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Summary Report

A PRELIMINARY REVIEW OF BIOMASS ENERGY OPTIONS IN COSTA RICA AND THE NATIONAL ALCOHOL FUEL PROGRAM

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PREFACE

This AID-sponsored report on the subject of biomass energy options in Costa Rica has been prepared as the result of a request for technical assistance made by Dr. Rodrigo Altmann, Primer Vice Presidente de la Republica, to the AID Mission to Costa Rica. The field work for the study was conducted by the author in cooperation with the AID Mission staff in San Jose, Costa Rica, during the period from October 31 to November 8, 1980. During the visit to Costa Rica, more than a dozen formal meetings were held with government ministry officials, university staff, AID Mission staff, and various business groups to discuss issues related primarily to a national alcohol fuels program. In addition, two trips were made to areas outside of San Jose to collect data on current sugarcane processing and conversion operations.

On November 25, 1980, a detailed trip report was submitted to the U.S.A.I.D. Mission in Costa Rica and to the USDA Bioresources for Energy Project by SRI. The contents of that trip report are shown in the Appendix.

This summary report is submitted as the final report for this project.

INTRODUCTION

For an oil importing country such as Costa Rica, where the agricultural sector dominates the economy and accounts for the majority of the export earnings, the possibility for expanded use of biomass for energy is a topic of great national interest. During the last decade as annual oil imports almost doubled from three million to between five and six million barrels per year, the total costs for oil imports increased over 20 fold from a 1970 level of $11 million to a level of $240 million by the end of the decade. During this same period, most world agricultural commodity prices did not keep pace with oil price increases. To illustrate the problem, the Minister of Energy of Costa Rica cited the fact that in 1970 a bag of exported coffee could buy 30 barrels of oil, yet today it will purchase only 4.

It is mandatory that import costs for petroleum be reduced so as to correct the current trade imbalance.

The goal of the expanded biomass energy program in Costa Rica is to reduce or replace current and future use of petroleum fuels. The major component of the new biomass energy program in Costa Rica is the production of ethyl alcohol. It is hoped that a substantial portion of current petroleum fuel use by the transportation sector can be replaced with alcohol fuels before the end of this decade.

This study is intended to assist the AID Mission and the Costa Rican government in identifying possible biomass energy projects that may be developed with partial financial support from the U.S. Government.

The major emphasis of this study was originally intended to be on conversion technologies for liquid fuels production from biomass. After reviewing the program status and options, it became clear that many agronomic issues and fuel distribution and use issues needed to be addressed and are as important, if not more so, than the conversion technology issues. These other issues have been addressed but not in-depth because the author's primary area of expertise is conversion technology.

SCOPE OF WORK

To assist the AID Mission and the Costa Rican government in identifying projects for which AID support may be possible, and desirable, we completed the following task items:

(1) Preparation of a summary of current energy use and energy resources and a review of alternative sources of renewable energy to replace petroleum fuels.

(2) The identification of biomass-based liquid fuels production options appropriate for Costa Rica.

(3) A review and summary of the current and proposed alcohol fuel programs.

(4) An analysis of the different alcohol fuel production options (including the Ex-Ferm process) and appropriate scales of operation for Costa Rica.

(5) An assessment of potential pollution problems and proposed resolutions for the alcohol fuels program.

SUMMARY OF FINDINGS AND CONCLUSIONS

Costa Rica currently depends on renewable energy sources (hydro power and biomass) for about 50% of its secondary energy needs. The other half is supplied by ~ 15,000 barrels/day of imported petroleum and refined petroleum products. The transportation sector accounts for about 60% of the petroleum consumption (25% is gasoline, 35% is diesel fuel).

The goal of the National Program for the Production of Alcohol Fuel is to substitute alcohol fuel for current petroleum-based transportation fuels during this decade. Current plans call for ethanol to be the alcohol fuel and for sugarcane to be the primary feedstock with molasses, cassava, and banana wastes as other feedstocks.

On the basis of a technical analysis of the other liquid fuels that can be obtained by using biomass conversion options, the choice of ethanol as the substitute fuel from biomass appears to be reasonable. Other substitute liquid fuels could become important in the future if wood can be produced on a sustainable basis as a feedstock for synthesis gas production and subsequent conversion to either methanol or Fischer-Tropsch liquids. The ability to sustain a high level of wood production does not now exist. Costa Rica has over 2 million hectares of forested land, but deforestation has been occurring in Costa Rica for several decades at a rate of over 50,000 hectares per year. This area is equivalent to 1% of the country's 5,100,000 hectares of total land area. It is estimated that 1 million dry metric tons/year of wood are now used for energy and another 300,000+ metric tons/year of wood products are produced for other purposes.

