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# Biofuels, International Institutional Concerns in a World of Uncertainty

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It's a pleasure to be here today. I hope to share some observations that speak to our mutual concerns. The title of this paper implies a perspective common to all international donors, however, I can speak only for the Agency for International Development (A.I.D.) as one institution in a diverse foreign assistance community. Before delving into the subject of biofuels, I will first outline the broad parameters of the energy problem and A.I.D.'s particular program in the Latin American region.

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The challenge of the current energy problems facing the world's people has aspects at once similar and different for all involved. The similarity is that the availability and use of energy provides the nations of the world with choices and limitations as to how they seek and satisfy the demands for quality survival. The difference lies in the diversity of local, national, and global energy systems and the unprecedented levels of uncertainty that enshroud the energy situation in almost every nation of the world. Energy is, in some form, an element of every physical activity in the universe, including every productive (and destructive) activity of mankind.

Energy flows and their pervasive role in our lives and in the increasingly complex systems in which we live is being connected more and more with influences and changes that were seldom if ever a consideration a decade ago. For example, ten years ago hardly anyone besides engineers worried about this necessary ingredient--energy. Where were energy issues included in our economics, sociology, and political discourses prior to, say, the OPEC embargo?

Nowhere has the energy uncertainty been more troublesome than in the oil importing developing countries. These countries, most with growing populations, have found that their ability to acquire needed resources is rapidly diminishing. In real terms, the world price of oil has risen only four times what it cost a decade ago. Nevertheless, the changes in terms of trade for major products are more sobering. Where 62 pounds of exported bananas used to purchase a barrel of oil, it now takes 16 times that, or 1,000 pounds. Likewise, in 1970 a 60-pound bag of coffee bought 30 barrels of oil, whereas it could pay for less than three barrels in 1980.

These numbers, however, may reflect short-term fluctuations in commodity prices. Therefore, it is useful to look quickly at some historical averages, as presented in the following table.

Table I. Critical Latin American and Caribbean region export commodities and the percentage of production increase (over 1960-73 base period) needed to buy one barrel of crude oil at average 1981 prices.

| Commodity | Nation | Production Increase Needed |
|---|---|---|
| Bananas | Many nations | 939 % |
| Cocoa | Many nations | 540 % |
| Coffee | Many nations | 450 % |
| Fishmeal | Peru, Chile | 840 % |
| Sugar | Most nations | 320 % |
| Bauxite | Guyana, Jamaica | 549 % |
| Nickel | Dominican Republic | 660 % |

To summarize, the rise in oil prices, since the 1960-1973 base period, means that it has become necessary to produce from 320 to 939 percent more in traditional regional export products in order to buy an equivalent barrel of oil at 1981 prices. And these numbers reflect only the uncertainty and profit squeeze brought on by energy costs. They do not include other factors that affect the profits of export industries and stresses on the economies of the region, factors such as inflation in the price of labor, insurance, transportation, taxation, and the unprecedented increase in the cost of money.

These declining terms of trade have led to growing foreign debt and balance of payment problems. Several Latin America and Caribbean (LAC) countries are spending as much as 50% of their export earnings on imported petroleum and debt service. This loss of foreign exchange is dramatically diminishing the ability of developing countries to finance supplementary energy sources or to shift to ultimately cheaper fuels while maintaining investments critical to national development.

Traditional fuel prices (e.g. for wood and charcoal) have risen in tandem with conventional fossil fuel energy costs. In many places, the urban and rural poor must expend from 20 to 40% of their average daily wage for firewood alone. The impact of this expenditure for cooking fuel is magnified when one considers the significant portion of the daily wage that is expended on housing, clothing and transportation, leaving only a meager remainder to purchase food.

Whatever the precise causes, diminishing fuelwood supplies and soaring petroleum prices are seriously aggravating the increasingly precarious social, political and economic situations in the majority of LAC countries.

The problems of oil imports and rising fuelwood prices are compounded by population growth rates that are outstripping the economic growth in many of these countries, thereby reducing per capita income and leaving national coffers with fewer resources to make needed investments. The enormity of the problem relative to donor budgets requires that we perceive our role as catalytic.

For example, A.I.D.'s energy-related programs aimed at the LAC region amounted to only $18 million in 1981 and an estimated $26 million in FY 1982. These amounts are almost insignificant when compared to that area's multi-billion dollar oil bills. It should be clarified here that A.I.D. assistance to the region is all concessional, the hardest terms being a minimum of 20 years at a maximum of 5% interest, and that this assistance is currently directed only to: Peru, Ecuador, Guyana, Dominican Republic, Haiti, Jamaica, many of the independent islands of the eastern Caribbean, Panama, and the countries of Central America. Although A.I.D. energy program budgets for Latin America have grown rapidly from about 2% in 1980 to what is now nearly 10% of the total U. S. economic assistance to these countries, it should be noted that despite this expansion, very little has been used for biofuels work, with the exception of fuelwood work, which I will address later.

A.I.D's Bureau for Latin America and the Caribbean (LAC) has adopted an approach to the region's energy problems that is essentially three-fold. To date, A.I.D. has given attention first to building the national and regional analytic, technical, and institutional capabilities necessary to address existing and anticipated energy problems and opportunities effectively. Coupled with training and technical assistance, a focus of this effort is to develop an understanding of the rates and directions of energy related change, through energy source and use accounting, energy balances, and energy systems assessments. The envisioned results include national energy plans with rational investment strategies.

