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ABSTRACT

Although Latin America as a whole is self-sufficient in the production of petroleum due to the large producers Venezuela and Mexico, most of the other countries are oil importers, most of the supply coming from the Middle East. They were therefore severely hit not only by higher prices but also insecurety of supply as it happened during the recent Irak-Iran war. As a consequence increased efforts are being made by several governments in oil prospection and in addition to that in the production of liquid and gaseous fuels from biomass and coal. Most of the Latin American countries are still heavily forested, and important producers of sugar cane, cassava and other agricultural products that can be converted either in ethanol, methanol or methane.

Brazil, the largest country of the subcontinent has embarked in a program of ethanol derived from sugar cane which might be able to reduce drastically the gasoline consumption of the country. A similar program for the use of vegetables oils as a substitute of diesel oil is being launched presently. These programs will be discussed in detail in this paper.

The application of those solutions to other oil-importing latin-american countries will be discussed. It is estimated that a significant fraction of the oil needs of this area of the world could be supplied from biomass by the year 2000.

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I - Introduction

Most of the South-American countries have presently very similar economical and energetic patterns: they are strongly dependent on oil as an energy source; they are net oil importers and this is the cause of serious economical difficulties since these imports consume scarce resources needed for internal development. Venezuela and Argentina do not fit in this description, since the former is a large oil exporter (and OPEC member) and the latter is almost self-sufficient in oil.

All the others are spending 50% or even more of their export revenues to pay the oil bill; in addition to that even the more pessimistic studies, forecast an increase in energy consumption to levels that will double the current energy consumption before the end of this century.

It is therefore very clear that fundamental changes of the profiles of the energy consumption are essential for most South American countries.

One of the most promising sources of energy in this part of the world is biomass which still represents a significant participation of the energy consumption in those countries.

The interest in biomass derives from the large extensions of land not yet exploited for crops and pastures. The use of biomass offers a quick return of the capital investment in man-made forests and other energy crops, as compared with more traditional forms of energy such as hydroelectricity and nuclear energy.

II - Utilization and Costs of Biomass

Our major concern in this paper is to assess the feasibi lity of an energy scenario based strongly on renewable biomass energy for the end of the century.

Table I presents the commercial and non-commercial energy consumed in 1976 in South America. Taking into account all nations (except Venezuela), biomass represented 22.2% of the total. The same Table has numbers for the World.

The possibility of using biomass as an energy source is already a reality as far as the technical feasibility is concerned. The majority of present programs for the commercial utilization of agricultural products as a source of energy is based however in crops that require high quality soil (corn and sugar-cane) . These programs are directed to the production of ethanol to be used as fuel in automobiles; only the interest in preserving this industry can justify such strategies.

On the other hand commercial programs for the transformation of wood to ethanol and methanol are becoming important since the use of wood offers a guarantee of availability of liquid fuels since low quality land can be used. This solution has also the advantage of minimizing the unpleasant fuel "versus" food competition.

In addition to that the use of vegetable oil as a replacement for Diesel oil is being considered very seriously in Brazil.

In the last two years biomass is becaming more popular since some industries in South-America convinced themselves that wood is the correct fuel to use for steam generation and electricity and as source of energy for the pig iron industry. The use of wood, and agricultural residues for steam and/ or electricity generation has been limited up to now by the high capital cost required for the investment as well as for operation

and maintenance when compared with a similar unit that burns fuel oil. This problem has been solved by the crescent cost of petroleum derivates.

There are also possibilities for the use of solid fuel derived from biomass, as particulates (with less than 100 μ in diameter). Such material can be mixed to oil in amounts of up to 50% in heat value and the slurry fed into burners designed for fuel oil, without any modification. This seems a very promising way of using equipment already installed in the low oil price era.

The cost assessment for fuels derived from biomass is presented in Table II. They include fuelwood, charcoal, fine wood particulates and ethanol. The energy content of gasoline is 8 GJ/dollar.

III - Land and Capital Needs and Availability

As shown in the previous section, the price of fuels derived from biomass is clearly competitive with fuel oil for direct burning, for charcoal production (used mainly in the pig iron industry), for solid fuel maxing with oil and less clearly for liquid fuel for gasoline replacement.