If wood does become available in the future as a feedstock for liquid fuels production, the production of ethanol from wood should be considered.

Costa Rica currently has over 400,000 hectares of land under cultivation for agricultural crops or between 8% and 9% of the total land area. Sugarcane production accounts for roughly 40,000 hectares of land use. Rice is the only grain now produced in quantities sufficient for export and is probably too valuable to allow use as an alcohol feedstock. Other starch sources, such as potatoes and cassava, now account for ≤ 5,000 hectares of agricultural land use.

Ethanol can be readily substituted as a supplemental fuel for gasoline engines in blends consisting of up to 20 vol% anhydrous ethanol and the remainder gasoline (gasohol). In 1980, Costa Rica commissioned a conversion facility that has the capacity to produce 240,000 liters/day of anhydrous ethanol from molasses and sugarcane juice. If the feedstocks were available for operation at full capacity during the normal sugarcane campaign of four months, the facility could produce about 30 million liters of alcohol or about 15% of the annual consumption of gasoline. Because of the very high current world sugar price, however, it is not economical to produce alcohol. In addition, storage and distribution of anhydrous alcohol or gasohol presents many problems because of the high humidity conditions in Costa Rica. Although a gasohol program will continue, the major thrust is to produce hydrous ethanol (95 vol% ethanol, 5 vol% water) as a replacement fuel for petroleum fuels. Six projects with a combined capacity of over 400,000 liters/day have been proposed. If all are constructed and operate at full capacity for 300 days/year, the total production would be 120 million liters/year or about 60% of the volume of gasoline consumed.

Based on published data from automobile companies with production facilities producing engines for the Brazilian market, the use of alcohol fuels in gasoline engines and diesel engines may require the following relative volumes of fuel:

Engines	Ratio of Alcohol/Petroleum Fuel
Gasoline	1.15 to 1.2/1 (could be higher)
Diesel	1.7/1

The data for use of ethanol fuel in diesel engines are preliminary in nature because no large-scale use of alcohol fuel alone in diesel engines is under way anywhere in the world.

Using the above fuel requirement figures plus estimated sugarcane yields of 60 to 80 metric tons/hectare/year, a cassava yield of 20 metric tons/hectare/year, and ethanol yields of 62.8 liters hydrous alcohol/metric ton of cane and 153.9 liters hydrous alcohol/metric ton of cassava, we calculated the following agricultural land requirements for an alcohol fuels program (1980 fuel consumption levels):

	1000 Hectares of Land	
	Sugarcane Only	Sugarcane (50%)/ Cassava (50%)
Gasohol program	8 to 11	--
Complete gasoline substitution	49 to 65	64
Complete diesel fuel substitution	96 to 128	126

In comparison to the total land area now planted in sugarcane and cassava (40,000 hectares and 3,000 hectares, respectively), the agricultural land requirements for complete substitution of petroleum fuels in the transportation sector are enormous. Complete substitution of all gasoline and diesel fuel by ethanol would require almost a 50% increase in the total land area now under cultivation in Costa Rica.

The current plan is to produce all of the sugarcane for alcohol in areas not currently producing sugarcane for sugar production. These areas include the Northern zone, the Atlantic zone, and portions of the Southern Pacific zone.

The major issues to initially resolve appear to the author (a conversion expert) to be agronomic. Some of the issues discussed during the field visit included:

- The feasibility of harvesting sugarcane and cassava all year in high rainfall areas in the Atlantic zone (the ability to use mechanical equipment for planting, cultivating, and harvesting sugarcane and cassava).
- The yields of sugar and starch crops in areas not now under cultivation in the North and in the Atlantic zone.
- The suitability or other crops, such as sweet sorghum, for inclusion in the alcohol fuel program.
- The characteristics of sugarcane grown in high rainfall areas without a well-defined dry season (total sugar content and variation of sucrose and hexoses content during the year).
- The desirability and feasibility of producing a high fiber content sugarcane.

On the subject of nonalcohol renewable energy options to reduce petroleum fuels consumption, several possible projects appear to warrant further consideration:

- Near-term use of conventional electrically powered mass transit vehicles to take advantage of Costa Rica's great hydroelectric resources.
- Near-term use, in mainly rural areas, of vehicle-mounted gasifiers operating on wood chips or pelletized fuels produced from excess bagasse.
- Future use of electric cars.
- Anaerobic digestion of animal manures and other agricultural wastes such as bananas.
- Recovery of energy from municipal solid wastes.

