Report on the Regional programme on Biomass energy – Gasification and Bui-fuels for productive uses in the LAC Region

H S Mukunda and S Dasappa, CGPL, IISc, Bangalore

October 2006

Contents

Abstract	
Chapter 1: Overview	
1.1 Introduction	2
1.2 The World Scenario on Energy supply	5
1.3 Fossil fuels and Economy in Latin America	6
1.4 Strategy for bio-residue use. – issues and perspectives	9
1.5 Biorefineries	13
1.6 Plantation and Forest resource base	14
1.7 Agricultural Residue base	15
1.9 Urban solid waste	18
Chapter 2: Global Experience concerning Bio-fuels	
2.1 General	19
2.2 Experience in Europe and America	20
2.3 World Bank reports and Indian developments	21
Chapter 3. Ongoing programs	22
Chapter 4. Key barriers and Issues	28
Chapter 5. Linkages and Productive uses	34
Chapter 6. Regulatory and Policy Framework	36
Chapter 7. Funding and Investment Opportunities	39
Chapter 8. Information dissemination	39
Chapter 9. Concluding Remarks	40

List of Tables:

1 Electricity, Oil and Natural gas – production and consumption in Latin American countries (p.7)

2 Exports of Oil and NG in Countries and their GDP (PPP) per Capita (p. 8)

3. Imports of Oil and Gas in Countries and their GDP (PPP) per Capita (p/ 8)

4 Oil production from land in kg/Ha for various oils (p. 10)

5. Biodiesel production in various countries (in 1000 tonnes). (p. 11)

6. Plantations and Forests of Latin America (p. 15)

7. Crop Residues of significant magnitude (in Million tonnes) for energy exploitation (p.16)

8. Scattered market (p. 23)

9. Martinet's issues (2001) and current observations (2006) (p. 32)

Appendix – Crops and crop residues for heat and power generation in Latin America (p 40)

Abstract

This report explores the issues of the use of liquid and solid biofuels in Latin American countries. While placing the issues in the context of a global energy scene, it is noted that the Latin American countries have a range of rich and poor with some countries rich in oil and gas, others rich only in oil and several others importing both oil and gas. Many of these countries specially the oil importing countries have economic (and political) problems that have limited the creation of infrastructure for providing universal access to electricity and high grade fuels that characterize a better quality of life and also routes for productive life of the communities. There are also other distinctions: A few countries are very well informed, and have the intellectual capacity in doing research and development on their own and are taking progressive steps to integrate renewable energy, more particularly biofuels into their economy in path-breaking manner. In fact, even though there is no immediate compulsion from an economic angle, certainly not as much as in the case of several others, they have taken progressive steps. Brazil is an excellent example in this regard. Other countries that import substantial amounts of oil can learn a great deal from the measures initiated by Brazil and this is something that should happen in coming times.

Liquid fuels and solid residues from biomass are addressed here. Both these resources are relevant to different class of applications and hence the approach and measures to be taken in terms technology, promotion and policy are different. Liquid bio-fuels are much better understood over most of the Latin American countries and a long positive experience of Brazil on alcohol permeates the environment. Biodiesel is a more recent entry and even here the steps to kick-start the deployment have taken place in Brazil. In so far as solid bio-residues are concerned, modern methods of using them for applications of distributed heat and power generation through gasification are very little known or understood. One of the most important issues is that even if plants are grown for liquid fuel as an end product, considerable waste solids remain and need to be exploited for their energy potential. The resource base – plantation residues, forest residues and agricultural residues form the core and their magnitude has been estimated and presented here. Urban solid waste could equally well form the resource base, particularly because, greater and greater urbanization is the hallmark of development and progress, albeit, an undesirable one. While recognizing, the urban slid waste as a resource, it is not explored in detail here. For even the vast agro-residue base is still to be explored and capitalized upon.

The technological status of modern methods of bioresidues use is discussed. It is identified that small scale power generation (ten to a few hundred kWe) using gasification of bioresidues most ideally suited to isolated and small habitats is the most economical route and issues around it are discussed in the chapter on global experience. Other aspects, namely key barriers, linkages with productive uses, regulatory and policy issues, funding and investment opportunities follow in a sequence.

The most important conclusion is that with regard to solid waste fuel utilization for heat or

electricity the international experience, for instance of India can be taken benefit off for cooperative arrangements on (a) creating awareness amongst decision making groups and others, (b) scientific collaboration, (c) technology transfer, (d) project implementation.

Chapter 1 Overview

1.1 Introduction

Much has been discussed and written on the subject of societal development and the distinction between developing and developed nations. It is concluded that the single crucial factor that ensures and indicates to development is the access to electricity. Electricity is considered an enabling intermediate for ensuring job potential and productivity that bring in financial returns to individuals and families enabling living with a minimum standard. Large scale electricity generation and distribution are essential components of a modern society. These are based on hydro-sources and thermal routes. The thermal routes need a fuel – usually, coal where available and oil if available in reasonable proportions. One of the most important roles of oil is to enable transportation – on road, over water or through the atmosphere. ***This role cannot be taken over by solid fuels like coal, biomass or intermediates, or gaseous fuels with equal facility***. Even though compressed natural gas (CNG) is used in city road transportation to reduce emissions, there is no disagreement that liquid fuels are far more convenient as energy carriers. All Arabian countries have depended on oil and gas for power generation as well as drinking water (through desalination processes), more certainly because they mine them in huge quantities and there is no other fuel source. Other countries that have coal as well as oil can profitably mix the uses. However, their availability controlled by pricing policies of Governments have been such that oil has been used even for low grade heat in many industrial applications in several countries because of ease of availability and the process hardware to use these fuels and it is only recently that the high oil prices coupled with only slight increases in the commodities/products produced based on the energy from these fuels have made the industries unable to transfer the fuel costs to their products and are looking for alternatives.

The global oil availability peaking in 2005–'07 is another major issue that is debated in documents, journals and over the internet over the last several years. While there are contradictory views on them, the fact that the global oil prices have risen from 30 USD per barrel to 70 USD per barrel in as short time as 2 years seems to support the peaking of the oil availability. Even here several arguments of geopolitical events are attributed to the price rise, and the debate on peaking of the oil availability is treated academic, the ground reality on price rise has already affected the inflation in the economy of several countries.

In this scenario, the oil importing countries will face the shock first. Even here oil importing ***developed*** countries can arrange to face the situation by suitable adjustment of other economic factors, but oil importing developing countries will have very little maneuverability and will suffer the most. Oil exporting developing countries will surely benefit from the price rise in the short term and can lull them into a state that they may take no actions to avert catastrophes when they strike.

The agenda of renewable energy that largely arises from global warming considerations for the west comes in from the economic accessibility to liquid bio-fuels for transport, solid bio-fuels for electricity and heat, both for domestic and industrial needs for oil importing developing countries. Quite often renewable energy is presented in most forums in a sequence: solar photovoltaic electricity, solar thermal systems for hot water, wind energy, mini-, micro- and pico-hydel systems and biomass energy. It is necessary to recognize that excepting biomass, other sources cannot provide a fuel for transport; such biomass also provides solid stock in forms of tree fallings due to natural means or cutting down on maturation. Also, biomass grown for timber has lops and tops amounting to 30 to 35 % of the timber extracted and this could be substantial amount. It is simple to note that biomass is stored solar energy and is available throughout the year. Constructing biomass based power plants that operate throughout the year with plant load factors in excess of 70 % is conceivable and this would make their performance comparable to centralized power stations at comparable investment and operational costs. These aspects of performance are ***rarely matched*** by other renewables. Yet the degree of understanding on the efficient use of bio-fuels for various purposes is ***perhaps the least*** among the renewables. It is often stated as being unfashionable to work in the area of bio-fuels.

