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BIOMASS: ITS UTILIZATION AS FOOD AND/OR FUEL

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Biomass: Its Utilization as Food and/or Fuel

Abundant and inexpensive supplies of food and energy were an important part of the unprecendent economic growth following World War II. By 1973-74, however, world events had reversed this favorable situation and marked a turning point from which there is no visible return. The OPEC oil embargo, crop shortfalls, and the Russian purchase of surplus grain stocks signaled the end of abundance and low prices for both commodities. Periodic poor harvests and OPEC supply control and pricing of oil since the embargo have been frequent reminders of the fragile supply conditions that continue in both energy and food markets.

Energy and food have not been affected equally by these events. Energy prices and particularly oil prices have risen more rapidly than food prices. As well, more countries are critically dependent on imported oil than on imported food. Concerns about energy supplies are further heightened by political instability in many of the oil exporting countries. These conditions have created a positive environment for alcohol programs. Some countries are initiating domestic alcohol programs as a partial solution to oil shortages. Others are giving serious study to potential alcohol programs. The search for secure domestically produced liquid fuels is the primary reason for this broad interest in alcohol. In addition, sugar and starch feedstocks are generally available in most countries; the processing technology is known and improving, and alcohol is a good substitute for petroleum products in many uses.

In many countries, however, there are serious food-fuel conflicts. Most agricultural resources are already committed to food, feed and fiber production, liquid fuel needs in relation to potential alcohol production are very great, and energy prices will continue to rise as energy supplies are further depleted. Thus, in the consideration of alcohol programs the food-fuel trade off is a very important issue and promises to become more important during the 1980s.

In the following section, I look briefly at the changing relationship between energy and food and at the issues this changing relationship raises. This is followed in order by discussions of energy supply and pricing, food production and trade, and non-market factors. A classification of countries is then presented to help identify which countries are likely to be early candidates for alcohol programs and hence what food supplies are likely to be affected. Finally, two case studies are described briefly; Brazil, which has already opted for a major alcohol program, and the United States, which is a dominant force in both energy and food markets.

The Food/Energy Relationship

The relationship between food and energy has been a most fortunate event for economic progress. It has been largely a one-way relationship with energy serving as a primary input to agriculture. In fact, modern agriculture and indeed most economic development has been built on a foundation of cheap energy. Fertilizers, mechanization, pesticides and irrigation all require large inputs of

energy, and with abundant supplies and low prices for natural gas and petroleum, these inputs have fueled the technological revolution in agriculture. In fact, it has been argued that over one-half of corn productivity in the United States results from direct energy inputs. Further, historic low energy prices relative to food prices have made food supplies uneconomic as energy feedstocks under most conditions. Thus, with the exception of crop residues and wastes, agricultural resources have been reserved largely for food, feed and fiber production in most areas of the world.

The food-energy relationship, however, is changing. Recent energy price increases and future anticipated increases promise to make the energy claim on agriculture resources more general throughout the world. In most cases, biomass sources have only limited potential to supply a significant portion of domestic energy needs. But the threat this holds for the availability and cost of food supplies has raised concerns about the dual food-fuel use of agricultural resources and about the energy intensive nature of modern agricultural technology. Since each country has a unique resource situation relative to energy supplies and agricultural production, the level and nature of concern varies considerably. Some countries feel the need to support an alcohol from biomass industry before it is economic. Others feel the need to protect domestic food production.

Rising energy prices will force policy makers in many countries to face the difficult food-fuel question directly. All countries, of course, will be affected by the food-fuel choices of others. Several

have already made substantial commitments to alcohol programs. Brazil for example imports 80% of its petroleum needs, is a major net exporter of agricultural products and has vast underutilized land resources. This situation has influenced Brazil to institute a massive alcohol program as a substitute for imported petroleum. Food importing countries may feel they do not have this choice or may in fact need to protect domestic food supplies. The situation in the United States is unique. The U.S. imports almost 50 percent of petroleum needs, consumes over one-fourth of all petroleum produced in the world, and is the major exporter of agricultural products to the rest of the world. The magnitude of both U.S. demand for liquid fuels and its share of world agricultural trade make the U.S. policy choices on food and fuel of critical importance both domestically and for many areas of the world. We will return to a more detailed look at these two countries later.

In the broadest context the urgency for making choices in energy or food will be determined by the relative world scarcity of food and energy and the subsequent impact of this scarcity on relative prices. Currently, food energy price relationships favor using agricultural resources for food production in most countries. Recent estimates suggest, however, that energy supply problems will become more critical than food shortages during the 1980s. When rising incomes and population growth estimates are balanced against production levels for both food and energy, it appears that energy markets will experience a more rapid demand increase and an earlier plateau of supply than is antici-

pated for food markets. As energy prices rise, more and more countries will be forced or enticed into alcohol programs.

Presently, alcohol from crops is the easiest to produce and to blend with gasoline. Woods, residues and other sources may eventually provide a larger base for alcohol production for some countries than will food crops. But in the immediate time frame, during the decade of the 1980s, crops and principally sugar and grain crops will be the primary source of alcohol. Since these crops are food crops and will occupy land used to produce other food crops we can expect food prices to also rise. But at least in the short term, food has a stronger supply response capability, therefore prices will not rise as rapidly as for energy. Since each country has a unique set of resources a series of non-economic factors will also affect the food-fuel choices. These include national security concerns, foreign exchange needs, a situation of excess or deficit food production, the existence of unused land, and the availability of domestic energy resources. These and other factors will either help the process along or impede its progress on an individual country basis. In the final analysis, however, the most important dominant factor will be the world price level for energy and particularly for oil. We turn next to a consideration of energy supply and pricing.