The average consumption of energy in South America is presently 1 kw. Another 1 kw "per capita" of available power would mean an increase of 100% in the overall installed equivalent potential of the countries under study. This increase probably will take place in the next 15 years (5% growth per year). One would need therefore an area of 0.56 ha per inhabitant[1)] if the rotation cycle of the biomass species used were higher than 15 years.

Considering that the rotation time can be less than an year for some herbaceous plants (grass), one to two years for wild cane species and up to 5 years for wood, much less land is necessary. Let us assume for the sake of argument the worse possible case i.e. a 5 year cycle. Then the total area required can be half of the number evaluated above or 0.28 ha/capita (since the energy demand grows doubles in 15 years, more area is required at the end of the period than at the begining; this is the reason why a factor of 2 is assumed). The total amount of land needed is 13% of the total forest and woodland area available in Chile and Equador, 6% in Brazil and less than 1% in French Guiana, Suriname and Guyana. (Table III).

The capital requirements can be assessed, assuming that all the feedstock will be used for the extra kw through thermo-electric generators, probably the most expensive conversion process, since the produced energy comes out in a high grade form of energy such as electricity. Other uses of biomass will require smaller investments.

The total amount of energy required to add one kw/capita in South America is 262 x 10^3 Mw_e. The total anualized capital cost will be 12.4 billion dollars (1980) for equipments plus 3.9 billions[2)] for forest implantation.

The total cost for equipment and feedstock requires, in this pessimistic scenario, an annual investment of 16.3 billion (12.4 + 3.9 billion) for all of South America. This means 70 dollars "per capita"/year or 10% of the GNP of the poorest countries (Bolivia, Paraguay and Peru) and 5% for Argentina, Brazil, Chile and Uruguay.

The number can be compared with the savings promoted by the displacement of oil by biomass. All but a few of these nations are net oil importers and if no effort is made to change the present distribution of energy consummed, this new kw "per capita" will require the duplication of the present oil consumption; instead of 42.2 million metric tons of coal equivalent (MMTCE) it will be necessary to burn 84.4 MMTCE.

This means an increase of 230 million barrels of oil per year at a cost of 8 billion dollars (1 barrel = US$35.00) or 35 dollars "per capita". This money, for most countries, will be spent in the international market (Brazil, Colombia, Paraguay, etc.). For a few others (Argentina and Venezuela) the lack of investment in biomass means the loss of oportunity to accumulate foreign money through exportation of their own oil.

The scenario discussed here, based exclusively in the use of renewable energy sources is an extreme of the situation which South America will face in 1995; the other extreme will be the preservation of today's energy profile. The real scenario will be somewere in between; there are many opportunities for hydro-electricity generation (limited by the large investments needed and long time of return for the capital invested) and huge coal reserves which will be exploited as the oil price goes up.

The "per capita" energy consumption in South America (for 1976) is quoted in Table I as 1082 kg of coal equivalent (KCE); the present energy "per capita" consumption (1980) is around 1218 KCE; according with our scenario the consumption will be 1898 KCE in 1995 (5% increase in total energy consumption and 2% growth per year in population). Out of the total energy consumption 410.2 MMTCE of biomass will be in use instead of the present 50 MMTCE. The traditional fuels (coal, oil and gas) will stagnate at 246 MMTCE, their present consumption.

The total solid, liquid and natural gas, fuel world consumption in 1976 was 8052.2 MMTCE. Assuming an average increase of 3% per year in this energy demand (mainly as a consequence of a modest growth in consumption in development nations and zero growth rate in developed countries) we will reach a total energy consumption around 13,000 MMTCE in 1995. South America will participe in this total with less than 1.9% of the world market of traditional fuels. This means a decrease from today's participation of 3.1%.

If the scenario analysed in this paper could be extrapolated to all developing countries, the participation of biomass would be increased from the present level of 430 MMTCE (as can be seen from Table I) which is approximately 5% of the total world energy consumption to 1550 MMTCE[3), which will then correspond to 12%. This is probably the upper limit of contribution to be expected from the developing nations to attenuate use of fossil fuels.

IV - The food "versus" fuel controversy

The large scale use of forest plantations will probably not interfere with other uses of land since forests require low quality land.

However large alcohol program (produced mainly from sugar cane) will use land that could be used for food production.

The same is true for vegetables oils. This is a novel program in Brazil and much less known than the well succeded Alcohol Program.