An anaerobic digestion system for manure from animals fed in confinement could be cost effective if the herd size is large enough. The product fuel gas could be used to replace a portion of diesel fuel currently consumed by stationary diesel engines that generate power or drive mechanical equipment on remote farms. Other agricultural wastes, such as bananas, could also be a feedstock for anaerobic digestion. A feasibility study for several typical sites appears warranted.

Solution of the current municipal solid waste disposal problem in the San Jose metropolitan area could possibly alleviate the fuel needs for some industrial boilers. Refuse-derived solid fuel could possibly be shipped to sites near the city for use as a fuel for ethanol production from starch crops.

Some topics to address concerning conversion technologies for the alcohol program include:

- The economics of using electric motor drives (using hydroelectric power) as opposed to steam drives for existing as well as future sugarcane processing operations to allow alternative use of the bagasse as a fuel.
- The possible sources and costs of energy for conversion of starch crops (such as cassava) to ethanol, including geothermal, wood, bagasse, or coal.
- The optimum method for treatment of stillage. (Support should continue for development work and demonstration of anaerobic digestion using fixed-film reactors.)
- The technical and economic feasibility of processes that employ one or more fermentation reactors containing chopped or milled sugarcane. (Ex-Ferm process or minidistillery project at the University of Costa Rica.)

The processes mentioned in the last item above require further research and development work before detailed economic analyses can be completed. Some of the development work could be efficiently done on the minidistillery project at an existing trapiche near San Jose. The project could serve as a portotype installation readily accessible to researchers as well as future users of the technology.

If excess bagasse can be produced at alcohol plants either by modifying the processing train or increasing the fiber content of the cane, fuel pellets could be produced for use as a boiler fuel or gasifier feedstock.

On the subject of the scale of ethanol production operations most appropriate for Costa Rica, it is impossible to make any definitive recommendation at this time. The government of Costa Rica strongly supports large projects with individual plant capacities of > 100,000 liters/day of alcohol.

Environmental impacts from the alcohol fuels program may be associated with:

- Agricultural production and delivery of biomass feedstocks
- Facilities to convert biomass to fuels or energy
- End use of biomass-derived fuels.

An integrated environment assessment should be conducted. Work is currently under way at the University of Costa Rica on the problem of stillage disposal and this effort should be continued.

The various organizations contacted by the author have many staff members whose knowledge and experience are vital to the success of any biomass energy program. Other organizations not contacted by the author are also reported to be able to offer assistance in key technical areas and may already be doing so. It does not appear, however, that all the professional resources now available in Costa Rica are being fully utilized. The formation of a government steering committee with several subcommittees in the areas of biomass production, biomass conversion, and biomass fuels utilization may be a solution to this problem.

At the time of the author's visit to Costa Rica, no comprehensive study had been completed to estimate the costs and the benefits of an alcohol fuels program. A study was in progress and results are to be released shortly. The study should be a valuable document to assist AID staff and consultants in identifying projects for AID support.

Appendix

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REPORT ON TRAVEL TO COSTA RICA
14-21 February 1981
GEORGE BEINHART
USDA-FS/SEA BIO-RESOURCES TEAM

Purposes of this trip were to attend an international seminar on technologies for converting biomass to fuels and chemical feedstocks; to establish contacts with organizations and individuals working with biomass-for-energy in Caribbean and Central- and South American countries; and to visit a "jojoba research center" and commercial jojoba plantation.

1. The seminar, "Fuels and Chemicals from Biomass through Fermentation Processes", was organized by Instituto Centroamericano de Investigacion y Tecnologia Industrial (ICAITI, headquartered in Guatemala City) with support from the Organization of American States (OAS), United Nations (UNEP/UNESCO/ICRO), and several Central American national and regional organizations.

Registration and a reception were held on Sunday, 15 February, at the Herradura Americano Hotel outside of San Jose. Technical sessions were held at the same site on the following three days: Monday was devoted to biogas production and utilization; Tuesday's program covered microbiology and production of chemial intermediates; on Wednesday, papers dealt with ethanol production (see copy of program, Attachment 1).