Energy Supply and Pricing

World energy resources are very unevenly distributed in terms of known reserves, production and use. Coal is the most abundant

resource, representing over two-thirds of the fossil fuel reserves but less than one-fifth of world energy use. Coal is found in abundance in only a few countries with 80 percent of the reserves located in the United States (31%) and the communist countries. Oil, which represents only about one-sixth of the world energy reserves is currently providing over one-half of energy use. Most of the oil reserves and almost all of the free world trade in oil come from the Middle East Arab OPEC countries. The rest of the world, including many of the industrialized countries and most of the tropical, less developed areas of Africa, Latin America, and South and Southeast Asia are relatively energy poor.

Oil is clearly the energy resource which dominates world markets. Very high use levels relative to known reserves, historic low production costs, ease of transport and use, and lack of readily available substitutes for this premium liquid fuel have led to over production and consumption of oil relative to reserves. Most future scenarios point to supply/demand imbalances for petroleum by 1985. There is general agreement that prices will go higher though some uncertainty about exactly when, how high, and how fast. The uncertainty on the demand side comes largely from the unknown level of conservation efforts, principally in the United States, the impact of the current recession on the demand levels for petroleum, and the degree to which the historic link between economic growth and energy use can be broken. On the supply side there are some uncertainties relative to the response to higher prices and to the political stability of the

major oil exporting countries. Thus, the timing of significant future price increases could be within a few months if political instability continues in the Middle East, by 1985 with normal supply/demand relationships, and perhaps extended closer to 1990 with favorable events on both the supply and demand side. However, in any of the alternatives, the time frame is fairly short for the development of alternative liquid fuels.

What then are the prospects for oil production levels and prices in the near future? As noted above, most scenarios call for a shortfall by 1985. Events through late 1980 in the major oil producing countries generally supported this possibility. U.S. new oil discoveries were running at only 20 percent of U.S. oil use and 40 percent of U.S. production. North Slope oil had temporarily raised U.S. production slightly, while Russian production has plateaued. The unexpected shut down of Iranian production in early 1979 caused a temporary shortage of oil in world markets. The current Iranian-Iraq conflict continues this instability. Saudi Arabia had raised production temporarily from 8.5 million barrels a day to 9.5 million barrels a day following the Iranian revolution and then to 10.4 million barrels a day to help make up losses from the Iran-Iraq conflict. However there is no indication of willingness to maintain this increased flow on a sustained basis. The strength of short run demand is evident in a general willingness by consuming nations to pay much higher oil prices. Clearly, retail gasoline prices two to three times greater than U.S. levels in many countries is further evidence that

demand for liquid fuels will continue at significantly higher prices. Thus, it seems plausible to assume that we are moving toward the substantially higher prices anticipated for the 1980s.

Higher petroleum prices will in turn cause two general reactions: 1) a more serious attempt at conservation to at least moderate the increase in petroleum demand, and 2) an expanded search for alternative energy sources. In the liquid fuel area, three major alternatives are being considered. They are the so-called synthetic fuels derived from shale oil, coal, and biomass. Like oil, shale and coal based synthetic fuels are located in a few countries only. In addition, capital, technology, environmental issues, and water requirements are likely to delay substantial production of these fuels until well beyond the projected oil supply shortfall. Biomass, a renewable resource, is currently available in various quantities in most areas of the world in both waste and food (or feed) forms. It is seen by some as the principal short-run solution to fill the gap in liquid fuel needs, but to others such as Brazil, it is the principal long-run solution.

Within the time frame of the oil problem as defined above, (before 1990) alcohol from sugar and starch crops is the only alternative that can provide significant quantities of liquid fuels. Shale oil, coal liquids and alcohol from cellulosic material all hold promise for providing eventually greater quantities of alcohol than is available through starch and sugar products. However, none of these sources will be available in any quantity before 1990.

It is also instructive to look at the relative cost of the alternatives. In October of 1980, imported cost of crude oil to refineries in the United States was about $35 a barrel (Table 1). An equivalent price for alcohol from sugar cane in Brazil is $30-$35 a barrel. This is based on a sugar cane cost of production of about $12-$14 a ton. Alcohol from corn in the United States is currently costing about $40-$45 a barrel equivalent. This would reflect corn prices of $2.50-$3.00 a bushel. The synthetic fuels from shale and coal in the United States are now projected to cost between $50-$60 a barrel. Technologies for producing alcohol from cellulosic material are still being developed and accurate estimates of production costs are not available at this time.

If we consider shale oil and coal liquids as the primary longer run price ceiling for liquid fuels, then it is clear that alcohol from biomass will be very competitive as an alternative energy source.

Agricultural Production and Trade

As in the case of energy, the basic food resources are not evenly distributed. However, while the basic production resource, land, is generally considered to be in finite supply, the application of technology, capital, and labor has allowed the natural productivity of land to be increased several fold in many areas of the world. As noted earlier, energy in the form of fertilizer, pesticides, machinery, and irrigation has been a major ingredient in increased productivity. Thus, as energy prices rise, costs of producing food

will also rise, especially in areas of intensive modern agriculture.