Second, A.I.D. is concerned with improving the strength and stability of the economies in the region by helping to seek solutions to national and local energy problems. Many of our energy programs are aimed at reducing the region's dependence on imported oil through 1) technologically increasing the efficiency of direct and indirect energy use, and 2) testing and developing substitutes for oil, ranging from coal to renewable sources.

The third element consists of continuously monitoring and evaluating existing programs and the context in which they are operating. This ongoing review process is designed to identify the impediments to project completion, so they can be minimized or eliminated, and to determine whether the original project plans remain valid or whether they need to be modified -- or sometimes radically redesigned. Through these exercises, A.I.D.'s energy activities in the region will hopefully become more efficient in their use of available funds and more responsive to the actual and specific energy needs of the individual countries. In other words, we do not wish to develop energy projects that merely represent a contemporary, static state-of-the-art, but rather to make current projects work to define an experiential basis from which more effective future programs can evolve, regardless of the source of investment funds.

Because of the relatively small amount of financial resources available to A.I.D., our projects in the energy area must use the Agency's comparative advantage in certain development techniques that are likely to have the greatest short and long-term positive impacts. These projects fund activities that would generally be difficult to finance privately because of the economic risk involved, low rates of return, and/or impacts that are too long-term.

Broadly speaking, these projects fall into two categories, with most projects being a hybrid of both. The categories are: 1) projects intended to improve and stimulate further activities, and 2) projects that directly produce, save, or substitute energy resources. Examples of activities in the first category include: energy assessments, energy planning, energy investment strategies, energy pricing and efficiency studies, and training and institutional development. Examples of activities in the second include: assistance in the implementation of energy investment strategies, changes in policy and taxation, direct investments in industrial audits and fuel efficiency adjustments, and demonstration and levered investments in mini-hydro, or wind electric generation, and woodstoves and solar technologies.

A.I.D. and other international donors are poignantly cognizant of the need to recognize and make appropriate use of all resources of importance in the recipient countries. The potential of biomass is no exception.

Photosynthetic conversion of sunlight is the basis of all living systems. If we include agriculture and fisheries, photosynthetically produced biomass can be seen as the basis for most of the economies in the LAC region. In addition, for the majority of countries where A.I.D. has active programs in the region, biomass fuels still supply nearly 50% of national energy requirements. These fuels, mostly firewood, charcoal, and agricultural residues (principally bagasse), are used for direct combustion in households, rural industries, and sugar mills. Although the quantities of biomass available are immensely greater than current consumption, there are some significant constraints to expanded bio-energy utilization, which I will discuss later.

The following is a brief enumeration of the bio-energy work the LAC Bureau of A.I.D. is currently pursuing. (An appendix to this paper summarizes the bio-energy program of A.I.D.'s Bureau for Science and Technology.) First of all, A.I.D. is funding resource management projects that principally concern themselves with reforestation, afforestation, and watershed and soil protection in countries such as Ecuador, Panama, Costa Rica, Honduras, Dominican Republic, and Haiti. Second, A.I.D. is financing species trials of fast-growing tree varieties for wood lots and energy plantations in Ecuador, all of the countries of Central America, and Hispaniola. Third, more efficient wood stoves, wood-burning kilns, and charcoal production technologies are being demonstrated in the same countries where new wood production techniques are being tested. Additionally, solar drying of wood and bagasse prior to combustion is being done in Guatemala and the Dominican Republic in order to explore improvements in the heat values of these resources. Finally, and of greatest interest to this audience, we are beginning to fund bio-conversion demonstrations that produce fuels that substitute directly for currently imported oil. These adaptations of known technologies include: biomethanation of animal wastes to produce gas for cooking and lighting, gasification of wood residues to fuel small electrical generator sets, utilization of coffee by-products to replace fuel oil used for drying, and wood-fired boilers to provide steam for electricity generation.

In many nations of the region, more than 60% of imported petroleum products were consumed by the transport sector, yet this major portion of oil used for transportation is the most difficult to deal with. Reducing liquid fuel requirements for transport through conservation and modal shifts is proving harder than energy savings in industry. One reason is that, for example, for freight, few alternate modes of transportation are cost-effective, and they often require enormous investments in railways, shipping lines and barges, and associated infrastructure. The only notable attempt at serious rationalization of the public transport sector, at a low cost, in the hemisphere is in Curitiba, Brazil, where the existing bus and road system was strengthened in order to make collective transport relatively more attractive. Because more energy-efficient transportation technologies seem to be either

non-existent or inordinately expensive, alternate transport fuels have attracted a great deal of interest from countries and donors alike. While a number of liquid fuels can be produced from biomass, particular emphasis to date has been given to the alcohols -- especially ethanol and methanol.

Among international donors the World Bank, the Inter-American Development Bank, and the Organization of American States have given special attention to alcohol for fuel. All three institutions regard alcohol as a minor component to the solution of national energy problems. Ethanol is also seen as a temporary solution which may eventually be substituted by methanol.

