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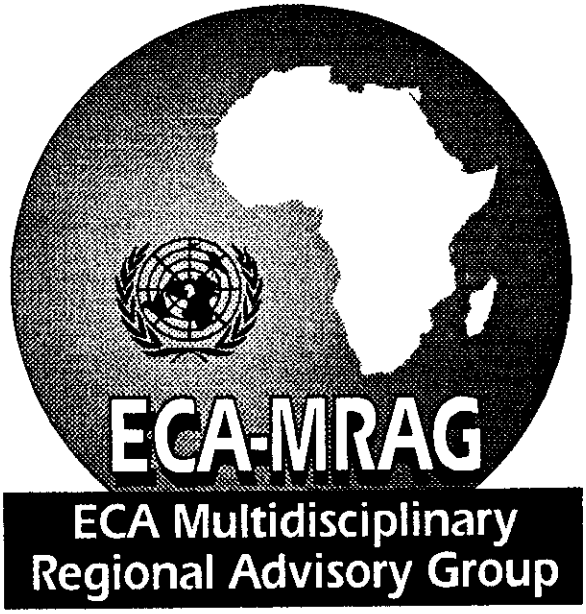

REPORT OF ECA-MRAG MISSION ON BIO-DIESEL PRODUCTION IN ZIMBABWE 18-21 NOVEMBER 1993

By
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Regional Adviser on Energy

November 1993

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Multidisciplinary Regional
Advisory Group (ECA-MRAG)

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Mission Request

The Ministry of Transport and Energy of Zimbabwe in a letter dated 13 April 1993, requested ECA to provide assistance with the study of the feasibility of cost-effective production of bio-diesel extenders which are biomass based liquid fuels suitable for blending with diesel fuel that the country has to import every year at considerable cost in foreign currency. A draft proposal of terms of reference (TOR) for the feasibility study accompanied the letter.

Rationale for the Study

Landlocked Zimbabwe currently imports all petroleum fuels used in transportation, agriculture, industry, mining, etc. at considerable cost in foreign currency. "Great savings" in foreign exchange had been made according to the draft TOR, by adding up to 20 per cent of locally produced ethanol to imported gasoline, to supply the gasoil fuel on which motorcars have operated in the country since 1980. The ethanol is produced from the molasses residue of sugar manufacture from cane. The Ministry expects that blending of suitable bio-fuels with imported diesel fuel would similarly help make substantial foreign exchange savings on the import bill.

The volume of annual diesel fuel imports constitutes about half of all petroleum imports and twice that of gasoline. The country's major foreign exchange earnings from exports of tobacco, cotton, maize, sugar, tea, coffee and meat pay for a considerable share of the petroleum import bill. The increase in annual diesel fuel requirements which grew 40 per cent between 1986 and 1990 is expected to continue due to increasing diesel fuel demand for

expansion of agriculture, transportation, construction, mining, trade and commerce.

Bio-diesel fuel investigations in Zimbabwe

The background section of the TOR includes a succinct summary of the work carried out by the Department of Energy of the Ministry on the performance of diesel engines operated on diesel fuel blended with three alternative bio-fuels namely, sunflower oil, butanol, and ethanol. Operating trials of diesel engine driven tractors and city buses on 80:20 per cent blend of diesel fuel and butanol are reported to have been the most satisfactory. On the basis of the successful results obtained, it is inferred in the TOR that at the price of 0.63 per litre of diesel fuel, the country would save $6,300 on the import bill on every 10,000 litres of butanol blended with diesel. The savings on the 654,000 litres of diesel fuel imported in 1990 would have amounted to $8.25 million if 20 per cent could have been substituted by butanol. The costs of local production of butanol appear to be regarded, in the TOR to be adequately off-set by employment generated in butanol production.

Objectives set for the feasibility study

Among the main objectives which the Ministry has set for the feasibility study are clarifications of the following:

a) The agronomic availability of feedstock for local production of bio-diesel extenders;

b) Financial/economic viability of local production of alternative bio-diesel extenders;

c) Requirements of bio-fuel production industrial plants to produce sufficient quantities for blending 20 per cent bio-fuel in all diesel fuel the country uses annually;

d) Requirements of safe storage facilities.

ECA discussions on bio-diesel production feasibility

The NRD which had received a request for similar assistance from landlocked Uganda, took the initiative of convening on 7 May and 9 July 1993, in-house discussions of bio-diesel production in Zimbabwe and Uganda. In view of the multi-disciplinary, multi-sectoral (agricultural, energy and industrial) nature of biodiesel production and utilization, JEFAD, IHSD and MRAG were invited to the discussions. Consensus was reached at the discussions that bio-diesel production may also prove to be of significant benefit to other landlocked African countries. Substantial additional foreign exchange costs of long distance overland transportation in land from sea ports, often raise the total landed costs of petroleum fuels in these countries to double or more of the f.o.b. price. Similarly heavy costs of overland transport of bulky agricultural commodity exports to seaports, mean correspondingly lower net foreign exchange receipts for the landlocked countries.