Table 1. Estimated Relative Costs of Alternative Liquid Fuels, 1980

Source	Value Per Barrel of Crude Oil Equivalent[1]	Value Per U.S. Gallon Of Liquid Fuel[2]
	(Dollars-U.S.)	
Imported Crude Oil--USA	$35	$1.08
Alcohol--Sugar Cane--Brazil[3]	$30-$35	$ .93-$1.08
Alcohol--Corn--USA[4]	$40-$45	$1.24-$1.39
Synthetic Fuels--Coal, Shale--USA	$50-$60	$1.55-$1.86

[1] Delivered to refinery
[2] At refinery or distillery
[3] Sugar cane production costs of $12-$14 per ton
[4] Corn costs of $2.50-$3.00 per bushel

The substantial differences among countries in the relative quality and quantity of food production resources has given rise to comparative advantages in the production of specific agricultural products and to differences in the total volume of production. Both conditions have lead to trade in agricultural commodities. Also, annual supply variations are greater in food markets than in energy markets since agricultural production is still largely affected by variation in annual weather. When poor crops are experienced simultaneously in major producing regions of the world, the impact on price and quantity of agricultural products moving in world trade is substantial.

These general conditions of food production and use have given rise to alternate feelings of optimism and despair concerning the

world's ability to feed itself. The uneven distribution of food resources, especially in times of crop failure, has raised moral issues of "over eating" by some populations when others suffer from "inadequate diets." Shortages and higher prices of petroleum reduce the availability or increase the cost of the energy input to agricultural production and hence affect food productivity. This, together with the use of traditional food production resources for the production of energy crops will increase further the moral concern.

A commonly held concept is that the U.S. with its great surplus of agricultural production should or could "feed the world." In fact, the great bulk of food consumed in the world is produced in the consumption areas with about 11 percent of world agricultural production moving in trade. The few major importers of agricultural products are industrialized countries or raw material exporting countries that generate sufficient foreign exchange earnings to enable them to purchase substantial agricultural products (i.e. Western Europe, Japan), and those few agricultural countries that possess unique production resources for specific food crops such as sugar, and coffee. The U.S. has a unique agricultural potential in the production of food and feed grains, and soybeans well in excess of domestic needs and at cost levels that are very competitive in world markets. As a consequence almost 30 percent of U.S. feed grain production (corn, sorghum, oats, barley), two-thirds of wheat production, and over one-half of soybean production are exported. However, while exports of grains and soybeans from the U.S. represent a significant quantity of

U.S. production, they account for less than 7 percent of world production. Among agricultural exporters, the U.S. occupies a dominate position accounting for over 40 percent of all cereals and about 20 percent of total agricultural products moving in world trade (Table 2).

The grains are the principal source of both calories and protein for most populations of the world (1). They are also a feed input for livestock, which in turn provides one-third of the protein in world diets. (Table 3)

Table 2. MAJOR AGRICULTURAL EXPORTING COUNTRIES, 1974-76

	Agricultural Exports			
		All	Total Exports	
Country	Cereals	Food	(Value)	%
	(Billions of Dollars)			
U.S.A.	10.7	17.4	19.2	21
Brazil	.2	3.2	4.9	5
Australia	1.6	3.8	3.8	4
France	2.2	3.7	3.7	4
Canada	2.3	2.8	2.8	3
Argentina	1.3	2.6	2.7	3
Thailand	.8	1.6	1.9	2
	19.1	35.1	39.0	43
World	25.1	73.3	90.6	100

Source: F.A.O. preliminary data.

Table 3. Food Sources for World Diet

Food Source	Total Food Energy Produced	Average World Diet	
		Calories	Protein
		(percent)	(percent)
Grains	68	52	47
Roots and tubers	8	8	5
Sugar	5	9	--
Vegetables, oils seeds, pulses	9	12	15
Fruits	1	2	1
Livestock	9	17	32
	100	100	100

Source (adapted from 1).

While root crops are a stable food for many populations in the world, their bulk and perishability dictate that they be produced largely for local consumption. Livestock products are similarly produced locally and in general feed is moved to the livestock when in deficit supply. Also, the distinction between food and feed varies by country. In the U.S. wheat is a principal food crop, while in Russia it is also a major feed crop. For certain non-market considerations--the food-feed distinction appears to be a significant concept.

Trends in world grain trade show a significant erosion in the number of surplus production areas and the dramatic emergence of North America as the principal source of surplus grain (Table 4). For example, in the 1930s all major areas of the world, with the exception of Europe, were surplus grain producers with minor net quantities exported to Europe. This has gradually changed over time and now in

the late 1970s North America, and principally the United States, is the only major grain export region. While individual countries may be net grain exporters, the major regions as a whole are not.

In spite of these regional differences in the production and trade in grain, overall production in agriculture is increasing. Therefore, while the prospects for energy markets appear to point toward substantial price increases as limited supplies are balanced against rising

Table 4. The Changing Pattern of World Grain Trade, Net Imports and Exports by Region.