In response to requests for financing from Kenya, Brazil, and Thailand, the World Bank began looking at alcohol in 1978. Their report, Alcohol Production from Biomass in Developing Countries, has been a major source of information for LDCs, and was distributed by the hundreds at the UN Conference in Nairobi. The World Bank is loaning Brazil U.S. $250 million over three years to provide foreign exchange to assist that country in financing its national alcohol program and related research. The Bank's Industrial Projects office is currently studying possible ethanol projects in several other countries.

The IDB is loaning the Companhia Energetica de Sao Paulo (CESP), in Brazil, U.S. $26.4 million to finance 20% of the cost of three methanol producing wood gasification pilot plants.

The OAS has several departments which have concerned themselves with alcohol fuels. However, the International Trade Office has assumed the most aggressive role in alcohol fuels promotion. This group is commodity and market oriented and their interest emanates principally from a concern about the decline of sugar industries in the region which cannot compete with the growing supply of cheaper cane sugar substitutes. Currently, this office is proposing an Inter-American Alcohol Program and has been conducting alcohol assessments in Colombia, Costa Rica, and the Dominican Republic.

Having given you all of the preceeding by way of an extended introduction, I would like to focus, during the remaining time, on some of the difficult issues all development agencies and public planners must face when considering biomass-to-energy programs in general, and particularly ethanol production projects. (Notable speakers before me in this symposium have admirably reviewed many technical aspects of and innovations in the production, conversion, and utilization of bio-fuels, and therefore, I will confine my remarks to the more systemic concerns and questions that A.I.D., as a donor institution, must address.)

As we all know, the bio-energy field is very broad, involving a large variety of resources, processes, and products. The possible combinations of feedstocks, conversion technologies, and end-use applications are innumerable. Many site-specific concerns ranging from the ecology, geography, and related characteristics of land and water masses, to the economy and energy consumption patterns of the region must be considered before a decision to finance these biofuels production activities can be made.

The complexity of the interactions between natural and human systems, between the ecological, social, economic, and institutional aspects of a region or country, requires that the best processes for identifying all possible options are used to evaluate bio-energy investments. One problem that inhibits the development of adequate information processes for wise decision-making is the lack of coordination and communication between recipient country organizations (i.e. Ministries of Energy, Commerce, Planning, Transportation, and Agriculture) and also between international donors on their related efforts. Pertinent, current, and reliable information is often insufficiently available or unsuitably organized to support development in the biofuels area.

The inadequacy of information and of information exchange between institutions is magnified by the dearth of skilled individuals with some biofuels expertise, who can collect, analyze, or exchange relevant information. Studies such as those done by the National Academy of Sciences on Firewood Crops and the Diffusion of Biomass Technologies, along with the Bio-Energy Council's Bio-Energy Directory, are helpful references, but they are admittedly first attempts at bridging the information gap. Much more needs to be done, and done in such a way that it reaches and is useful to all actors in the development process, from donors and investors, to country planners, technicians, and extension workers.

I think it is fair to say that, as a consequence of the lack of biofuel expertise in both developing countries and donor institutions, bio-energy technologies have not yet precipitated the development imagination into overt action. Of course, another, more significant reason for limited biofuels development is the absence of experience with good, bankable projects with decent feasibility analysis. In other words, unless we understand a project and have confidence that it will pay for itself and has a fair chance of being continued and replicated elsewhere, most donors will be reluctant to fund it. Additionally, for the same reasons and with few exceptions, there has been no great clammering from LAC countries for international assistance with biofuels development.

The question now is why. Why, despite the apparent potential and the great need, are there not more bio-energy activities in the region? Why has A.I.D., despite growing expenditures in energy, not given more attention to biofuels? A partial answer, from the A.I.D. perspective, will be the subject of the remainder of this presentation.

In the report from the Technical Panel on Biomass Energy prepared for the United Nations Conference on New and Renewable Sources of Energy held in Nairobi last summer, it was stated that, "It is quite clear that although biomass is one of the best (renewable energy) options it is one which has not received much attention from policy planners at the national and international levels." I think this is somewhat misstated. Increasing attention is being given to biofuels. But, to date, the information has been either incomplete or it has indicated that biomass may be a lesser option than advertised, particularly in the long run. As variables such as raw materials costs,

technology costs, prices of other fuels, job creation, environmental management, traditional relationships to the land, and political imperative, and national security, are evaluated an emerging uncertainty about bio-energy projects can be identified.

Additionally, there are a number of cross-cutting issues that go beyond the economic, social, environmental, financial, institutional, and managerial factors commonly considered. A partial listing of concerns that may not normally be included but that can not be ignored, by national and international planners, follows:

-- The structure, function, efficiency, and factors of competition in the existing energy-using system to which the biofuel is applied.

-- Agroeconomic analysis of the opportunity cost of producing fuel versus food or export products.

-- Private sector involvement; what is necessary to reward the entreprenuer for his or her participation in biomass development?

-- The scale of operation and its microeconomic effects on profitability versus the macroeconomic distributional aspects of decentralization.

-- The fraction of the "oil barrel" being replaced. If the light distillates are substituted by alcohol, what does that mean for making efficient use of the refinery mix of products? Or how do you substitute for the medium and heavy distillates?