One of the major problems of solid bio-fuels is the lack of their status in the energy mix. Every kg of dry biomass can replace a 200 to 250 ml of liquid fossil fuel (kerosene, gasoline or diesel) whether it is for cooking or power generation. Yet a quarter liter of kerosene is valued highly, for it costs money (cash) to get it. Solid Bio-fuel, on the other hand, is obtained from picking it around in plantations, forests and virtually not costed. This has its positive and negative features. The positive feature is that the rural poor can access these with very little hard money. The negative feature of “finders, keepers” is that its energy is not valued as appropriately as it should be. If bio-fuels have to play their role as energy suppliers, there is no getting past a situation that they must enter the main stream of fuel chain with all the attendant issues of processing and quality. No longer can the biomass be accepted with the inherent moisture at 50 %. It should be dried. It should also be sized. In short, it must become a standard bio-fuel with its characteristics meant for thermal use displayed – bulk density, calorific value, etc.

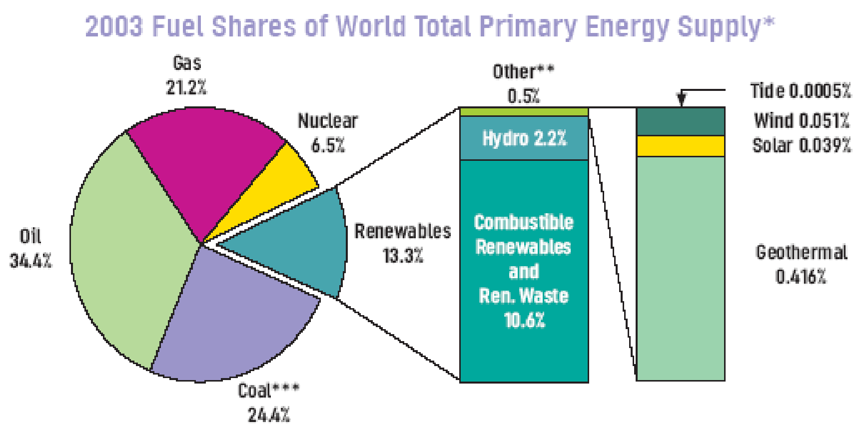
The problem of meeting energy needs of the population in most developing countries is that the communities are widely dispersed and connecting by grid would be too expensive and the energy pumped through the grid to such communities would incur losses and the actual delivered cost would be high. Many developing countries have power generation capacities less than the demand and as such find it difficult to meet the demand of communities that have little leverage to get the necessary attention to service them. It is in this context that distributed power generation using local renewable fuel would make the greatest sense and bio-fuels fit this requirement eminently.

Biomass has a splendorous variety. Apart from food producing biomass, oil seed bearing trees, trees with large stock for timber applications all with substantial residues can form the resource for several applications. In developing countries, most wastes of cereals go into fodder for animals. In times of draught, even this is insufficient. Interstate trading of the wastes as fodder occurs at relatively high cost to the buyers since the livestock maintenance is a principal necessity for their living. Even so, nature is bountiful many times and enormous excess of the residues get generated. These are not stored for very long times as it is too expensive to do so and they therefore, get used in various ways very inefficiently.

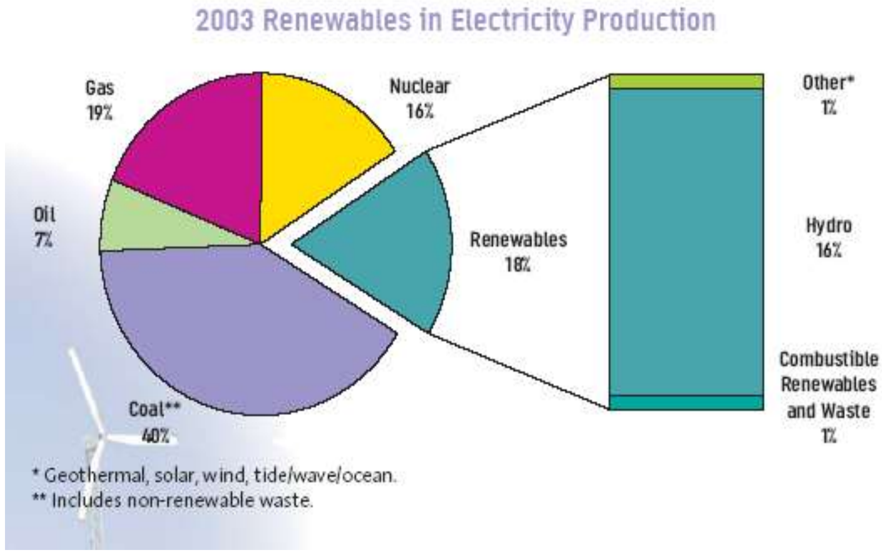
12 The World Scenario on Energy supply

The global energy supply that goes into servicing industry and commerce is so substantial that the energy fraction that goes into the domestic quality-of-life electricity (defined as that needed for illumination, TV, refrigerator and fans), particularly in developing countries is a small fraction, typically less than 10 % in developing countries in tropical environment. Even so, the fact that rural communities have no access to this fraction of electricity is the real tragedy that needs to be overcome by suitable deployment of non-grid and mini-grid strategies with local power generation at small capacities.

Drawn from the IEA fact sheet entitled Renewables in global energy supply the pie chart below represents the main fuels in the world total primary energy supply, with a dis-aggregation of the share of the main renewables categories. In 2003, renewables accounted for 13.3% of the 10 579 Mtoe (million tons of oil equivalent) of World Total Primary Energy Supply (TPES)*. Combustible renewables and waste (97% of which is biomass, both commercial and non-commercial – italics and bold ours) represented almost 80% of total renewables followed by hydro (16.2%). The same report discusses the growth of the total renewables supply at an annual rate of 2.3% over the last 33 years, marginally higher than the annual growth in TPES.



* TPES is calculated using the IEA conventions (physical energy content methodology). It includes international marine bunkers and excludes electricity/heat trade. The figures include both commercial and non-commercial energy.
** Geothermal, solar, wind, tide/wave/ocean.
*** Includes non-renewable waste.



The IEA report shows that "renewables are the third largest contributor to global electricity production accounting for 18% of production in 2003, after coal (40%) and natural gas (19%), but ahead of nuclear (16%), and oil (7%). Most of the electricity generated from renewables comes from hydro power plants (90%) followed by combustible renewables and waste (6%). Although fast growing, geothermal, solar and wind still accounted for less than 4% in 2003".

The fact that combustible renewables and waste contribute 6 % to global electricity production indicates to the possibility of even greater contribution when this sector is recognized for its importance.