Region	1934-38	1960	1975	1978
		(million metric tons)		
North America	+ 5	+39	+84	103
Latin America	+ 9	0	- 3	- 4
Western Europe	-24	-25	-20	-19
Eastern Europe & USSR	+ 5	0	-20	-28
Africa	+ 1	- 2	- 8	-12
Asia	+ 2	-17	-45	-50
Australia & New Zealand	+ 3	+ 6	+12	+10

Source - Brown, FAO (2, 4)

demand, the projections for food markets indicate continuing production increases that will mitigate to some extent the price pressure from increased demand. World food production has increased at an annual rate of just under 3 percent during the 1970s, placing it slightly ahead of population growth. USDA and FAO projections through

1985 indicate that this relationship will be maintained though there will be times and places of critical shortages. Some areas of the world will fare better than others. Food production levels in Africa and Latin America, for example, have not kept pace with populations increasing at near 3 percent per year. Asia is maintaining historic food-population balances and may be showing slight improvement. North America (principally the United States) shows strong potential for continued food production growth well in excess of projected demand based on growth and income. Thus, within the assumptions of normal weather patterns and the absence of disruptions by non-market factors, a fairly constant real price level for food is projected through 1985. We may then expect an increase in the relative profitability of energy crops as they compete with food crops for the use of agricultural resources.

World markets, however, are not free to choose the "most profitable" economic use of resources. Nation states and other groups often intervene in markets to achieve political ends. These non-market forces are considered next.

Some Non-Market Considerations

The uneven distribution of food production and energy resources among countries results in the trade of these commodities as described earlier. However, it also gives rise to some non-market activities that are undertaken by nations to protect their own interests. In some instances, these activities take the form of direct intervention

in the market mechanisms. Price supports for domestic food production, input subsidies, tariffs, etc. are various means of altering the relative profitability of production and trade. Import quotas and production limitations are more direct forms of intervention.

The issue is to recognize that the political process may intervene in a substantial way in the operation of free markets if this will better serve the national interests. We have many examples. Brazil, for years, has supported inefficient domestic wheat production in order to have at least a minimum domestic supply of this basic food commodity. Europe, a deficit food producing region, supports domestic agricultural production in a number of ways. The U.S. supports a sugar industry. These actions are taken to mitigate against the potential break down of free trade markets. Similarly, on the energy side, South Africa supports a synthetic fuel industry, Brazil a major alcohol industry, and the U.S. is willing to pay higher prices for North Slope oil. These actions are taken to lessen dependence on uncertain international supplies. Thus, when a country is short (in terms of production) of a critical commodity, it will often place a higher value on domestic supplies of that commodity than will the free market.

In the case of national security, most will agree that a barrel of domestically produced oil is worth more than a barrel of imported oil. By extension, domestically produced alcohol will also command a higher value than imported oil. But specifying this value is a poli-

tical decision. The problem for policy makers intervening in energy markets is to know how much more. There is no easy answer to this question, however two areas of costs which are generally not reflected in market prices can be identified. First, many of the economic and military costs associated with maintaining friendly relations with oil exporting countries and protecting international oil supply routes could be assessed legitimately to the cost of imported oil. Second, a less tangible non-market cost is the potential economic disruption that would result from an interruption of international oil supply. This of course is not a cost until disruption occurs and then the level of cost depends on the length and severity of the supply interruption. In assessing this cost, an estimate must be made, not only of the potential cost but of the probability of occurrence. Continued political instability in some oil exporting countries makes this an increasingly likely possibility. The emergence and interest in synthetic and biomass fuel programs in a number of countries is indicative of the level of non-market costs that the political process is assessing to imported oil. The issue, in terms of the food-fuel conflict is that alcohol need not be competitive with petroleum before it becomes a politically attractive alternative.

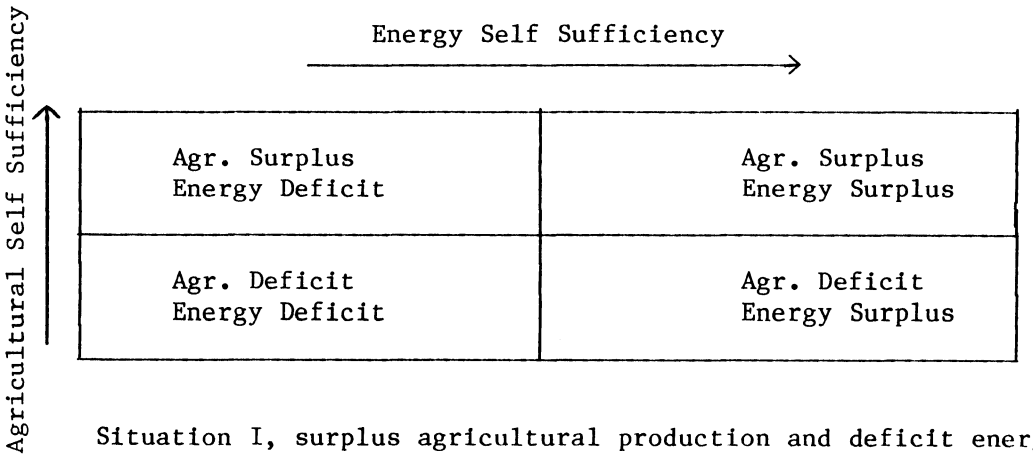
An Energy-Agriculture Classification

The previous discussion has concluded that in general, energy markets will experience relative price increases in the near future, food markets will probably be able to accommodate commercial demand

within reasonable price ranges given "normal" weather conditions, and market intervention will be limited largely to protection of national food and energy interests. An important issue for world food and energy markets is to identify which countries will opt for alcohol programs in the next few years.