-- Government policy and strategy. What kinds of subsidies, tax credits, and incentives will be used, and what impacts will they have?

-- How to encourage local involvement, through adaptive R&D, training, and utilization of available skills.

-- Intersectoral environmental aspects, such as effects on soil fertility and stability, water resources, animal populations, or atmospheric $CO_2$.

-- Calculations of the energy returned for energy invested as a measure of the physical competitiveness of a particular biofuel product.

All of the standard analyses have been applied to site specific cases of bio-fuels development, and most of the additional concerns just listed, have been addressed by various researchers and academic panels at one time or another. Rather than edit this voluminous and mostly competent body of literature, I have chosen to focus on only one of the listed concerns -- the last one -- related to net energy analysis, e.g., the amount of energy profit resulting from an energy investment. Because energy analysis is often so poorly understood by both planners and technicians, I thought it would be useful to briefly discuss some of its advantages, disadvantages, and implications for biofuel technologies.

I realize the subject of energy analysis is controversial and that there is little agreement on the methodologies for dealing with it. The following discussion is, principally, intended to deal with one type of energy analysis -- net energy analysis -- as a quick case study of the kinds of problems all decision-makers face when attempting to objectively review new technologies.

The focus of net energy analysis is not so much to determine whether a technology has a positive or negative yield as to apply a physical measure to the technology and the system in which it is developed and used. A physical measure allows evaluation in terms that are minimally affected by human bias, and thus offers the potential to reduce the uncertainty associated with a number of factors related to the development of energetically competitive systems.

Some examples of where net energy analysis can be of value are as follows:

-- Where non-market forces, such as energy related ecological circumstances of soils, water, climate and plant populations need to be measured. Energy analysis can get at the kinds of numbers economic analysis is looking for more effectively because it is a harder measure of the externalities of the process being evaluated.

-- Where energy measures are used in conjunction with money measures to gain a better understanding of the time delays and other distortions in price signals, often caused by regulations, incentives, and hidden subsidies. In other words, energy measures can provide a perceptual hedge against inflation and indicate caution where short-term economics may make a technology attractive, but where, in the long run, it may be outcompeted by cheaper alternatives -- for example, ethanol by methanol.

-- Using energy -- in net energy profit analysis -- to provide a physically based measure of the relative merit of various technological options. The measure would be particularly useful in comparing the capabilities of different energy systems to concentrate energy into useful forms and in refining the efficiency of low but positive yielding technologies.

-- Using energy measures to evaluate the implications of certain by-products that may or may not have significant economic value, for example, excess bagasse from a distillery, or the octane-boosting qualities of ethanol that can allow petroleum refineries to produce lower quality gasoline with much greater efficiency.

The technologies and industries developed and employed around the world to make energy resources useful to our society will eventually compete on the basis of their physical performance -- how much energy they actually produce for all energies invested. This physically based measure of the productive advantages of various energy technologies can in time be a major determinant of commercial and social viability.

It must be remembered that net energy analysis is just a term for using energy as a physically based measure of the costs and performance of energy technologies. Energy analysis can only be used as a complement to other analytical measures, particularly money-based measures such as cost/benefit, return on investment, opportunity costs, and domestic resource cost calculations. Net energy analysis is illustrative of the complex nature of the questions we must ask about all biofuels activities. It is a useful, and perhaps should be an essential, tool for reducing the uncertainty in all energy investments.

One simple way to graphically show many of the relationships that are important in understanding many of the implications of net energy profit numbers is to show the relationships of different technologies on a common gain curve. By using a gain curve similar to those used in electronics, economics, and biology, one can plot the numerical values of various net energy analyses done on different energy producing technologies in a straightforward manner.

This energy gain curve can be made by placing the energy gain -- the relation of energy cost to energy profit -- on the horizontal axis. The vertical axis can then be used to show the percent of gross energy in the system that can be attributed to profits versus costs for a technology option.

Then, every individual and/or aggregate energy activity has a net energy profit yield that must fit somewhere on this energy gain curve. These points can be identified either individually or in groups, and must exist somewhere on the curve at any particular time in an energy system's life -- whether we can measure them or not. As net energy profit ratios are identified for the various energy supply and use technology options, they can be clearly compared in terms of their energy return on investment. Because all energy gain ratios on these particular charts are positive, what becomes apparent is the difference in gain -- which thereby gives an indication of the relative merits of various energy technology option.

In order to show where certain technologies fit on this energy gain curve, Table 2 lists the results of some of the net energy studies done during the past five years. These net energy numbers are simply taken from the studies cited, then selected results have been transferred to Figure 1. The list is far from being comprehensive and just includes some of the numbers prepared for two U.S. Agencies. On the second figure that are added net energy numbers on ethanol done by two scientists at the University of Sao Paulo. Many other numbers exist for ethanol done by reputable groups, including the Instituto Maua in Brazil, which show energy gain ratios of a much greater magnitude. The problem is that without a lot of detailed review a planner doesn't know which energy costs these numbers include or exclude.

Figure 2 focuses on the portion of the curve with energy gain ratios of less than 7:1. This is the section of the curve where most of the renewable energy technologies are found and, simultaneously, where minor improvements or cost omissions in the energy gain ratio can make significant differences in energy profitability.

