural based growth by creating job in feedstock production, bio-fuel manufacturing, and in transporting and distribution of feed-stocks and products;
- Reduction of environmental pollution by harmful pollutants from vehicles exhausts (GHG emissions).

## **5. PRINCIPLES OF THE STRATEGY**

The strategy will be implemented guided by the following principles.

5.1 Ensure that it supports food security;

5.2 By looking seriously its negative effects on economic development, environmental and cultural values and by assuring land, water and grazing land being used by farmers and pastoralists;

5.3 By devising means for broad participation of farmers and pastoralists for benefit sharing.

5.4 Ensure that it maintains environmental sustainability. In this regard, emphasis will be given to the conservation and improving of soil fertility, water quality and biodiversity.

5.5 The by-products of biofuels will be utilized for various economic benefits and those which are toxic are to be detoxified for environmental safety.

5.6 Ensure sustainability of the country's economic resource development and secure the benefit on the use of biofuels.

5.7 The biofuel development will conform to the international effort on the mitigation and principles of greenhouse gases.

## **6. The Content of The Strategy**

In order to achieve the above stated strategic objectives and principles for bio fuel development and use, the strategy is adopted consisting of the following points.

## **7. Strategy for bio-fuel development and use**

### **7.1. Accelerating bio fuel technology transfer, research and development.**

7.1.1. Since the short term bio-fuel development strategy is to produce ethanol from sugar cane and bio-diesel from Jatropha, castor oil and palm oil, the technology transfer, research and development shall focus on these plants.

7.1.2. In the medium and long term development plan, the technology transfer shall focus; in addition to sugar cane, castor oil, Jatropha, and palm oil, on those imported or locally available seeds which may be mixed with benzene and naphtha or which may be substitute for benzene and naphtha, by improving their productivity and use while ensuring their compatibility to the environment.

7.1.3. To study the possibility of availing detoxified bio fuel byproducts for animal fodder, energy production, input to industries, and to prepare detoxification guideline to serve this end.

### **7.2. Increasing bio fuel development**

#### **7.2.1. Ethanol**

7.2.1.1. To produce ethanol from sugar cane.

7.2.1.2. To coordinate ethanol production with the Governments sugar industry development program. To ensure that land use for ethanol production shall be that allocated for sugar cane production and that which is not assigned for other use. In the event of demand increase for ethanol and when this is viable, to expand sugar farm accordingly and along with this to increase Ethanol production by decreasing, as may be necessary, sugar production.

7.2.1.3. To encourage participation of private developers in sugar cane and other related plant development.

7.2.1.4. To facilitate local and international market for ethanol production.

## **7.2.2. Biodiesel**

7.2.2.1. To produce bio-diesel from *Jatropha curcas*, castor crop and palm tree.

7.2.2.2. To ensure that allocation of land for development of bio-diesel such that;

in low and barren areas where rain fall is scarce the livelihood of the pastoralists should not be affected; and by coordinating with other farming activities without jeopardizing the farmers food production needs.

7.2.2.3. To support the participation of farmers and cooperatives in bio-diesel plant development and processing.

7.2.2.4. To coordinate bio-diesel development with rural and agricultural development and extension program.

## **7.3. Increasing bio-fuel use and export earnings**

### **7.3.1. Ethanol**

7.3.1.1. To commence low level mix of ethanol with benzene for use by vehicles and to increase the share of ethanol in the mix.

7.3.1.2. To ensure that government establishments play a leading role in the use of Ethanol.

7.3.1.3. To ensure that benzene driven imported vehicles are fit for mixed fuel of which Ethanol has a relatively higher level of share. To device incentive to encourage import of Flex Fuel Vehicles (FFV) and to issue and enforce directive accordingly.

7.3.1.4. To substitute ethanol for domestic fuel. Study and create favorable conditions for the domestic manufacturing, efficiency improvement and use of these bio-ethanol stoves and equipments.

7.3.1.5. To facilitate export market for ethanol production when satisfies the national need.

### **7.3.2. Biodiesel**

7.3.2.1. To ensure use of bio-diesel for transportation.

7.3.2.2. To ensure that imported diesel vehicles can be operated with mixed fuel of a higher level of bio-diesel. To device an incentive scheme for imports of vehicles fully operated with bio-diesel and accordingly to issue and implement directive.

7.3.2.3. To substitute bio-diesel for domestic cooking and lighting fuel, to study bio-diesel stove, lamps and other equipments, and create favorable condition for their domestic manufacturing efficiency improvement and use.

7.3.2.4. To achieve international standard for bio-diesel, in order to protect efficiency, standard and durability of vehicles and other equipments and also to win acceptance of the product in export markets.

7.3.2.5. To facilitate access to local and export market for bio-diesel product.

### **7.4. Involve Biofuel Actors**

7.4.1. To ensure that government sugar industries have leading role in bio ethanol production, use and expansion.

7.4.2. Comprehensive incentives scheme shall be devised for the private sector in order to engage them in the production of bioethanol from sugar cane and in the development of sugar cane in various areas.

7.4.3. Local and foreign investors shall be encouraged to extensively engage in the production of seeds appropriate for bio-diesel. To avail land at sites identified for purpose of bio-diesel plant development either at zero cost or via a long term lease.

7.4.4. To avail comprehensive support for the construction of bio-diesel processing plants and to include them in priority sector list.

7.4.5. To enable farmers to produce bio-diesel plants at deforested areas and at the adjacent margins of their farming lots and to facilitate market access for these products.

## **7.5. Efficient coordination and leadership for bio-fuel development**

7.5.1. A unit shall be established under the Ministry of Mines and Energy responsible for coordinating bio-fuel development.

7.5.2. A coordinating unit shall be established within the Ministry of Mines and Energy to facilitate collective efforts with other Ministries and government development agencies.

7.5.3. A forum shall be formulated where leading players in the field, investors and non governmental organizations are appropriately represented.

7.5.4. Continuous public awareness and public education on bio-fuel development and use shall be pursued to achieve comprehensive recognition and understanding.

7.5.5. The Ethiopian bio-fuel development and use strategy and its implementation shall be communicated to the international community in a sustained manner to solicit support.

## **7.6. Increasing finance for bio-fuel development**

7.6.1. To increase Federal Government investment on bio-fuel, to avail comprehensive support for bio-diesel processing plants, to include bio-fuel in priority sector, to avail

comprehensive support to establish ethanol processing plant at all sugar manufacturing factories.

7.6.2. To avail sufficient financial support for technology transfer and to ensure their practical use.

7.6.3. To facilitate finance and its sustained increase for enterprises engaged in bio-fuel development.

7.6.4. To enhance grant and loan facilities for bio-fuel development and enable Ethiopia secure maximum benefit from related international agreements.

7.6.5. To provide financial incentives for bio-fuel industry developers.

## **7.7 To enhance international cooperation for bio fuel development**

7.7.1. In line with the principle of international cooperation, enhance bio-fuel technology transfer around supply of seeds, bio-fuel production and application technology and sustain technology transfer and supply.

7.7.2. To work along with research and development institutions in other countries in order to achieve technology transfer and local manufacturing of bio-fuel processing equipments.

7.7.3. To work along with research and development institutions in other countries to achieve technology transfer in regard to bio-fuel application equipment.

**Ministry of Mines and Energy**

***The Biofuel Development and Utilization  
Strategy of Ethiopia***

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