A two dimensional country decision matrix is presented in Figure 1. While it is clear that each nation state considers many factors in determining energy and food policies, the simple matrix presented in Figure 1 allows us to catagorize broadly a distribution of countries in the world. Two scales are suggested representing levels of self sufficiency in energy production and in agricultural production. This allows a four quadrant characterization of countries and hence policies that are related to deficit and surplus production levels of agricultural products and energy.

Figure 1. ENERGY--AGRICULTURAL COUNTRY CLASSIFICATION



Situation I, surplus agricultural production and deficit energy production, is likely to be characterized by policies that favor agricultural exports, protect domestic energy production, and as energy

prices rise give incentive to alternative energy sources including biomass. The relative strength of these policy actions will of course depend on the specific location within the quadrant. Situation II, surplus production in both energy and agricultural domestic markets, will generate less policy intervention in the production choices than I. Energy from biomass will be attempted only when profitable but will not be discouraged. Situation III, deficit domestic production in both markets will elicit protection (incentive) policies for domestic production in both agriculture and energy. Energy production from biomass is not likely to be encouraged except for the use of waste agricultural products. Situation IV will be similar to III with even less emphasis on energy from biomass. Therefore, as energy prices rise, initial efforts to convert agricultural products to energy would be expected in countries falling in the first quadrant (Situation I), that is, net agricultural exporters with deficit energy production.

Energy and agricultural self sufficiency ratios were developed for most countries of the world. These ratios are presented in Table 5 along with additional descriptive data. The ratios for selected countries are located in appropriate positions on the policy matrix (Figure 2).

Several general conclusions are apparant from the data in Table 5 and Figure 2. First, the industrialized countries of Western Europe and Japan are the principal countries with deficits in both food and energy production. Rapid industrialization was possible for these countries during an era of abundant and inexpensive supplies of both