Table 2. "Net energy" profit ratios from studies done for Department of Energy, and Office of Technology Assessment.

| Energy Technology | Organization | Energy Gain Ratio (EGR) | Energy Investment Cost (EIC%) | Energy Profit (EP%) |
|---|---|---|---|---|
| Natural gas: | | | | |
| | TRW | 242 : 1 | .4 % | 99.6 % |
| | DSI | 70 : 1 | 1.4 % | 98.6 % |
| Crude oil: | | | | |
| (to refinery) | TRW | 30 : 1 | 3.3 % | 96.7 % |
| (1000 mi. trans. | TRW | 24.7 : 1 | 4 % | 96 % |
| Product mix: avg. gasoline----\| residual----\| distillates-\|--- | TRW | 11.8 : 1 | 8.5 % | 91.5 % |
| | DSI | 13 : 1 | 8 % | 92 % |
| Coal, surface: | | | | |
| | DSI TRW | 55.5 : 1 | 1.8 % | 98.2 % |
| Coal, underground: | | | | |
| | DSI | 43.4 : 1 | 2.3 % | 97.7 % |
| Biomass, ethanol: | | | | |
| | OTA | 1.5 : 1 | 66.6 % | 33.3 % |
| | TRW | 1.03 : 1 | 96.87 % | 3.13 % |
| Electricity: | | | | |
| Coal, surface | | | | |
| | DSI TRW | 6.8 : 1 | 14.7 % | 85.3 % |
| Coal, underground | | | | |
| | DSI TRW | 6.2 : 1 | 16.1 % | 83.9 % |
| Nuclear | DSI | 4.2 : 1 | 25 % | 75 % |
| | ORE | 5.1 : 1 | 19.4 % | 80.5 % |
| | ILL | 4.7 : 1 | 21.2 % | 78.7 % |
| | IEA | 4 : 1 | 25 | 75 % |
| | DOE | 3.8 : 1 | 26.2 % | 73 % |
| | KYL | 2.7 : 1 | 37 % | 63 % |

Organizations

| | |
|---|---|
| Department of Energy (and predecessors) | DOE |
| Development Sciences Inc. | DSI |
| State of Oregon Energy Study | ORE |
| University of Illinois | ILL |
| Institute of Energy Analysis | IEA |
| Office of Technology Assessment | OTA |
| TRW Corporation | TRW |
| C. R. Kylstra, University of Florida | KYL |