1.3 Fossil fuels and Economy in Latin America

Tables 1 – 3 have been constructed by using the information from ***CIA – Factbook*** available on the internet. The information has also been checked with those from FAO sources on the internet. The electricity supply-demand scenario is such that many countries have some excess that is transmitted via international grid to neighboring countries, a situation that is undergoing greater and greater improvements with time through better mutual understanding. The position on oils and natural gas is different. Oils in particular, diesel and gasoline support heavy and light transport. Natural gas can support heavy transportation as it happens in some countries. Heavy oils are used for stationary power generation or heat in industries. The raw data presented in Table 1 has been used to construct Tables 2 and 3. These data are very instructive. The magnitude of the gross domestic product adjusted for purchase power parity on a per capita basis is considered as a measure of the strength of the economy. The magnitude of (production – consumption) of liquid and gaseous fossil fuels is considered as the principal input to the economy. This is because the wheels of the economy are tied to transportation of goods and services quite heavily, more truly with liquid fuels like diesel and gasoline. Only liquid and gaseous fuels are considered because most Latin American countries are dependent on them and coal is a small part of the fuel-mix for most countries. The main crude oil exporters are Mexico and Venezuela. Among the English speaking countries, Trinidad and Tobago, a producer of natural gas and oil, has been the only exporter of petroleum since 1912. Venezuela, Brazil and Mexico are the largest exporters of oil products, accounting for approximately 70% of the total exports from the region.

Most of the islands of the Caribbean are relatively poor and continue to struggle for survival. Petroleum imports continue to dominate the energy profile of the countries. Developing countries hold 50% of the world gas reserves, yet they account for only 17% of world consumption due to the technological development of the gas industry in industrialized countries.

Table 1 Electricity, Oil and Natural gas – production and consumption in Latin American countries

Country	*Popuation (July 2006 est.)*	*GDP - per capita (PPP) $ (2005 est.)*	*Electricity production billion kWh (2003-4)*	*Electricity consumption billion kWh (2003-4)*	*Oil production bbl/day (2003-5 est.)*	*Oil consumption bbl/day (2003-5 est.)*	*Natural gas production billion cu m (2003 est.)*	*Natural gas consumption billion cu m (2003-2004 est.)*
Argentina	39,921,833	$13,100	87.16	82.97	745,000	450,000	41.04	34.58
Bolivia	8,989,046	$2,900	4.25	3.963	42,000	48,000	6.72	1.74
Brazil	188,078,227	$8,400	387.5	359.6	2010000	1610000	15.79	21.74
Chile	16,134,219	$11,300	45.3	44.13	4,000	228,000	1	7.06
Colombia	43,593,035	$7,900	50.43	48.83	512,400	270,000	6.08	6.08
Costa Rica	4,075,261	$11,100	7.726	7.12	0	40,000	0	0
Cuba	11,382,820	$3,500	13.27	15.65	72,000	205,000	704	704
Dominican R	9,183,984	$7,000	12.6	11.71	0	128,000	0	300
Ecuador	13,547,510	$4,300	11.27	10.55	493,200	155,000	50	50
El Salvador	6,822,378	$4,700	4.158	4.45	0	40,000	0	0
Guatemala	12,293,545	$4,700	6.898	6.025	22,300	66,000	0	0
Haiti	8,308,504	$1,700	546	507.8	0	11,800	0	0
Honduras	7,326,496	$2,900	4.338	4.369	0	37,000	0	0
Jamaica	2,758,124	$4,400	3.717	2.974	0	69,000	0	0
Mexico	107,449,525	$10,000	209.2	193.9	3.42	1.752	47.3	55.1
Nicaragua	5,570,129	$2,900	2.887	1.848	14,300	25,200	0	0
Panama	3,191,319	$7,200	5.398	4.87	0	78,000	0	0
Paraguay	6,506,464	$4,900	51.29	3.528	0	25,000	0	0

Peru	28,302,603	$5,900	22.68	21.09	120,000	157,000	560	910
Trinidad+ Tobago	1,065,842	$16,700	6.076	5.651	150,000	29,000	24.7	12.79
Uruguay	3,431,932	$9,600	8.611	7.762	435	38,000	0	60
Venezuela	25,730,435	$6,100	87.44	81.32	3081000	530,000	29.7	29.7

Table 2 Exports of Oil and NG in Countries and their GDP (PPP) per Capita

Country	Populn Millions	GDP (PPP) per capita, USD	Net Oil, KYP	Net NG, KYP	Comments on the current use of biofuels
Argentina	40.0	13100	370	3560	Little attention to biofuels
Brazil	188.0	8400	110	-3280*	The most progressive country in the world – a role model
Columbia	43.6	7900	280	0.0	Little interest
Equador	13.5	4300	1240	0.0	Little interest
Mexico	107.5	10000	770	-4300	Awakened interest for remote habitat electrification
Trinidad, Tobago	1.1	16700	5640	6570	Little interest
Venezuala	25.7	6100	4820	0.0	Little interest

*The word Net oil or gas implies the difference between production and consumption. The negative sign implies import; these are based on data from CIA fact book accessed through internet, KYP = kg per year per person

Table 3 Imports of Oil and Gas in Countries and their GDP (PPP) per capita

Country	Populn Millions	GDP (PPP) per capita USD	Net Oil, KYP	Net NG, KYP	Comments on the current use of bio-fuels
Haiti	8.31	1700	70	0.0	Charcoal from bagasse is discussed
Nicaragua	5.57	2900	100	0.0	Lack of awareness
Bolivia	9.00	2900	30	E2750	Oil & gas are produced but oil consumption is larger
Cuba	11.38	3500	580	0.0	Awakened interest recently
El Salvador	6.82	4700	290	0.0	Lack of awareness
Guatemala	12.33	4700	180	0.0	Lack of awareness
Paraguay	5.64	4900	190	0.0	Lack of awareness
Peru	27.15	5900	60	19310	Lack of awareness
Panama	3.19	7300	1210	0.0	Higher standards due to other revenues
Uraguay	3.43	9500	540	33100	High standards due to other

					exports
Chile	16.10	11100	690	3340	High standards due to other exports

Based on the data from CIA Fact book accessed through internet, **no sign implies import**. E = export, KYP = kg per year per person

1.4 Strategies for bio-residue use – issues and perspectives

Biomass is grown for food, timber and fuel. Leafy biomass has a greater content of cellulose than solid stock. Half of Solid stock is cellulose and about 25 % hemo-cellulose and the rest lignin. The lignaceous matter is not touched by bacterial attack; it requires fungal attack to convert most of the solid matter to gaseous products – carbon goes to carbon dioxide and hydrogen to water vapor. Thus leafy biomass, human and animal excreta can usually be handled by bacterial means to a significant extent and the residue that remains from such a treatment can go back to the soil as a natural fertilizer. Even though considerable research is done world over on treating wastes like paddy straw and rice husk, they are better treated by a thermo-chemical conversion process. Urban solid waste is composed of bio-waste in variety of forms and plastic materials. While bacterial treatment of these wastes is one standard process adopted world over, when the wastes are segregated and only the bio-wastes are handled through this process, the process leaves behind residues that do not have a graded quality for qualifying to be a fertilizer. There have been several issues of marketing of these residues and in fact, some plants have been closed after substantial investments have been made..