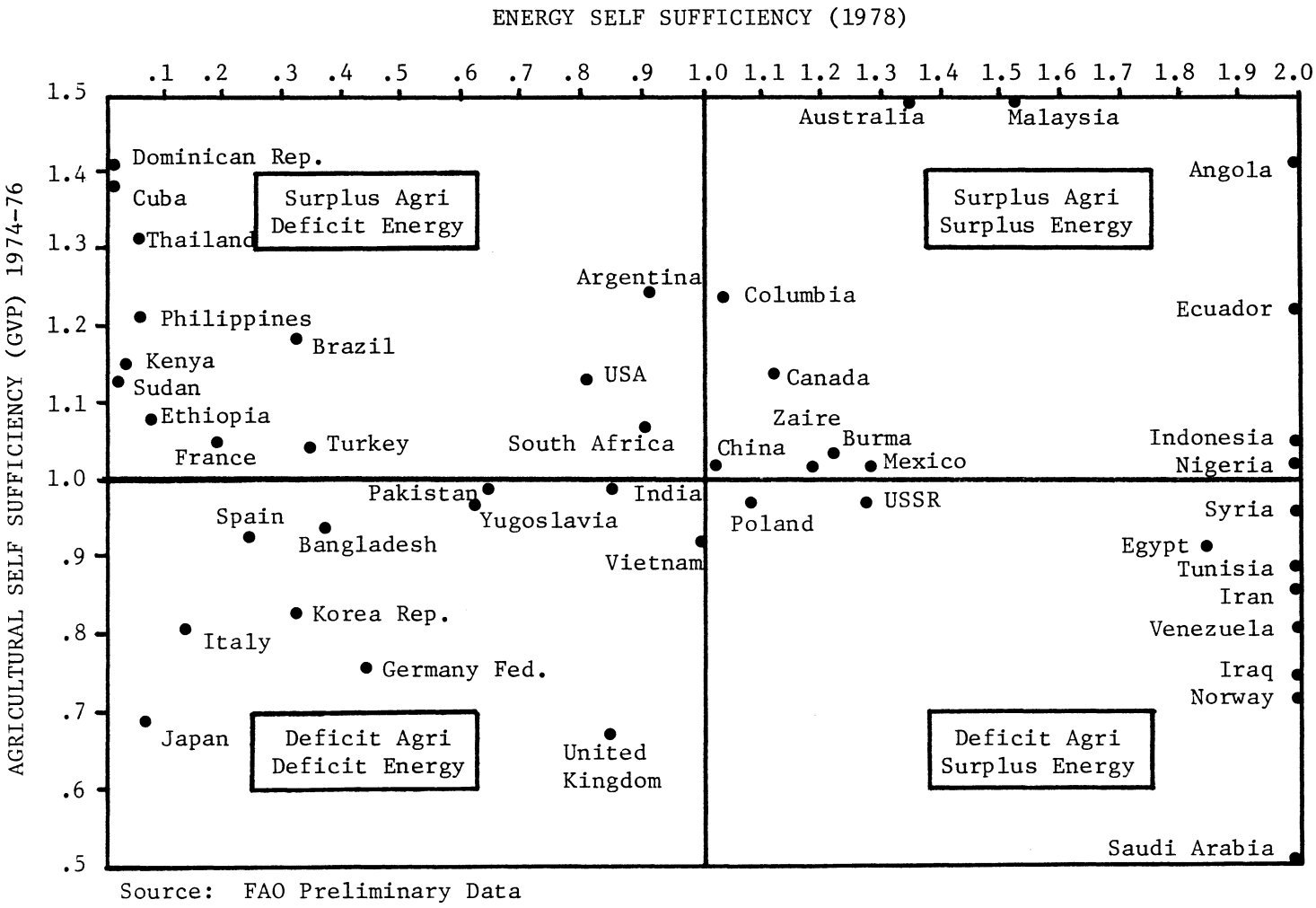


Figure 2. ENERGY AND AGRICULTURAL SELF SUFFICIENCY

energy (oil) and food. Second, with the exception of Canada and Australia, the major agricultural exporting countries have energy deficits. Third, at the present it appears that energy self sufficiency has been more difficult to achieve (or less necessary) than food self sufficiency.

Specific major countries that appear to be early candidates for energy from biomass programs are Brazil and much of Central America in Latin America; Kenya, Ethiopia, South Africa, and the Sudan in Africa; Thailand and the Philippines in Asia and the United States in North America. Of these countries, Brazil has initiated a substantial alcohol program, while most of the others are giving serious consideration to initiating alcohol programs. The dominant position of the U.S. as an agricultural exporter and its critical position as a major energy importer clearly focus the food-energy issue and make U.S. policy choices in both food and energy important for the world. The specific situations for Brazil and the United States are examined in more detail below.

Brazil - A Tilt Toward Energy

Over the past twenty years, Brazil has embarked on an ambitious industrialization program. Central to this program have been the development of an automobile industry, a truck transport industry, a highway system, and areas of highly mechanized agriculture. Strong and increasing reliance on liquid fuels (from petroleum) has been a concomitant result of following this development path. Imports now

account for over 80 percent of petroleum use. Brazil is thus faced with the option of dramatically changing development strategy away from dependence on liquid fuels or producing synthetic fuels principally from biomass.

A political decision was made in 1975 to support an alcohol industry at a time when alcohol production costs in Brazil were still substantially higher than imported petroleum. At the same time, prices of petroleum products have been maintained at higher than free market levels. This "alcohol plan" is the result of the energy realities faced by Brazil and the considerable agricultural potential for producing alcohol. Hydro electric power and eventually shale oil are the only conventional domestic energy resources of significant quantity in Brazil.

In addition to a favorable agricultural self sufficiency ratio, Brazil has large underutilized land resources. The full agricultural potential of this resource is unknown, but will add to the agricultural production base when developed. There are currently about 45 million hectares under crops in Brazil. Full substitution of alcohol for imported petroleum at current use levels would require about 16 million hectares of cropland. The current demand for liquid fuels relative to this actual and potential agricultural base leads Brazilian authorities to project a probable substitution of biomass produced alcohol for a major portion of liquid fuel needs within the near future. Currently, over 20 percent of gasoline needs are being met by alcohol.

The change to alcohol has been relatively easy in the initial stages, since some alcohol has traditionally been produced as part of a substantial sugar industry. Sugarcane, however, is produced on prime agricultural land, and expansion in area planted will put pressure on traditional food and export crops such as corn, coffee, and soybeans. Alternative crops, such as cassava and sweet sorghum which have a broader regional adaption and can be produced on more marginal land and under semi arid conditions, are being investigated and may eventually be more important than sugarcane as an alcohol source. Studies have shown that use of these crops would have positive regional employment and income effects as well as reduce the pressure on export and food crops in prime agricultural areas (6).

It should be noted that Brazil made the tentative political decision to proceed with a major plan when alcohol prices were at least twice as high as world gasoline prices (6). As petroleum prices have increased rapidly again, the projected expansion rate for alcohol production in Brazil has been significantly advanced and the decision made to produce new automobile engines that run on pure alcohol.

While the unique conditions of Brazil cannot be duplicated exactly in other countries, it is significant that Thailand, the Philippines, Sudan and others are now beginning to explore the possibilities of producing alcohol from biomass. The Brazilian experience should provide valuable information for these countries.

The United States - A Choice

Unlike Brazil and many other energy poor countries, the United States has several options for dealing with liquid fuel needs. The urgency for making a choice is beginning to be felt in political circles. Declining domestic oil production and an increasingly vulnerable oil import situation are bringing economic, political and national security concerns to bear on the energy choices. The overall goal is to reduce dependency on imported petroleum. The alternatives are conservation, substitution of more abundant energy forms such as coal for oil in non-critical uses, and synthetic fuels production from coal, shale oil and biomass. Market forces are not likely to provide signals soon enough to allow a smooth transition, nor are they likely to reflect the full extent of political and national security concerns relative to oil imports.

Within this framework, alcohol from biomass may play a small but critical role. If further delays in other choices occur, the demand for alcohol in energy markets could put substantial pressure on food producing resources. First, it is important to note that unlike Brazil, the demand for liquid fuels in the United States far exceeds the capacity of agriculture to supply a significant portion. Gasoline needs alone are over 100 billion gallons a year. It has been estimated that from 2-5 percent of this need could be met by alcohol produced from corn without significantly affecting food prices. Beyond this level, a clear choice between fuel and higher food prices would have to be made. Second, the two major synthetic fuel

alternatives, coal liquids and shale oil, cannot be brought on stream in any significant quantity until the 1990s, well beyond the expected shortfall in world oil production. In the interim, conservation, coal substitution and alcohol from biomass are principal short run alternatives. Alcohol from biomass is currently not competitive with petroleum, though new technologies and rising petroleum prices will probably make alcohol competitive by 1985.