Of the 16 technical papers presented, 10 came from U.S. public institutions and private companies, 3 from Mexican (two by U.S.-trained authors), and one each from Canada, Guatemala, and Brazil. The majority of the presentations were academic in nature, heavily weighted toward sophisticated treatments of engineering and biochemical principles, and drawing mostly from laboratory and pilot-plant research performed in the U.S. Most of the speakers were well acquainted with each other and with each other's work, and apparently represent the mainstream of the U.S. biomass engineering establishment.

A total of 77 attendees registered for the seminar including 17 speakers and 3 ICAITI representatives who carried out the organizational work (see list of attendees, Attachment 2). Costa Rica (33 persons) and Guatemala(7) had the most attendees. Other nations represented were Honduras (2), El Salvador (1), Nicaragua (4), Dominican Republic (1), Venezuela (1), Ecuador (2), Peru (2), Uruguay (2), and Paraguay (1); most of these persons received OAS and/or UN scholarships to attend the seminar. At the conclusion of the seminar, the scholarship recipients were to proceed to Guatemala for two weeks of "hands-on" training in biogas and ethanol production in ICAITI facilities. Since the attendance list only became available on Wednesday, I was unnable to identify all of the scholarship recipients, nor their institutions, nor the state of biomass-for-energy programs in their respective countries. On the basis of several informal conversations, however, I gained the impression that most of them are involved in academic research and teaching, rather than in action programs of government ministries.

The speakers were all well prepared and the general quality of presentations was very good. Despite my own misgivings (was theory emphasized at the expense of practice? Were cited examples in U.S. really comparable to Latin American situations? And so forth.), all of the attendees with whom I talked expressed satisfaction with the program. The seminar seems, therefore, to have been a complete success.

2. Informal discussions during the week provided opportunities to discreetly advertise our Bio Resources Team and our relationship to USAID, and to talk about possible future situations in which we might interact with national or regional activities. We have already made contacts with OAS, and I made a particular effort to establish similar contacts with ICAITI; both of these organizations are supporting biomass work in Latin America, and collaboration with them could be useful to our team in fulfilling our PASA responsibilities.

On a visit to the University of Costa Rica campus in San Jose, I observed work on a biogas generator (Department of Chemical Engineering) that is to be installed at a rural school. In the Chemistry Department, we met Dr. Orlando Bravo who is receiving (or seeking) some AID money for an ethanol-from-sugar cane project. A consultant had been sent recenly by our team to review this project; there had been some adverse reactions to that visit, I believe, so I did not emphasize it in my conversations with Dr. Bravo.

3. Jojoba has relevance to our team because we were recently asked by AID Africa Bureau to comment on its potential value as an introduction in some African LDCs. Monte Galan S.A. is a Costa Rican company (apparently owned by non-Costariccenses) that is promoting jojoba as "the super bean of the future". On Thursday, 19 February, I drove a rental car to Liberia (near the Nicaraguan border in the Province of Guanacaste, some 200 kilometers northwest of San Jose), near which I eventually found the Monte Galan Jojoba Research Center. With well-arranged seed germination and nursery facilities, offices, a laboratory (not yet equipped), at least two modern residences situated in the shade of a mango orchard, and neat rows of young jojoba trees (irrigated), the research center is an impressive sight. After explaining my interest in jojoba, I was given a brief tour of the center and permitted to take photographs. The guest book contains many names, and it is obvious that visitors are not rare; presumably those interested in investing in the company receive warmer welcomes than those who come representing the USDA Bioresources Team--which is understandable.

I was given directions to Monte Galan's plantation (reputedly 1000 hectares already planted) and found it in a hilly region south of Liberia. The hillsides are being terraced and seedlings set out in contoured rows. The foreman of a labor crew politely refused me permission to inspect the plantation until I could produce written authorization from a company official whose whereabouts were not known. My zeal for jojoba wilted before the prospect of a prolonged search for an elusive quarry, and so I settled for general observations as I drove past the terraced plantings on my way out.

The plantation is in an area that is (at least seasonably) dry but certainly not arid; surrounding lands are mostly rangelands and the cattle appear well fed. I saw no evidence that the terraces are irrigated but water for irrigation is available in the region. Land preparation, including terracing the hillsides, must be a major expense for this plantation, and the entire operation appears to be based on extensive use of heavy equipment. I did not see any trees and assume that they are still seedlings (one to two years in age) not easily visible from a moving automobile. I have no reason to doubt that the Monte Galon jojoba trees will eventually clothe the slopes; the company seems to be proceeding in an orderly fashion. On the other hand, a meaningful evaluation of jojoba as a commercial crop in Costa Rica will have to await the time when this young plantation is actually producing marketable seed--and that is at some time in the future.

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