The idea of this program is to replace diesel by oil from oilseeds. All experiments so far have been conducted with oils from industrial units that produce edible oils. They have been used either pure or in mixtures with diesel. The main results obtained so far are the following:

A) Diesel motors with precombustion chambers accept either pure vegetable oil or mixtures with diesel oil. The performance of the motors is very good for some models; in other, carbonization and excessive wear are intolerable; the use of precombustion chambers implies in power losses of 15%.

B) Diesel motors with direct injection do not accept well vegetables oils even if mixed to diesel oil in low percentages.

C) The use of untreated vegetable oils containing glycerin presents problems due to high viscosity, strong odors and undesirable exhaust gases and particulates.

It seems therefore highly advisable to process vegetable oils before using them in diesel motors; this processing might be less expensive than present processes of preparation of edible oils. This is particularly true in the case of glycerin carrying oils, in which case a simple chemical process called "trans-esterification" is highly advisable; this process breaks the molecules of "in natura" oils producing hydrocarbonates very similar to diesel oil with the advantage of permitting the recovery of the glycerin fraction.

Questions of cost are unclear yet since no large scale experiments have been conducted. However vegetable oils in the international market are worth close to US$ 700/ton presently, at least twice present diesel oil costs. It might therefore make more sense to export vegetable oil and import petroleum except for supply security reasons.

To give an example of food "versus" fuel competition let's analyze the case of Brazil.

The large ethanol program envisaged so far (10,7 billion liters in 1985) will require some 4.3 million ha, oilseeds another 1,2 million ha and energy forests another 1,8 million ha with a total of 7.3 million ha. The total agricultural area in 1985 will be 73,7 million ha (Table IV). Energy production will account for 10% of the used land which seems tolerable.

After all,the agricultural are of the United States is 20.5% of its area and only corn covered 3,1% of the total area (28,315 x 10^3 ha in 1978), as seen in Figure 1. The idea that su gar cane and other energy plantations will convert in Brazil into a monoculture is not to be taken seriously.

Notes

1) As is well known it is possible to produce 2400 ℓ of ethanol per ha (160 ℓ/ℓ ODT x 15 ODT/ha) in a well conducted wood farm, in tropical areas. The amount of energy embodied in 2400 ℓ of ethanol, 51 GJ, (1 liter = 21300 k) is equivalent to an installed capacity of 1.8 kw_{th} running 8000 hours per year.

Biomass probably will be used, in this scenario, in more efficient ways, such as feedstock for charcoal or as fuelwood, which means conversion efficiencies of 50 and 70%, respectively. Instead of 20%, as is the case when ethanol is the final product. Consequently, it is reasonable to set 0.5 ha/capital as an upper limit.

2) Assuming US$ 900.00/ha for implantation of a wood farm, 0.25 ha requires US$ 225.00 or US$ 30.00 anualised investment. 262 x 10^6 x 30 US$ = US$ 7.86 x 10^9. The replantation cost is zero and the investment is linearly distributed in 15 years, yelding an average of US$ 3.93 x 10^9.

3) This number is obtained from the 1976 data for total energy consumption of developing countries (2045 MMTCE, Table I), up dated to 1980 assuming 3% growth rate per year (2300 MMTCE) and projected to 1995 at the same growth rate (3450 MMTCE). Then we substract the 1980 figure for commercial energy use (1900 MMTCE).

Table I - Energy Consumption (million metric tons of coal equivalent)

	Commercial Energy (1976)					Fuelwood & charcoal	1976 Per Capita	
	Total	Solid Fuel	Liquid Fuel	Natural Gas	Hydro-Nuclear Electricily		Energy Consumption (kg)	GNP US$
World	8279.6	2695.6	3697.3	1659.3	227.4	383.7	2080	1639
Developed	6573.9	1890.6	2974.5	1528.2	180.4	43.4	6458	5191
Developiny	1705.7	804.9	722.8	131.1	46.9	340.3	652	479
OPEC	182.9	2.0	110.6	67.8	2.5	62.9	815	940
South America	208.3	13.6	145.1	34.2	15.4	54.2	1082	1083
Argentina	46.3	1.4	32.6	11.4	.9	1.1	1837	1549
Bolivia	1.8	-	1.5	.2	.1	1.2	616	603
Brazil	79.8	6.6	62.2	1.0	10.0	37.3	1014	1088
Chile	10.4	1.4	6.6	1.6	.8	1.2	1114	1060
Colombia	16.7	3.7	9.4	2.4	1.2	7.0	969	611
Ecuador	3.4	-	3.2	.1	.1	.6	569	717
Guyana	.9	-	.8	-	.1	-	1138	534
Paraguay	.5	-	.5	-	-	1.1	533	579
Peru	10.4	.2	8.8	.6	.8	1.9	776	694
Uruguay	3.0	-	2.9	-	.1	.3	1158	1286
Venezuela	35.1	.3	16.6	16.9	1.3	2.5	2856	2365