In a landlocked country where it is viable, biodiesel production thus offers prospects of substantial foreign exchange savings not only from reduced diesel fuel import volume but also due to reduced requirements of foreign exchange for overland

transportation. It would in addition help curtail the rate of build-up of fossil CO_2 in the global atmosphere, by reducing the volume of diesel fuel consumption, as CO_2 is re-absorbed from the atmosphere during the growth of the biodiesel crop.

Because of such considerations, a consensus emerged in the in-house discussions, that ECA respond to both the Uganda and Zimbabwe requests with proposals of multi-disciplinary missions to provide assistance with formulation of comprehensive terms of reference of feasibility studies of biodiesel production and utilization. It was however decided that because of the extensive operating trials already conducted, clarifications be obtained by correspondence on the status of butanol production if any, in Zimbabwe prior to mounting a mission.

Interest in production and use of biodiesel world wide

Diesel engines (or compression ignition engines) are widely used to provide motive power for both land and water transportation, farming, irrigation, rural power generation and rural small industry. Their role is particularly predominant in developing countries. Historically, vegetable oils were used to operate early diesel engines and in the 1930s and 1940s vegetable oils fuelled diesel engines often in emergency situations, but were later displaced completely by readily available diesel fuel from cheap crude oil. Diesel engines also operate readily on diesel fuels blended with various vegetable oils.

The oil crises of the 1970s revived interest and r & d into renewable alternatives to diesel fuels. Tests and demonstrations of diesel engine operation on diesel-vegetable oil blends have been

conducted in recent years in Belgium, Brazil, China, India, Indonesia, Malaysia, the Philippines, South Africa, Thailand, the USA and Zimbabwe to name just a few.

Research into the use of vegetable oils was taken up in South Africa in the mid 1970s. Development work from 1979 to 1985 had as an objective, the provision of a diesel like substitute of fuel for agricultural machinery in case of an effective international oil embargo. However, commitments to work which showed that sunflower oil has significant potential as an extender for diesel fuel, declined in the second half of the 1980s with the sharp fall of petroleum prices and the receding threat of an oil embargo.

A comprehensive state-of-the-art review of the status and opportunities of diesel fuels from vegetable oils, was published early in 1993 by Dr. E. Grifin Shay of the US National Academy of Sciences. He notes that much of the research, development, demonstration and production of diesel fuel substitutes and extenders continues to take place in the industrialized countries, but the potential and the need for such production and use is much greater in developing countries.

Some of the industrial facilities for biodiesel fuel production recently reported include:

- 10,000 tons per annum (tpa) from rapeseed oil in Austria;
- 20,000 tpa from palm kernel oil in Malaysia since 1984;
- 60,000 tpa from palm kernel and coconut oil in Indonesia, due to go into operation in 1993;
- 60,000 tpa from rape seed and other oil crops planned in Italy;
- 16,600 tpa from coconut oil designed in Canada;

- 10,000 tpa from soybean oil in USA;
- 36,000 to 360,000 litres per day plants evaluated in USA.

The industrial processing includes oil extraction from seed, removal of impurities and esterification to degum the crude seed oil to obtain a liquid ester with characteristics more similar to mineral diesel fuel. The process also yields chemical by products such as glycerin.

Annual oil yields

The African oil palm's 3 to 5 tons oil yield per hectare per year appear to be the highest among the cultivated oil seed plants. This is two to three times as much as the yield of groundnuts in second place, two to four times that of sunflower ranked third and four to seven times that of rape seed in fourth place (Shay 1993). The African palm a perennial, is cultivated best in wet tropical zones such as those found in Africa in a belt 10 degrees wide on either side of the equator. The annual crops of groundnuts and sunflower, are cultivated extensively for edible oils, particularly in the semi-arid zones which are widespread over Africa.

Among the less well known non-edible oil crops, Jatropha Curcas, a perennial with up to 4 tons per hectare annual oil yield (reported), is recently attracting much attention because it is well adapted to marginal land in drought-prone arid and semi-arid areas extensive in Africa. Cultivation of Jatropha Curcas for multiple benefits including soil protection and biodiesel fuel has recently been launched in Maharastra State in India with World Bank promotion. Its cultivation is recently being looked into in some African countries such as Mali with similar objectives in view.