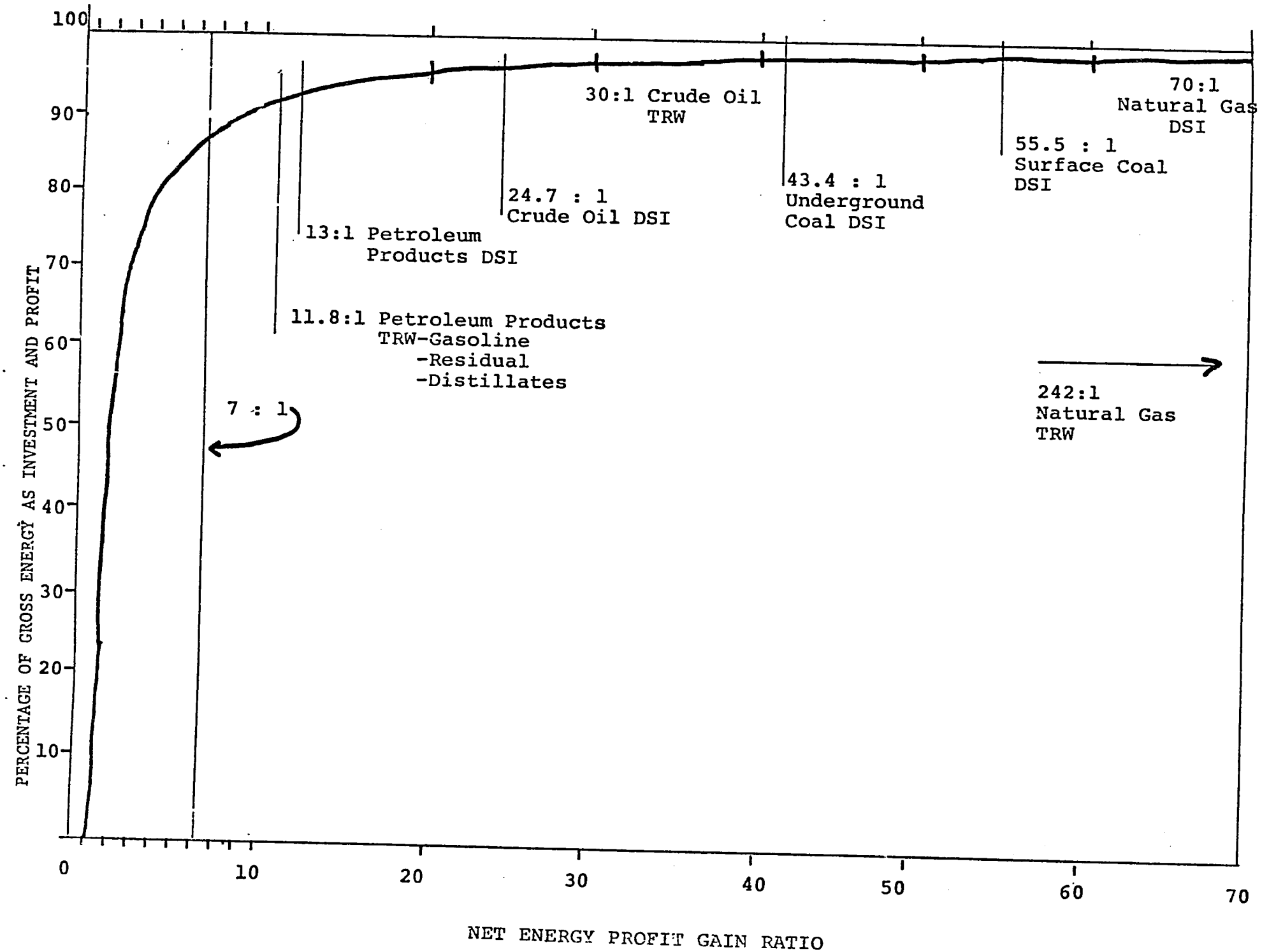
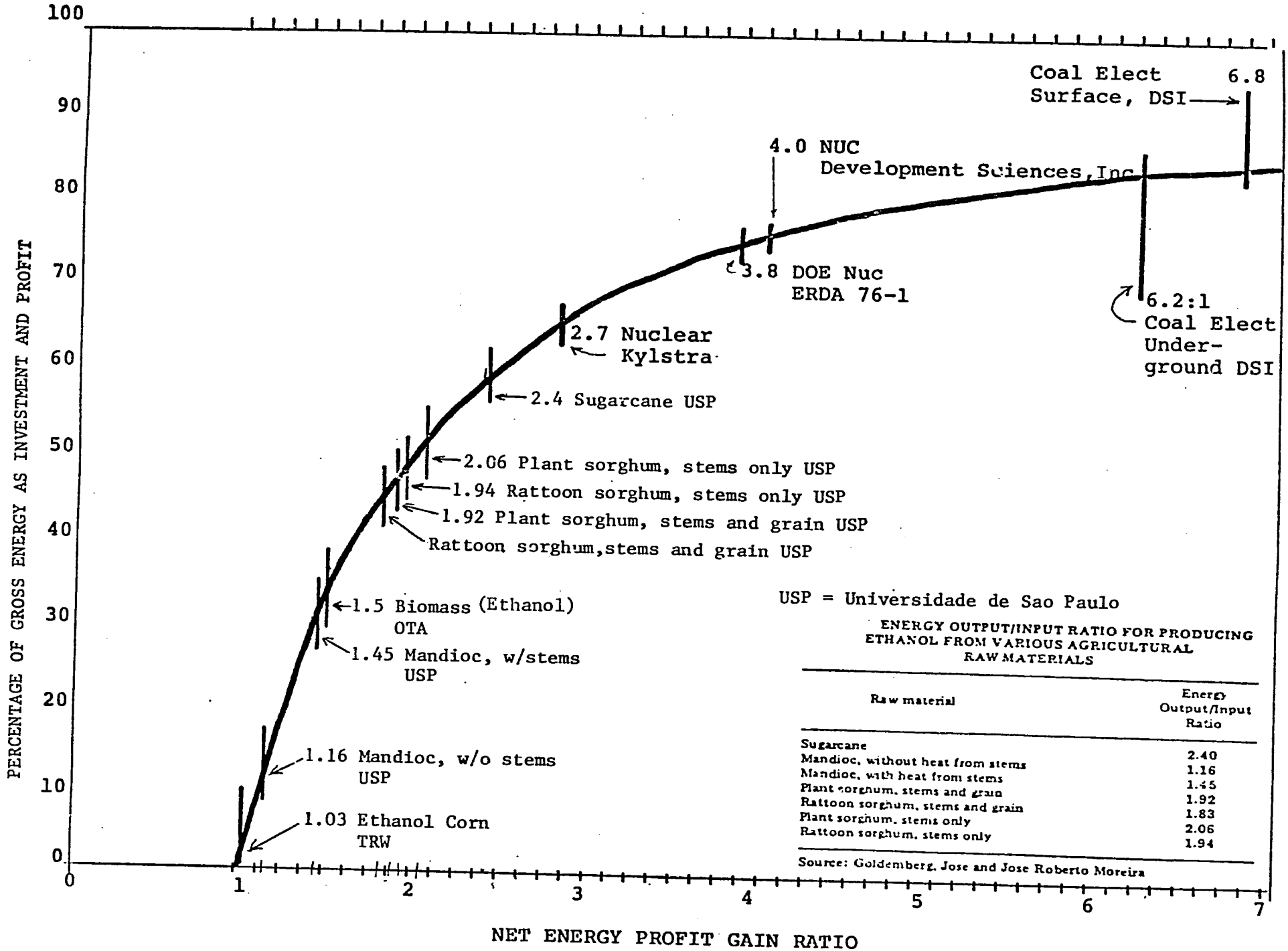