In all these cases, waste handling through a thermo-chemical conversion process (incineration, pyrolisis and gasification) should leave behind ash and a very small fraction of unconverted carbon and can be disposed of in a landfill or marketed as a fertilizer after it is appropriately enriched and qualified. Plastics can be recycled where possible when the scale of operations justifies it. But they are also frowned upon in thermo-chemical treatment as well, even though there is no choice. The frown arises from a short-shrift in the treatment process. Even though plastics like polyethylene offer no problems in use, plastics based on poly-vinyl chloride generate oxygen and chlorine based compound called dioxin that is considered carcinogenic. This compound that has a melting point of 325 °C collects in several places in a incineration system and occasionally gets exhausted through the chimney in magnitudes beyond limits. As such the treatment process needs to be exhaustive and is therefore expensive. The gasification process, by the very nature is a sub-stoichiometric operation (les than the air required to completely burn up the fuel) and hence the chances of oxygen being made available to form dioxins is very much reduced. Limited research shows very little dioxins in the gas from a gasification process. More detailed studies are required to capitalize on the technical benefits of this process. Even pyrolisis process has not been technically qualified for dealing with this process.

Oils are an important way of storing the energy. The modern transportation system al over the world is very strongly dependent on oils – gasoline for light motor vehicles and high speed diesel for heavy motor vehicles. One needs to find alternatives for each of them because gasoline fuels can be carbureted and the engines use spark ignition whereas diesel based vehicles use compression ignition. The replacement for gasoline is ethyl alcohol that cab be obtained from molasses in the simplest possible manner or by a separate process if te feed stock has to be any biomass. The replacement for diesel would be any plant oil – edible or non-edible. The seeds of several plants and trees contain starch or oil. There are at least a hundred varieties of oilseed bearing plants. Better known of these are: Pongemia, Jatropha curcus, Anderoba (Amazon forest species) among the non-edible variety and Palm oil, Coconut oil, Sunflower oil, Safflower oil, etc among the edible variety. The oil productivity is a function of the seed output per hectare and the fraction of oil in the seed. One of the strongest suggestions made in the literature is to use degraded lands and grow hardy oilseed bearing trees. On the degraded lands, the plant species considered to be grown is Jatropha Curcus considered hardy. This species has an origin in Latin America and Africa as can be seen in the Figure drawn from the excellent work of Joachim Heller, IPGRI, Rome

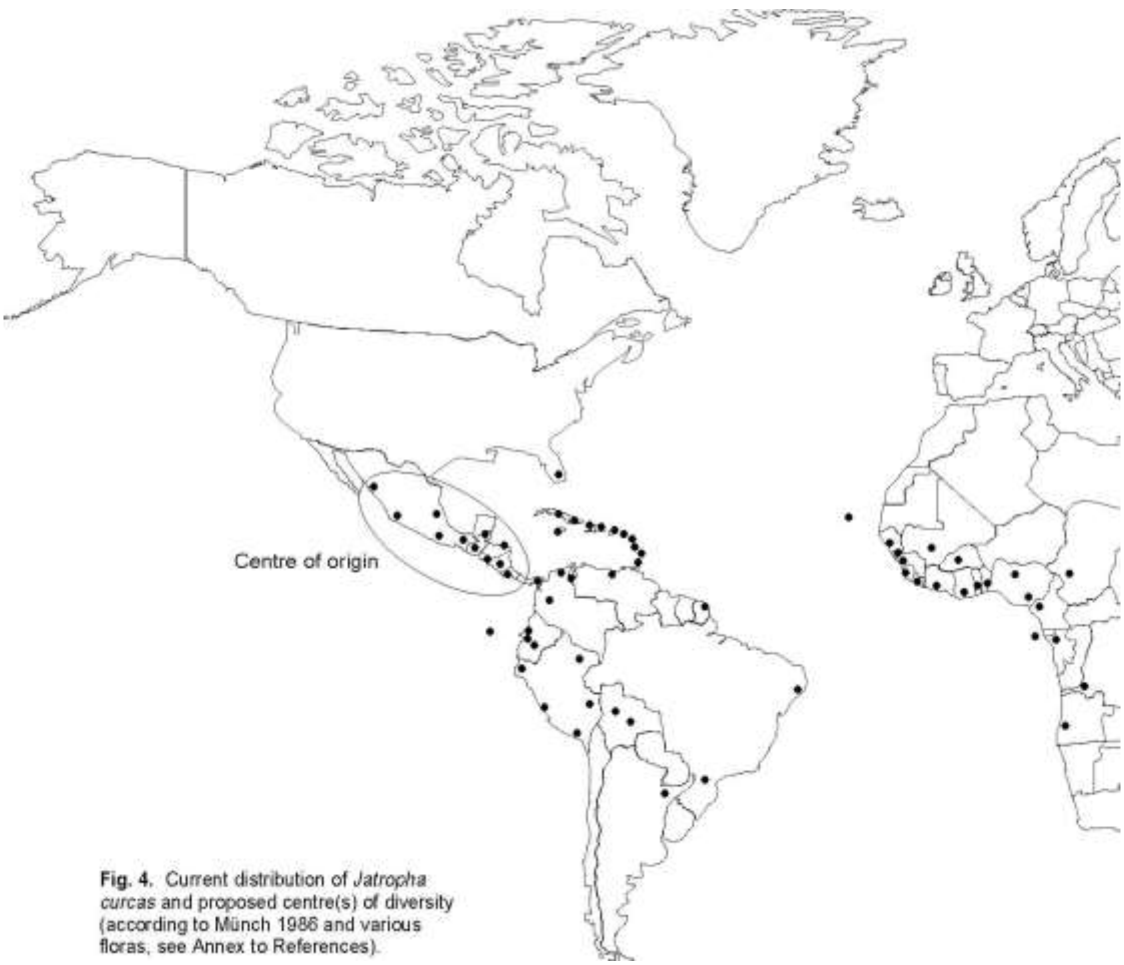


Fig. 4. Current distribution of *Jatropha curcas* and proposed centre(s) of diversity (according to Münch 1986 and various floras, see Annex to References).

However, growing good plantations implies paying attention to the addition of water and nutrients. There is considerable argument as to what would be more appropriate for the use of edible oils as a transport fuel instead of the non-edible variety. Answering it in a theoretical sense by stating that edible oils should not be used for energy generation purposes would be incorrect and this question can truly be answered in the context of the extent of the availability of edible oils in the country. In some countries edible oils are produced in such excess because geo-climatic conditions favor high productivity that denying the use of such oils as a transport fuel would be improper. This argument would be seen with greater clarity if we examine Table 4 that contains the production of various oils from plantations. For instance, if there is a choice between Pongemia and Palm oil, it appears better to go in for Palm oil by suitable choice of soil conditioners and other necessary treatments since the productivity is very high indeed. If there is demand for growing soybean, say because of other requirements of the society, and the geo-climatic conditions allow growth over wide area, then it would be appropriate to choose the route of soybean oil even if the yield is low. Germany and several parts of Europe have concentrated on rapeseed oil and the USA has concentrated on soybean oil. Latin American countries have looked at palm oil where it can be grown or Jatropha plantations. European collaboration with Nicaragua has been in existence for more than a decade on this subject.

Table 4 Oil production from land in kg/Ha for various oils

Crop species	Output oil* tonnes /Ha
Palm oil	5.0
Coconut	2.2
Brazil nuts	2.0
Jatropha	1.6
Jojoba	1.5
Rapeseed	1.0
Groundnut	0.9
Sunflower	0.8
Pongemia	0.8
Soybean	0.4

*The maximum that can be obtained with appropriate addition of water and nutrients.