Consultations on the Zimbabwe biodiesel study

The possibility of holding first-hand consultations on Zimbabwe's bio-diesel production study, suggested itself in the course of preparations for an ECA-MRAG mission to Mozambique scheduled 2 to 18 November 1993. Enquiries by facsimile and telephone in late October confirmed that senior staff of the Department of Energy would be available for consultations, if the report writer were to stay over in Harare 18 to 21 November on the return journey from Mozambique. It was learnt that there may also be an earlier opportunity for discussions while the senior staff member in charge of the bio-diesel study was participating in a SADC Energy Workshop 15-19 November, in Maputo.

It proved eventually possible to hold consultations in Maputo on 17 November 1993, with Mr. J.T. Chiguada, Asst. Director, Department of Energy. Further depth consultations took place in Harare on 19 November with Mr. C.T. Mzezewa, Director, Department of Energy together with his senior staff. The consultations clarified various aspects of the Department's interest in bio-diesel feasibility studies and of the trial operation carried out with butanol-diesel blends, which ECA had been unable to obtain by correspondence. The exchange of documents, information and ideas at the consultations has led to a consensus on a broader framework for the TOR of the feasibility study. Agreement has been reached in principle for the finalization of the TOR jointly with the Department during a MRAG mission to Zimbabwe early in the first quarter of 1994.

The main findings of the consultations

The main findings of the consultations in Maputo and Harare are summarized hereunder:

1. Zimbabwe has gained significant foreign exchange savings since 1980 by blending up to 20 per cent ethanol (locally produced from sugar cane molasses) into imported gasoline for the gasohol fuel of cars. The prospect of substantial additional savings on the country's diesel fuel import bill, has motivated the Department of Energy to conduct the trial operations of diesel engine driven tractors and buses using blends of diesel fuel with sunflower oil, butanol, and ethanol, which may be produced locally.

2. The availability in 1989 of some 900,000 tons of surplus maize stocks which had built up in Zimbabwe over and above supply of domestic and export demand of maize from which butanol could be produced with a well known industrial process, made butanol-diesel fuel blends of particular interest.

3. The 10,000 litres of butanol blended with diesel fuel in a 20:80 ratio for the tractor and bus operation trials, were not locally produced, but imported from SASOL in South Africa.

4. The surplus maize stocks were drawn down completely by domestic demand when maize harvests fell drastically during the severe drought of 1990-1992. Ethanol supplies for gasohol also fell drastically because of very poor sugar cane harvests during the severe drought.

5. Ethanol is a co-product in the process of producing butanol from starch. There is, therefore, interest in assessing the feasibility of producing both butanol and ethanol from drought tolerant starch crops such as cassava which can be grown in semi-arid areas widespread in Zimbabwe.

6. The feasibility of other biodiesel fuels such as edible and non-edible oils that blend well with diesel fuel should also be assessed.

7. The feasibility study should include the following additional factors in the assessment of a short-list of three to five most promising biodiesel fuel crop options suitable for biodiesel production and use in Zimbabwe.

7.1 Contribution to enhancement of security of supply of fuel at the national and local levels.
7.2 Job-creation in agriculture, industry, etc.
7.3 Rural income generation from the cultivation of the biodiesel crop by small holders.
7.4 Contribution of biodiesel crop to soil protection and conservation.
7.5 Mitigating global warming by avoiding additions of fossil carbon to the atmosphere that would occur if diesel fuel were used rather than renewable biodiesel which only recycles the same amount of carbon over time.
7.6 Co-products of bio-fuel crops and processing including food, fodder, fibre, fuelwood, fertilizer, industrial chemicals, etc.
7.7 Viability of biodiesel crop cultivation on large plantations and/or small farms.

7.8 Viability of biodiesel crop pre-processing on small scale on and off the farm.

7.9 Competition for land between food and biofuel as well as between export corps and biodiesel cultivation and comparative assessment of environmental impacts.

7.10 Comparative economic assessment between production of export crops to import diesel fuel versus production of biodiesel for (partial) import substitution of diesel fuel.

7.11 The foreign exchange component cost of biodiesel output per unit.

7.12 Additional costs of distribution and use of biodiesel extender.

Recommendations

In light of the foregoing, it is recommended that an ECA mission assist Zimbabwe's Ministry of Transport and Energy in the finalization of terms of reference for a comprehensive feasibility study of biodiesel production and use in the country.

The TOR should call for consideration of the following factors in the feasibility assessment of biodiesel production and use in Zimbabwe.

Economics, agronomic, industrial, energy balance, environmental, employment, rural income generation, balance of payments, competitions for land between food and biodiesel and between export crop and biodiesel crop cultivation.

The multidisciplinary mission could be mounted in the first quarter of 1994, and undertake finalization of the TOR working in close collaboration with staff of the Ministry of Transport and Energy.

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