Figure 1 Technologies with Energy Gain Ratios under 70 : 1

Figure 2 Technologies with Energy Gain Ratios under 7 : 1




ENERGY OUTPUT/INPUT RATIO FOR PRODUCING ETHANOL FROM VARIOUS AGRICULTURAL RAW MATERIALS

| Raw material | Energy Output/Input Ratio |
|---|---|
| Sugarcane | 2.40 |
| Mandioc, without heat from stems | 1.16 |
| Mandioc, with heat from stems | 1.45 |
| Plant sorghum, stems and grain | 1.92 |
| Rattoon sorghum, stems and grain | 1.83 |
| Plant sorghum, stems only | 2.06 |
| Rattoon sorghum, stems only | 1.94 |

Source: Goldemberg, Jose and Jose Roberto Moreira

It is important to note that, although the numbers presented in these tables and graphs do not necessarily conform to any standardized measure of accuracy, they nevertheless fall into patterns that can provide useful information not usually seen with economic analysis alone. Of course, the energy gain ratio number can also change over time and from case to case, depending on such factors as the stage of depletion, location, technological changes, etc. - but even then the basic patterns of energy ratios tend to hold, if the same analytical boundaries are used.

I know net energy analysis opens a Pandora's box full of issues. My intention is not to fend off these issues, but rather to say that energy gain ratios, if derived by a standardized methodology, can provide some valuable insights to energy development projects. It is important to note that energy analysis, including net energy considerations, is a methodology more than twenty years old. And yet there has been little attempt to establish the essential agreement that would bring about a broader and more accepted use of its findings.

In the case of biofuels, net energy analysis serves to identify some of the physical differences between certain energy resources and conversion technologies. However, it is not an analytical tool that can be used in isolation for policy decisions. The salient physical difference between biomass resources and their more concentrated fossilized cousins -- natural gas, petroleum, and coal -- is illustrated by their low position on the curve, which is indicative of their diffuse and dispersed nature.

What this means is that utilizing biomass materials for energy production gives low energy yields principally because of (1) the relatively low concentration of biomass; (2) the relatively small percentage (less than 1%) of light energy converted; and (3) the high moisture content, which makes collection and transport energy-intensive and conversion relatively inefficient.

The net energy yield of biofuels may be low, but they can still make a positive contribution to a local and national economy. The point of the energy gain curve, in this regard, is to show that small differences in net energy yield make big percentage differences in competitiveness. Careful energy accounting could give clues as to where significant changes can be made in a biofuel energy system in order to improve its overall physical energy productivity. Such things as changes in agricultural practice, improving boiler efficiency in distilleries, recovering waste heat from gasifiers, and improving charcoal kiln efficiency can make important differences in the net energy profit of a system.

Upgrading biofuel net energy yields through genetic innovation, collection improvements, and new conversion technologies may make these systems more attractive. However, there will always remain serious concerns about the long range implications of biofuel technologies because of their marginal net energy productivity. The implication of this is, if we are going to work so much harder for our energy, we better make the best use of it.

The example of net energy analysis was chosen because it is illustrative of both the utility and inexactitude of its application to biofuels project analysis. As with all the other concerns listed earlier and the project examination these concerns imply, net energy analysis offers another perspective on projects, their risks, and the possibilities for increasing their chances of success. In other words, the planner's concerns with agroeconomic analysis, end-use efficiency, environmental questions, distributive impacts, government policy, and private sector involvement, all provide necessary qualifications to project survival. Obviously, because there are so many variables and aspects of biofuels projects, it will be necessary for planners to evaluate all the implications and then give weights to the various positive and negative aspects before making rational decisions. In certain cases, developing extensive vacant land areas and using unemployed rural labor may be high on the list of priorities, whereas in other situations waste problems or national security may be predominant concerns. This weighting of factors in decision making, however, is extremely site-specific and impossible to discuss here adequately.

My point is, essentially, that while there is still considerable uncertainty associated with all technologies, including biomass, much of this uncertainty is unnecessary. Although biofuels can present some specific short-run opportunities for alleviating certain energy problems, particularly for liquid fuel substitution, they also may cause other unanticipated longer term energy/economic/environmental and social problems. If large-scale biofuel systems fail because of misinformation or miscalculation about some of the aspects mentioned, it could mean tremendous costs in terms of lost time, money, and hopes.

We may not be able to wait for all the questions to be answered. But I believe that without a more complete and systematic investigation of the dynamics of energy systems, our technological interventions, and their diverse impacts, we are surely running a great risk of augmenting, instead of diminishing, the problems of worldwide energy uncertainty.

To avoid creating greater uncertainty in our energy future and possibly increasing the vulnerability of our economies and the fragile carrying capacity of our environment, the best way to promote and develop biofuels systems is to apply them in limited ways and continue to develop and use appropriate accounting processes.

The current state of analysis of biomass technologies requires that we devote attention to small experiments, preferably producing energy where it is immediately useful and manageable by local communities. Specific opportunities for biomass technologies already exist in many situations where an agricultural or urban by-product is collected but is currently not used: sawmill debris, coffee pulp, rice hulls, animal manures, cane bagasse. In locations where these centralized biomass resources exist and/or where energy has already become very costly or supplies undependable, bio-conversion techniques should be tried and monitored. In essence, our focus should be on getting energy to those who need it without unnecessarily destabilizing their economic and social systems and without jeopardizing their environment -- the source of their livelihood.