In summary, plateauing and then declining world oil production during the 1980s will bring about sharp increases in oil prices and vulnerability for import dependent countries. National policies to stimulate and protect local energy production are likely to become more common. Alternative sources, including alcohol from biomass will become increasingly competitive. Intervention in energy and food markets will likely be undertaken, especially in agricultural surplus and energy deficit countries. Tropical countries with sugarcane potential are likely to be the first to initiate significant alcohol production. Grain exporting countries other than the U.S. are not expected to enter the alcohol market until alcohol production costs are competitive with petroleum. Choices made in the U.S. are critical for both food and energy markets since U.S. transactions dominate both international markets. Within the U.S., alcohol from biomass can play a critical role in providing a bridge from projected declining domestic oil production in the 1980s to initiation of a synthetic fuel industry based on shale oil and coal liquids in the 1990s.

Table 5. Energy and Agricultural Measures for Selected Countries

Country and Region	Self Sufficiency Ratios: Agricultural Production (1974-76) Cereal (1)	Food (2)	G.V.P. (3)	Commercial Energy (1978) All Sources (4)	Petroleum (5)	Population Mid-1979 (millions) (6)	Per Capita Consumption: Food (calories) (7)	Energy (kilograms of oil equivalent) (8)	Oil (8)	Arable Land Used (% of potential) (10)
Africa										
Algeria	48	70	66	779	1269	18	2357	468	232	83
Angola	74	95	141	935	1101	7	2063	131	109	8
Benin	92	104	107	0	0	3	2153	38	36	51
Burundi	94	100	108	15	0	4	2260	8	6	83
Cameroon	88	111	131	20	0	8	2408	81	65	50
Central Africa	87	91	108	9	0	2	2250	30	27	23
Chad	95	113	131	0	0	4	1793	15	15	41
Congo	31	90	91	1188	1322	2	2234	119	106	6
Egypt	74	87	90	186	217	41	2716	315	250	99
Ethiopia	97	104	108	8	0	32	1838	13	12	57
Gabon	12	67	47	1726	2262	1	2403	1246	937	4
Gambia	62	143	144	0	0	1	2281	73	73	70
Ghana	79	139	137	31	2	12	2014	112	80	46
Guinea	91	98	99	2	0	5	1921	62	61	61
Ivory Coast	86	135	190	2	0	8	2563	243	238	81
Kenya	102	102	115	4	0	15	2060	95	86	59
Liberia	79	89	122	5	0	2	2374	269	255	28
Libya	29	52	49	3113	3004	3	2946	1285	1285	83
Madagascar	95	99	108	3	0	8	2480	53	49	13
Malawi	99	103	123	13	0	6	2282	35	22	59
Mali	88	98	103	3	0	6	2114	21	21	81
Mauritania	1	150	151	0	0	2	2557	138	135	95
Mauritius	20	86	85	2	0	1	1894	277	270	43
Morocco	79	94	92	19	1	20	2568	194	160	87
Mozumbique	79	107	113	89	0	10	1930	103	49	17

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Africa (cont'd)										
Niger	96	103	103	0	0	5	2051	26	25	93
Nigeria	91	102	102	1811	2178	83	2291	72	59	80
Rwanda	92	100	107	23	0	5	2277	12	9	91
Senegal	59	109	116	0	0	6	2228	123	123	58
Sierra Leone	93	99	101	0	0	3	2101	68	68	85
Somalia	66	105	103	0	0	4	2129	67	67	56
South Africa	127	112	107	93	0	28	2945	2162	390	66
Sudan	96	104	113	2	0	21	2247	117	115	27
Tanzania	76	96	108	16	0	17	2089	44	41	25
Togo	93	111	118	0	0	2	2035	65	61	95
Tunisia	77	92	88	202	225	6	2657	369	313	95
Uganda	98	99	126	14	0	13	2070	33	30	18
Upper Volta	94	103	107	0	0	7	1997	17	17	79
Zaire	67	97	103	120	147	28	2312	47	28	6
Zambia	90	88	91	68	0	6	2018	322	136	10
Zimbabwe-Rhodes	100	106	130	73	0	8	2545	394	90	14
North America										
Canada	168	119	114	112	95	24	3346	6755	3316	48
U.S.A.	149	111	113	81	60	231	3537	7737	3642	49
Central America										
Costa Rica	76	153	187	16	0	2	2477	384	322	49
Cuba	25	139	138	1	1	10	2636	794	782	99
Dominican Repub	56	124	141	1	0	6	2107	316	314	89
El Salvador	84	96	164	10	0	5	2075	181	163	87
Guatemala	84	117	167	5	3	7	2166	177	172	72
Haiti	83	95	102	10	0	6	2040	39	35	83
Honduras	83	128	149	6	0	4	2074	193	181	32
Jamaica	3	77	77	1	0	2	2663	1240	1235	87
Mexico	86	98	102	128	142	66	2668	941	642	67
Nicaragua	90	122	184	4	0	2	2453	351	338	36
Panama	82	112	112	2	0	2	2357	674	660	34
Trinidad, Tobag	12	68	69	372	750	1	2684	3377	1414	63