Several countries in the world have addressed the question of obtaining bio-diesels and dispensing them for use along with conventional diesel and gasoline dispensing stations. These are listed in the Table 5 drawn from the report “Liberalization of Trade in Renewable Energy and Associated Technologies: Biodiesel, Solar Thermal and Geothermal Energy” by Ronald Steenblik, OECD Trade directorate, Joint Working Party on Trade and Environment April 2006. It is clear that Europe is ahead of other countries, Germany, in particular has shown leadership role in producing as much as a million tonnes of biodiesel

Table 5 Biodiesel production in various countries (in 1000 tonnes).

Country / year	**2002**	**2003**	**2004**	**2005 e**	**2006 (est.)**
Mexico	—	—	—	—	—
North America	51	70	86	292	412
Czech Rep.			60		
France	366	357	348		
Italy	210	273	320		
Germany	450	715	1035		
Spain	0	6	13		
UK	3	9	9		
Australia	**27**	**27**	**29**	**36**	**187**
Japan	2	2	3	3	3
China	-	20	45	64	150
Brazil	-	-	6	176	238
Phillipines	-	-	29	29	50

One of the countries that has taken visionary steps in Latin America is Brazil. It has been implementing bio-fuel promotion policies since1930 with addition of 5% alcohol (ethanol) to petrol in response to economic problems as well issues in the sugar industry.

In the 1970s, the oil crisis led to the creation of the program called "*Proálcool*". This provided tax incentives for the sugar industry to diversify and was backed by public and private sector investments. This enabled the expansion of sugar cane plantations and the building of alcohol distilleries. The government ordered a 20% addition of anhydrous alcohol to petrol. Several other changes followed in the 1980s, when the manufacture of first hydrated alcohol fuelled vehicles took place. By 1989, there was lot of critical problems in which logistics problems led to a localized supply problem and annual production of alcohol fuelled vehicles dropped from 63% in 1988 to 47% in 1989, to 10% in 1990, to 0.44% in 1996 and to 0.06% in 1997, at which point the market rebounded to 3.3% by 2002. Despite these problems, *Proálcool was* carried on, thanks to the maintenance of a compulsory addition of 25% alcohol to gasoline.

One of the most important developments that Brazil has undertaken that has had a substantive stabilizing influence on the **acceptability of alcohol based systems is the fuel-flex idea. In this approach, sensors meant for emission control measure the oxygen fraction in the exhaust and send a signal to the engine control unit (called DECU) indicating the level of ethanol in the fuel line that helps set the spark timing and fuel injection. In 2003, the "flex fuel" car engines (that run on any mixture of alcohol and petrol), were introduced, alcohol made a comeback as an alternative to gasoline. In that same year, 48,100 vehicles of this type were placed on the market. As of this writing, the total number of alcohol fuelled cars on the road has exceeded 5 million (including flex fuel cars), a truly magnificent achievement by any standards.**

Brazil consumes 13 billion liters of alcohol per year, and is presently the world's largest producer, with an annual installed capacity estimated at 16 billion litres. Average annual production stands at 12.5 billion liters, of which 7 billion is anhydrous alcohol (for mixing with petrol) and 5.5 billion hydrated alcohol. In 2004, production in the Central-South region of Brazil (responsible for 85% of the total sugar cane production crop) was 13.5 billion litres. Brazil ended 2004 with record ethanol exports, a total of 2.36 billion litres. Japan has regulated the addition of 3% of alcohol to petrol as from 2004, with projections for a future increase to 10%, representing an annual requirement for six billion litres. To meet its medium and long-term needs, Brazil, will need to significantly increase its industrial and farming capacity, either through intensified use of technology or by expanding its plantations.

In addition to alcohol, vegetable oils are also a main source of biofuels Even though research was being carried out from 1950, in recent times the momentum was picked up by the Government. In October 2002, the *MCT* (Ministry of Science and Technology) created *Probiodiesel* (Brazilian Technical Biodiesel Development Program) aimed at developing the fuel from pure or residual vegetable oils and evaluating its technical, social, environmental, and economic feasibility. In January 2005, the federal government authorised the use of biodiesel in Brazil. This allowed for the addition of 2% of biodiesel to diesel oil until 2008, when the mixture (known as B2) would become compulsory. The guidelines and the rules applicable for production and distribution in Brazil may not be applicable to all the developing countries since the freedom provided by the Government for the mixed fuels to be produced is fraught with the danger of adulteration to make quick money. But the leadership role provided in recognizing these aspects is highly commendable.

Apart from Brazil, a few countries like Nicaragua and Honduras have programs for growing Jatropha plantations. Nicaragua has grown Jatropha plantations and gained considerable experience in producing these oils. But these efforts are still in incipient stages in comparison to Brazil since there are no statutory steps to enhance the production and utilization yet. Jatrophas has been studied a great deal and it appears that the plant is native to Latin America and the west coast of Africa (see the following world map with the dots showing the location of Jatropha plantations, drawn from International Plant Genetic Research Institute report, via delle Sette Chiese 142, 00145 Rome, 1996).

The most important action taken by Brazil is creation of a new Law, under which *ANP* (National Petroleum Agency) became the National Petroleum, Natural Gas and Biofuel Agency. The Agency has defined biodiesel and its production, distribution and marketing chain structure specifications, and has also acquired authority over the activities of biofuel producers. Eighteen of the Agency's regulations on the national supply of fuels were revised as a result of the inclusion of biodiesel. Fuel distributors will generally carry out the addition of biodiesel to diesel oil. But refineries are also authorized to do so. The legislation permits, in certain cases, the use of mixture ratios greater than that established by the government, provided it has *ANP* authority. The Agency is also responsible for authorizing the production of biodiesel by companies. The latter will be required to send monthly data on processing, turnover, production, inventories, quality and listings of receipt and delivery of raw materials and products. Furthermore, these producers and distributors must certify the quality of the product to the dealers, guaranteeing, via laboratory analysis, that it meets all technical specifications.

1.5 Biorefineries.

The range of biofuels being wide, the approaches to producing liquid fuels from bio-resources also several, it has often been suggested that there should be bio-refineries that have several streams of equipment to manage the variability. The situation is not unlike fossil fuel refineries where the crude that is procured can vary depending on the source and the age of the well. Initially, the liquids that are pumped out have lighter fractions and as time proceeds the same well will provide heavier fragments in the crude. If the output product specifications are maintained the same, the process parameters need to be modified according to the quality of the crude characterized on its arrival at the refinery. Such a situation is also expected form a bio-refinery. The input feed stock could be soybean in one season, palm fruit bunches in another season. The product quality demanded might need a process that uses gasification to generate synthesis gas that is later converted to a liquid fuel One distinguishing feature between a bio-refinery and a fossil fuel refinery is that the maximum capacities of bio-refineries might need to be smaller than in fossil fuel refineries. Fossil fuel refineries are usually located on coastal locations to enable sea transport to help procure large tonnages at cheaper transportation cost and not load inland transportation systems. The fuel for bio-refineries arrives from several small locations much like sugarcane grown by farmers. Perhaps, a time will come when fossil fuel refineries get converted to bio-fuel refineries if the peak oil problem perceived by several people is indeed real.