I encourage continued development of limited biofuel work so that we can get a better analytical handle on what it means to get, for example, less than two units energy back for each unit of energy invested. Biofuels have always had low energy yields, and that is why they were abandoned when concentrated fossil fuels became available. Now, as fossil fuel supplies are diminishing, it is crucial to develop and introduce new technologies, such as biomass, to local and national energy systems when they are economically and energetically competitive.

Biofuels, properly managed, are, in general, socially and environmentally attractive, but to date they have been betrayed by economics and energetics. Biomass will still be standing when most of our petroleum, natural gas, and coal are gone. Within the stressed economic and social context described at the beginning of this paper, how, and to what extent can it give us the energy "insurance" we are seeking?

I would like to close with a quote. This quote comes from a book about the abuses of excessive pumping of underground water in the southwest United States and northern Mexico, written by Charles Bowden, titled Killing the Hidden Waters.

> "If a man poured more calories into his body in raising a crop than he could reap from the crop, he would need no elaborate calculus to compute the energy flow. He would starve to death."

What this tells me is that at no time in history have people been better able to appreciate and manage their economic fit in their environment. And yet the major task may now be to direct our technological enthusiasm in ways consistent with the real, long-term, needs of all people.

APPENDIX

Summary of A.I.D.'s Bureau for Science and Technology (S&T) project for Bio-energy Systems and Technology managed by the S & T Office of Energy.

AID supports the development of LDC biomass resources as new energy sources through its central Bureau for Science and Technology. Two years ago this bureau, then known as the Development Support Bureau, established an Office of Energy to 1) deal with problems and obstacles common to most developing countries worldwide, and 2) stimulate and support development of promising approaches to these problems on all levels (country, regional, global). Through its programs, the Office of Energy provides professional and technical leadership in AID energy programs as well as technical support to the regional Bureaus and field missions. The Office of Energy supports bioenergy activities through its project, "Bioenergy Systems and Technology."

The Bioenergy Systems and Technology Project assists USAID field missions in their efforts to work with their host country energy counterparts to identify and plan bioenergy projects. These consultancies are available upon mission request and normally follow three steps: 1) an initial reconnaissance; 2) a pre-feasibility study; and 3) a comprehensive, site-specific feasibility study sufficiently detailed for a project paper. Steps one and two are normally carried out through short visits by an on-call four-man technical staff under contract to AID through a PASA with the U.S. Department of Agriculture Forest Service and Office of Science and Education. Step three requires that a team of bioenergy specialists be contracted for a longer time period of in-country work.

The technical support provided by the BST project is aimed at the development of "bioenergy systems." These systems are organized programs to satisfy a defined market need by the production of a fuel through conversion of a biomass resource to a useful biofuel. The biomass is obtained either through cultivation of a special crop such as sugar cane or trees which are dedicated to energy production or through processing of a waste such as crop residues or industrial by-products.

The planning of a bioenergy system requires that particular attention be paid to the linkages between system components. For example the relative locations of areas of biomass production and biofuel consumption strongly influence the biofuel's market penetration and hence the overall economic feasibilty of the system. Establishing woodlots or building biogas generators as separate activities by themselves will not automatically, or even likely, lead to development of significant new energy sources.

If a bioenergy system is expected to figure significantly in national development plans, then the system must be planned in the context of a country's total energy resource/need picture. Not only must the biofuel be competitive with conventional fuels and other renewables, it must also be as reliable. More so than any other renewable energy systems, such as hydropower, bioenergy systems require carefully thought out implementation and management plans. There are no "off the shelf" bioenergy systems; each must be tailored to fit local conditions. The Bioenergy Systems and Technology Project attaches great importance to system planning and hence emphasizes the provision of expert consulting services through USAID field missions.

In Latin American countries with USAID programs, the Office of Energy has provided technical consulting services for the following projects:

1) Guyana: a pre-feasibility study of the use of rice husks to supply power at a rice mill.

2) Ecuador: a pre-feasibility study of the potential role of biogas in national energy planning.

3) Panama: a pre-feasibility study of the management of an existing forest resource to supply feedstock for electricity generation.

4) Dominican Republic: a set of recommendations for the cultivation of woody biomass to supply a range of national fuel needs, including charcoal and firewood for household and industrial use, and as feedstock for electricity generation.

5) ICAITI: a recommendation for a R & D program for use of coffee hulls as energy sources for coffee beneficios.

In addition to the provision of project design support, the Bioenergy Systems and Technology Project through its contract with the USDA Forest Service and Office of Science and Education has contracted for a small number of publications for use by USAID field missions. The first of these is a Bioenergy Handbook. The bioenergy handbook is designed to be a tool that helps with the selection of the best conversion system. Also available are reviews of the state-of-the-art of the most important biomass conversion technologies. The project is also sponsoring a series of four reports to be issued quarterly in 1982. These reports are to focus on presentation of current activity worldwide in digestion, fermentation, and combustion of bioresources.

A final activity of the Bioenergy Systems and Technology Project is sponsoring workshops to provide opportunities for USAID host country energy planners to see operational bioenergy systems first-hand. In late March of this year there will be one of these workshops in Belo Horizonte, Brasil, to study the integrated charcoal production system owned and operated by Acesita/Florestal. Approximately twenty LDC energy planners from around the world will attend.