Table II - Total Cost for Conversion of Wood to Fuel

(In 1980 dollars)

	GJ Fuelwood 1)	GJ Charcoal 1)	GJ Agrifuel*	GJ Ethanol	GJ Gasoline
I) Wood production in energy-farm	0.54	0.99			
II) Harvest and load	0.38	0.70			
III) Wood transportation (200 km)	0.87	-			
IV) Conversion of wood to charcoal		0.16			
V) Charcoal transportation (400 km)	-	0.63			
T o t a l	1.79	2.48	2.21 2)	12.70	8

*Trade Mark

1) Dry weight of charcoal/m^3 = 250 kg.
   Lower heating value of charcoal = 27 MJ/kg
   Lower heating value of one m^3 charcoal = 6.8 GJ
   Dry weight of one stẽre of Eucalyptus Grandis = 390 kg (oven dry)
   Lower heating value Euclyptus Grandis = 18 MJ/kg (oven dry)
   Lower heating value of one stẽre Eucalyptus Grandis = 7.0 GJ (oven dry)
   Standard Yield of charcoal from wood ----- 1.8 stẽre produce 1 m^3 charcoal.
   Conversion factor for wood ----- 1.38 stẽre = 1 m^3.

2) Assumptions

   I) Lower heating value of Municipal solid waste (MSW) = 18 GJ/kg = lower heating value of wood (oven dry)

   II) 50% in weight of MSW is converted to ECO II fuel

   III) ECO II fuel quoted at US$ 4.42/GJ (1980) - then Agrifuel price is US$ 2.21/GJ (1980.

Table III - Forest and Woodland in South America*

Countries	F Forest d Woodland ($x10^3$ ha)	P Population ($x10^6$ inha)	F/P (ha per capita)
Argentina	60220	26.40	2.38
Bolivia	56200	4.89	11.50
Brazil	509000	119.47	4.28
Chile	20680	10.83	1.91
Colombia	77190	26.01	2.97
Equador	14850	7.80	1.91
FR Guiana	8001	0.06	129
Guyana	18109	0.84	21.4
Paraguai	20400	2.89	7.05
Peru	73800	16.72	4.44
Suriname	14300	.46	31.0
Uruguay	13550	2.88	4.69
Venezuela	47970	13.33	3.60
Total	934270	232.58	

* From FAO Production Yearbook, vol. 32, 1978

Table IV

Vegetable Oils in Brazil

Source	Productivity (Tons/Hectare/year)	Fraction of Oil %	Amount of Oil (Kg/Hectare)
DENDÊ	20 - 25	17 - 20	3,400 - 5,000
COCONUT	23 - 29	5 - 7	1,115 - 2,100
BABAÇU	2.0 - 3.0	3 - 4	60 - 120
SUNFLOWER	1.8 - 2.5	30 - 55	480 - 1,375
COLZA	1.2 - 2.0	40 - 55	480 - 900
PEANUTS	1.2 - 3.0	30 - 40	360 - 1200
SOYABEENS	1.3 - 2.0	16 - 22	240 - 660
COTTONSEEDS	1.3 - 2.0	14 - 16	170 - 320

T A B L E V

Agricultural Areas in Brazil (Millions of Hectares)

	1977	1985	Increment	% / Year
PRODUCTS FOR INTERBAL CONSUMPTION	29,9	42,1	12,2	5,1
PRODUCTS FOR EXPORT	15,0	24,3	9,3	5,5
ENERGY PURPOSES	-	7,3	7,3	40% / Year
TOTAL	45,9	73,7	28,8	6,7% / Year