1.6 Plantation and Forest resource base

The distribution of the forest in various countries is presented in Table 6. The data is obtained from FAO sources on the internet. What is clear from the table is that most land mass in Latin America is blessed with forest wealth. Any such forest implies forest related operations for logging the trees for timber. Such operations are accompanied by wastes that amount to 25 % to 30 % called lops and tops. More importantly, the plantation can be harvested and this magnitude can be seen to be substantial

Table 6 Plantations and Forests of Latin America

Country	Plantation Area	Est.Biomass Output * Mill. Tns /yr	Total Forest MHa	Natural Forest MHa	Tropical Forest – MHa	Protected Trop. Forest Area - MHa
Argentina	0.83 MHa	8.0	34.0	33.4	4.3	0.24
Bolivia	20000 Ha	0.12	48.3	48.3	68.6	8.33
Brazil	4.8 MHa	72.0	551.1	546.2	301.2	20.6
Chile	1.75 MHa	11.0	7.9	6.9	0	0
Colombia	0.3 MHa	2.0	53.0	52.9	53.2	5.8
Costa Rica	0.13 MHa	0.8	1.2	1.2	1.5	0.6
Cuba	0.47 MHa	4.0	1.8	1.6	1.8	0.3
Dominican R	20000 Ha	0.12	1.6	1.6	1.2	0.2
Ecuador	0.12 MHa	1.0	11.1	11.1	13.5	3.2
El Salvador	8000 Ha	0.05	0.1	0.1	0.1	0.005
Guatemala	0.067 MHa	0.4	3.8	3.8	3.86	1.23
Haiti	12000 Ha	0.07	0.02	13	0.063	001
Honduras	40000 Ha	0.24	4.1	4.1	5.3	1.0
Jamaica	6200 Ha	0.04	0.17	0.16	0.4	0.08
Mexico			55.4	55.3	45.8	1.9
Nicaragua	23000 Ha	0.14	5.6	5.5	5.3.	1.3
Panama	16200 Ha	0.1	2.8	2,794	3.7	1.1
Paraguay	18000 Ha	0.13	11.5	11.5	9.3	0.24
Peru	0.35 MHa	2.1	67.6	67.3	75.	3.9
Trinidad + Tobago	18000 Ha	0.11	0.16	0.15	0.12	0.008
Uruguay	0.35 MHa	2.1	0.81	0.66	2	0
Venezuela	0.59 MHa	0.35	44,0	43.7	55.6	32.8

* For the output in terms of dry tonnes per hectare per year, it is taken as 15 for Brazil due to its demonstrated experience in growing plantations, 10 for Argentina, and 6 for other countries. Those countries following the practices and experience of Brazil can double the plantation output.

1.7 The Agricultural residue base.

All the countries grow a variety of crops, fruits and vegetables. Fruits and vegetables are discounted in the present assessment because the wastes from the processing are usually dilute with water and hence qualify for biomethanation processes rather than thermo-chemical conversion. Also the dry matrial would be small for consideration here. Coffee and tea plantations are also excluded. Coffee plantations do produce periodical trimming of shade trees like those of Silver oak or a similar variety. Countries like Columbia have a large share of these plantations. These wastes can be dealt with in the same way as plantation tree wastes. Appendix I contains the details of the crops grown in the countries of LAC region drawn from the statistics of FAO. The residues from each of the crops, their magnitude are assessed from research study conducted at the combustion, gasification and propulsion laboratory at the Indian Institute of Science (CGPL at IISc) over the last decade. In a major effort to map the agricultural residues in India, the ministry of non-conventional sources of energy (MNES) started a program initially of taluk level assessment of agro-residues and later to district level assessment. These were expected to be integrated into a map based on geographical information system (GIS) so that the data can be integrated into modern information access system. During this process, the residues were collected and magnitude obtained as a ratio of the crop. This is called crop-to-residue ratio. These quantities were revisited on a yearly basis in joint meetings with consultants doing field studies and other experts. Those crops that have a life of a year or less could be best assessed by satellite maps that are combined with vegetation index to determine the quality of output. These are otherwise used regularly by the Space department to provide advice to the government on the expectation of crop output for advanced planning. Hence a joint project was initiated to utilize the satellite data and combine them with NDVI to obtain the crop details that were subsequently calibrated on a overall scale with statistical data. There are other plantation crops like coconut, coffee and tea plantations that also generate residues on an annual basis that need to be accounted. These are based on statistical information of the crop, its yield and the residue output per tree suitably scaled. The details are available in Appendix. All crops whose net output is less than about a 0.1 million tonnes, vegetable wastes and fruit wastes are excluded from this list. These wastes are better handled by biomethanation route. A brief summary of principal crop residues that could be used for energy generation purposes is presented below in Table 7.

Table 7 Crop Residues of significant magnitude (in Million tonnes) for energy exploitation
(Bagasse is a captive fuel of sugar industry. It is currently used, perhaps not in the most efficient way. Use of high pressure boilers can help overcome this inefficiency. It is not counted here)

Country	Maize stalk and cobs. MT	Wheat stalk and pod, MT	Soybean stalks, MT	Coconut shell, and fronds MT	Sugarcane Trash, MT	Paddy straw, husk, MT	*Total Oil Eqlnt MT	Population Million, Rural fraction, %
Argentina	30, 7.5	21.5, 13.1			0.97		14.60	40.0, 10 %
Bolivia	1.4, 0.35	0.17, 0.1			0.24	0.45, 0.06	0.55	9.0, 37 %
Brazil	83.6, 21.9	8.6, 5.2	84.6	0.5, 2,2	20.1	20.0, 2.0	50.00	188.0, 17 %
Chile	2.64,	2.9,				0.2,	1.60	16.1, 13%

	0.66	1.7				0.02		
Columbia	2.8, 0.7				2.0	4.0, 0.54	2.00	43.6, 24 %
Costa Rica					0.19	0.38, 0.05	0.12	4.07, 39 %
Cuba				0.02, 0.09	1.2		0..26	11.4, 25 %
Dominican R				0.03, 0.14	0.28	0.87, 0.12	0.31	9.18, 41 %
Ecuador	2.7, 0.37		8.98		0.33	0.17, 0.27	2.56	13.5, 38 %
El Salvador	1.3, 0.33			0.02, 0.08	0.26		0.40	6.82, 40 %
Guatemala	2.14, 0.54				0.9		0.72	12.33, 54 %
Haiti	0.18,0.70				0.05	0.09, 0.01	0.21	8.31, 63 %
Honduros	1.0, 0.50				0.27		0.05	7.30, 54 %
Jamaica				0.03, 0.13	0.11		0.05	2.76, 45 %
Mexico	43.34, 10.84	3.48, 2.09	0.22		2.42	0.42, 0.06	12.60	107.4, 22%
Nicaragua	0.88, 0.22				0.2	0.35, 0.05	0.34	557, 43 %
Panama	0.16, 0.04				0.02	0.48, 0.06	0.15	3.19, 43 %
Paraguay	2.24, 0.56	1.08, 0.65	6.09		0.18	0.2, 0.03	2.21	6.51, 43 %
Peru	2.36, 0.59				0.48	2.73, 0.36	1.30	28.30, 26 %
Trinidad+Tbg					0.03		0.01	1.06, 22%
Uruguay	0.44, 0.11	0.8, 0.48	0.65		0.01	1.89, 0.25	0.93	3.43, 7 %
Venezuala	4.36, 1.09			0.03, 0.12	0.44	1.46, 0.19	1.54	25.7, 12 %

*The oil equivalent of biomass varies from 3.3 to 5 for fuels with little ash to large ash (from coconut shells, corncobs and wood to paddy and wheat straw). A factor of 5 has been chosen uniformly to get the most conservative estimate.