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South America										
Argentina	168	124	124	92	99	27	3359	1274	885	66
Bolivia	74	98	102	218	134	5	2134	250	218	1
Brazil	94	108	118	34	18	124	2522	540	404	19
Chile	55	84	81	53	27	11	2644	678	466	96
Columbia	92	104	124	103	105	26	2255	476	259	17
Ecuador	82	114	122	371	382	8	2109	344	331	61
Guyana	132	157	154	0	0	1	2431	728	728	5
Paraguay	88	111	122	12	0	3	2779	136	123	6
Peru	59	89	95	109	112	17	2286	442	375	24
Surinam	158	107	104	16	0	-	2286	1463	1182	1
Uruguay	135	125	119	7	0	3	3098	717	660	17
Venezuela	40	77	79	471	858	14	2480	2033	998	17
Asia-Middle East										
Cyprus	45	112	110	0	0	1	3047	1338	1338	98
Iran	81	84	86	672	1136	38	3193	1230	658	99
Iraq	63	76	74	2458	3352	13	2306	430	312	101
Israel	18	92	93	1	1	4	3145	1607	1596	60
Jordan	37	65	63	0	0	3	2067	364	364	99
Lebanon	13	73	71	3	0	3	2495	637	614	88
Saudi Arabia	24	50	47	4818	5178	8	2472	888	825	87
Syria	87	89	96	200	213	8	2616	659	580	86
Turkey	97	100	104	35	15	44	2916	539	399	98
Yemen, A.R.	81	82	81	0	0	2	2179	36	36	89
Yemen, P.D.R.	37	64	65	0	0	5	1897	356	356	87
Asia-Far East										
Afghanistan	100	103	105	434	2	15	1974	32	22	94
Bangladesh	93	93	94	39	0	88	1945	29	15	100
Burma	106	104	104	121	142	34	2211	43	32	24
China	101	102	102	103	113	1024	2439	569	100	131
Kampuchea	89	94	95	0	0	8	1857	2	2	64
India	95	98	99	85	51	670	1949	121	34	93
Indonesia	92	98	105	344	384	148	2115	189	159	55

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Asia-Far East (cont'd)										
Japan	58	73	69	8	1	116	2847	2602	1934	81
Korea, D.P.R.	100	99	97	96	0	19	2730	1838	74	92
Korea, Rep.	79	87	83	36	0	40	2682	925	565	107
Lao	87	92	92	14	0	4	1979	41	39	40
Malaysia	71	137	187	153	171	13	2594	487	429	54
Nepal	104	100	100	12	0	14	2070	7	6	85
Pakistan	101	98	99	65	13	80	2255	117	47	72
Philippines	91	122	121	6	0	47	2155	231	217	66
Sri Lanka	58	82	112	10	0	14	2043	74	67	83
Thailand	125	129	131	5	0	46	2193	222	210	57
Viet Nam	88	92	92	99	0	53	2032	85	13	77
Western Europe										
Austria	96	96	91	34	17	8	3547	2754	1397	75
Belgium	41	98	91	14	0	10	3565	4134	2113	72
Denmark	104	158	148	2	2	5	3432	3689	3001	73
Finland	100	101	92	9	2	5	3130	3541	2425	54
France	166	110	105	20	3	54	3458	2971	1867	67
Germany, Fed. R.	82	81	76	45	4	61	3362	4092	2013	80
Greece	85	105	109	25	0	9	3441	1310	942	60
Iceland	0	88	80	30	0	-	2939	3295	2309	100
Ireland	73	158	153	24	0	3	3519	2239	1549	41
Italy	74	83	81	14	1	57	3462	2197	1552	65
Malta	4	45	41	0	0	-	3103	736	736	57
Netherlands	26	121	113	132	9	14	3324	3624	1387	73
Norway	54	79	72	228	212	4	3126	3790	2017	42
Portugal	48	81	78	13	0	10	3424	701	581	68
Spain	78	96	93	26	3	38	3210	1636	1121	58
Sweden	122	98	88	18	0	8	3168	4050	3160	61
Switzerland	34	80	74	22	0	6	3386	2510	1909	64
U.K.	66	72	67	84	65	56	3305	3546	1428	63
Yugoslavia	97	99	97	62	29	22	3469	1384	640	73

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Eastern Europe										
Albania	94	100	104	191	244	3	2624	679	428	88
Bulgaria	96	106	106	32	1	9	3594	3415	1488	73
Czechoslovakia	89	94	90	73	1	15	3450	5123	1097	65
German Dem. Rep.	70	91	88	70	1	17	3610	4844	980	73
Hungary	113	115	111	58	29	11	3494	2348	893	75
Poland	81	98	97	109	2	35	3647	3806	429	79
Romania	98	105	103	92	98	22	3368	2749	714	88
U.S.S.R.	95	97	97	128	171	264	3443	3742	1314	66
Oceania										
Australia	254	170	161	135	85	14	3413	4505	1864	29
New Zealand	87	164	158	57	16	3	3443	2579	1316	36

Sources: Agricultural Production, F.A.O. preliminary data (3)
Energy - United Nations
Population - Environmental Fund

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