Table 8 Oil importing countries and the Bioenergy (Oil equivalents)

Country	**Net Oil imported,** KYP	**Agroresidue – Oil equt**, KYP	**Plantation residue oil equt,** KYP
Haiti	70	24	8
Nicaragua	100	60	25
Bolivia	30	60	13
Cuba	580	22	353
El Salvador	290	60	8
Guatemala	180	60	32
Paraguay	190	390	23
Peru	60	50	77
Panama	1210	50	33
Uraguay	540	270	621
Chile	690	100	700

Note: Forest logging also contributes to biomass that can be used in domestic use. This biomass is not counted here., KYP = kg per year per person

The most important observation of the Table 6 is that the energy equivalent of the biomass is substantial. This is of particular importance for oil importing countries. Biomass like corncobs and coconut residues can be treated like wood chips. Corncob does not even have to be sized. It should be dried, something that can be done in the plant that uses this to generate heat or electricity as a part of the process. Agro-residues are distributed over wide land mass and also in proximity to living habitats because people grow these for their need. Coupling these features one can set up distributed power generation plants in clusters to enable economic and reliable operation of the plants on a commercial basis.

1.8 Urban Solid Waste

The subject of urban solid waste is usually not discussed when considering clean fuels like biomass. Nevertheless if one examines the composition of urban solid waste, one will not fail to recognize that its composition is largely biomass, albeit with some plastic material – typically less than 10 %. In most towns and cities, the average amount of waste generated varies from 0.2 to 1 kg per person per day the lower end valid for small townships and the larger value for cities. While segregation forms the first process in any waste handling system, the material that comes out has a composition close to biomass. Preparing it further for power generation depends on the approach chosen. Simple composting will not lead to power generation; one has to adopt biomethanation, incineration or gasification. Biomethanation leaves behind residue that could be used as a soil conditioner when the material is characterized properly. This process is usually more expensive compared to incineration or gasification. Incineration has the issues of gaseous emissions when the feed stock is mixed with chlorinated plastics that need extensive treatment before the gases are released into the atmosphere. Gasification process allows for confining the difficult constituents to within the gasification island, but all the aspects have not been demonstrated yet. World over, the systems have used biomethanation or incineration both being relevant at large throughputs. Smaller throughputs, implying less than 50 tonnes per day of active organic matter that amounts to 100 to 120 tonnes of as received waste require gasification technology adoption and this has not happened anywhere yet. A few demonstration projects are under consideration in India at this point of time. The central problem in urban solid waste in developing countries is that the question of delivering the waste to waste handling facility itself is to be realized practically. Very few townships go beyond composting at this time. Hence much needs to be done on this subject in coming times.

Chapter 2 Global Experience

2.1 General

Biofuels, as described above can be used for both liquid fuel production as well as gaseous fuel generation. The processes involved with liquid bio-fuels, particularly from oil seed bearing trees have been researched for long time and much is known about them (see for instance, the excellent IEA report "Biofuels for transport" that can be accessed from internet that describes the technical, financial and management aspects of biofuels). Those governments that recognize the benefits and create a program with public-private participation that involves a minimum of investments from the Government but provides facilitation and tax incentives like Brazil will stand to gain substantially.

One missing link in all these initiatives, however, is the fact that whenever biomass growth occurs as a plant or a tree, there will be tree fallings and bio-waste that can be integrated into the approach to deal with bio-fuels. ***Unfortunately, not a single initiative over the world recognizes this feature. The projects and programs ignore this connectivity. Either they are overly concerned with liquid biofuels or with solid wastes separately.*** It is extremely valuable to deal with them together as the benefits that flow from such a conceptualization are very significant. To state briefly, the biofuel plantations would usually be grown in locations with scattered habitats and it is not easy to provide the quality of life electricity to such a scattered population if grid electricity is sought to be taken to such locations. The simplest issue of economics would be against such a plan. The solid wastes from such a plantation could be effectively used for generating electricity or heat locally, particularly when these generating stations are used in a cluster mode with the entire management handed over to professional operator(s) so that the community can benefit from electricity services much like in cities or townships. The liquid fuel whose role is better capitalized by deployment in the transport sector (that may include farm equipment like tractors and other machinery) will bring in better revenues to the community or the organization involved in the entire operations.

Solid biofuels have occupied the bottom of the development ladder in all the countries. In developing countries, the rural environment placed at distance from urban centers and their way of life have always depended on bioresidues for many of the domestic needs – from thatched roof, soft bedding, animal fodder and cooking fuel. The urban population has moved to piped gas or bottled liquefied petroleum gas. There are a number of research groups across the world involved in research and development on biomass conversion technologies. There are a whole group of enthusiasts and NGO's dealing with biomass based stoves. Several important web sites provide information about the individual experiences ("Bioenergy_Lists" is a very comprehensive web site). Biomass stoves have not reached significant commercial arena yet. Marketing has always been supported by some form of governmental subsidy with all the attendant limitations of a trickle reaching the true needy even when the inputs by Governments have been considered significant – financially. Unfortunately, countries like India and China where significant Governmental inputs have been provided by the Ministry, no attempt has been made by them to do the necessary research and development so that market forces can take over. Several countries in Africa and Latin America have been the sites for NGO activity with regard to stoves. The results have been locally significant but no global reach is seen. One of the reasons is that the devices sought to be introduced have not had sufficient scientific and technological inputs to enable market recognition and capitalization.

2.2 Experience in Europe and America

The position of gasification is not vastly different. The work done in Sweden, Germany and France was lost sight of because of the easy availability of fossil fuels. There was no motivation to develop biomass based technologies since they turned out to be more expensive compared to fossil fuel based solutions. Sporadic effort has gone on and only a few groups have sustained the research and development efforts by bringing in intellectual and financial support. NREL, USA with Dr. Thomas Reed leading the effort and a number of groups in India, three of the higher institutes of learning like Indian Institutes of Technology and Indian Institute of Science nourished active groups over the last three decades. Unfortunately, there has been severe attrition in most institutions and there are three active research groups at present. Gasification technologies for thermal applications are serviced by several industries in India, China and some Latin American countries like Uruguay. Thermal applications like non-ferrous metal melting, drying fruits and industrial products like rubber, water boilers are applications that are serviced by using raw hot gas and these are dealt with by using simpler technologies. Thermal applications when the gas has to be transported over distances and heat delivered in dual-fuel mode with a capacity to allow complete fossil fuel usage as a back-up option can be met with by a clean gas as the gas has to pass through very fine passages without creating deposits. These can be serviced by only one or two technologies.

Thomas Reed and Siddhartha Gaur have written a report in 2001 "A survey of biomass gasification 2001" (one can get this from the website http://www.woodgas.com/tombio.htm where they have described (a) the fundamentals of gasification and (b) over fifty designs of systems and (c) over hundred projects in various countries – both developing and developed. One would imagine that coming from the expert hands of Dr. Thomas Reed, one would get a clear picture of working systems through a defined criticism of the issues with various systems. Unfortunately, one would be left with lot of information without accompanying clarity as to what is working and what is not as well as what will not, no matter what the claim is.

Realizing the importance of the role of gasification technologies, particularly the small gasification technologies, the BTG biomass technology group, E4tech and the Institute for Energy Economics and the Rational Use of Energy (IER) of the University of Stuttgart created and maintained a web site on the internet so that this site could be accessed by gasifier manufacturers and input the data corresponding to their products. The summary of their experience in October 2001 is that "the current information in the databases is relatively limited, i.e. suppliers of installations and contact persons are not very willing to provide the requested information. Therefore, much information is compiled from literature and existing information at the project partners. Once the information is published on the Internet more comments and corrections were received on the data although there are still many empty fields. Information on costs, emissions and other technical performance indicators are quite limited. This is either due to the limited experience, the bad experience or simply by not knowing, i.e. not measured. Most visitors are "end-users" looking for a gasifier manufacturer and/or delivery of a plant, indicating sales opportunities for those listed in the database. The author has kept the database updated for two years and due to the still increasing interest in gasification, it is recommended to continue with this updating".

An experience from Costa Rica is quoted from literature: "In 1986, a co-operative effort involving the French and Costa Rican governments and the Organization of American States implemented a project bringing electricity to Buena Vista de Guatuso, a farming village with 300 inhabitants. The purpose of this project was to supply the village with electricity, thus improving quality of life through an economically competitive technology, while also testing its reliability.

This village was selected for this pilot project as it was not included under short-term rural electrification plans. With easy access to ample supplies of wood fuel from clear-cutting needed to open up forestlands for farming and grazing, it could guarantee plenty of timber to fire the plant.

At a cost of around US$35 000, a French wood fuel gasifier was installed, together with a 30.4 kW generator. An emergency plant was also set up, as well as a wood fuel dryer running on recycled exhaust and ventilator gases from the gasifier.

The project encountered various operating problems, due mainly to the high moisture content of the wood fuel, and remained in operation for only six months. This village is currently supplied by the grid".

The reason for all these conditions is that in the past, the biomass gasification technologies had not been addressed on a fundamental level and has been dealt with by enthusiasts through development of projects and associated hardware local problem solving for a long time with great hesitation to open up the developments to other communities for independent examination.

2.3 World bank reports and Indian developments

Two World bank investigations have resulted in reports [Stassen, H.E.M., 1993. ‘‘UNDP/WB small-scale biomass gasifier monitoring report, Volume 1 – Findings the final findings appearing in the Journal of Energy and Sustainable Development, pp 41 – 48, Vol II, May 1995] and [Scaling up biomass gasifier use: applications, barriers, and interventions, Debyani Ghosh, Ambuj Sagar and V V N Kishore, November 2003, World Bank report posted on the internet]. The earlier report became the focal point for World bank to stop financing biomass gasification projects for the next ten years. The next report based on the developments in India is somewhat more positive with respect to thermal systems, but is very cautious about electrical systems. The support for thermal gasifiers cannot be termed exceptional as other countries are also practicing this art; the understanding arising out of such systems will be wholly inadequate for electrical gasifiers used on naturally aspirated reciprocating engines. Even the understanding and technological elements for a gas to be used on a naturally aspirated engine are not adequate for turbo-supercharged engines. That these are wholly new findings not found in European or American literature is not entirely easy to appreciate for most people and the authors of the world bank report are no exception. While the developments were in place by the time the WB report was finalized, since no feed back was obtained on the draft report to World bank from the principal scientists and developers in the Indian Institute of Science, the report carries conclusions that could have been substantially modified in the positive way. Indian Institute of Science released an important work “Biomass-to-Energy, The science and technology of the IISc Bio-energy systems” in December 2003. The key to this enthusiasm arises from an analysis of industrial systems that intend reaping financial benefits by running the system on a 24 x7 basis. At least three systems, one thermal and two electrical systems were monitored for almost 18 months on a continuous basis. Issues of failures were analyzed and traced to either design or operational aspects and addressed suitably. Beyond the first six months, the issues of operation had got slowly resolved. Both systems, one at 130 kWe and another at 1 MWe have operated for more than 7500 hours and more than 30, 000 hours as of this writing.

Even before this, a partnership was struck with M/s Cummins India, Pune to jointly examine the engines operating on producer gas. For this purpose, a 55 kWe gas engine went through a joint 24 hour test in which the initial conditions and final conditions were rigorously monitored. The fact there was little dust and tar in the system gave the initial confidence to M/s Cummins India to go ahead and test the larger systems in the field (~ ppb). They conducted tests on the engines after every thousand hours of operation. After these tests and analysis of the P and T (Particulates and Tar) matter as well as the lubricants, and a number of other discussions on the science and technology of the gasification system designed to achieve these standards, they agreed to partner with Indian Institute of Science systems and are intending to market producer gas based engines. The operation and maintenance expenditure for the operations over one year were analyzed and it was determined that these are about 2 US cents per kWh for the small system (130 kWe) and about 1.7 US cents per kWh for the larger size system (250 kWe of the 4 x 250 kWe = 1 MWe system). ***It is important to recognize that such a condition in which a major engine manufacturer supplies producer gas engines with appropriate guarantees and warranties has not been obtained with any other design or manufacturer till now***. It is clear to the authors of this report that unless and until the gasifier manufacturers partner with the engine manufacturers and conduct independent verification tests, it is not possible to instill confidence in the user community. And if these procedures are gone through as usually happens with any new technology, it is possible to expect that such systems will perform creditably in the field.

Chapter 3. Ongoing Programs

The information is available only for a few countries. They are provided here as examples. The actual situation in most developing countries is so similar that even these examples are adequate to plan out strategies for further biomass use. This part is drawn from **http://www.worldenergy.org/wec-geis/publications/reports/rural/case_studies/case_studies.asp**

Argentina

About 10% of the Argentinian population lacks access to electric power mainly in rural areas where 2.3 million inhabitants subsist without this service.

Five provinces have already joined the Scattered Community Electric Power Supply Program: La Rioja, Catamarca, Jujuy, Santa Fé and Salta. Clustered in Northwest Argentina – a poor region that lacks many basic services – the widely-dispersed market in these provinces features the following characteristics (Table 8):

Table 8 Scattered market

Province	Potential Private Users[a]	Public Services
La Rioja	3,800	164
Catamarca	5,515	277
Santa Fé	38,000	-
Jujuy	34,000	158
Salta	83,000	462

[a] inhabitants lacking access to electric power services

At the moment, a number of projects are under way to develop decentralised systems powered by renewable fuels to supply widely-dispersed markets with electric power. Most of them are` related to wind, and solar photovoltaics and only a few of them are related to biomass. Even here the current status seems unclear. (a) Implementation of a thermo-electric plant powered by biomass wastes from sawmills in the Entre Rios Province, with planned power generation of 24

GWh p.a. (b) The state is subsidising the operation of wind-power for individual systems in Chubut Province, to replace diesel. (c) Large amounts of forest biomass left by logging companies will be used to generate electric power in Chaco Province.

It is clear that the attempt to combine wind with diesel implies that any fossil fuel replacement will not exceed 30 % as the wind power availability is about this magnitude. Solution with biomass gasifiers would be far more eminent since one can expect it to provide availability as much as diesel engine would. Argentina has 4 % biomass in the energy mix, a magnitude that can at least be enhanced to take care of distributed electricity needs of scattered villages.

Brazil

Brazil is an oil rich country. It is a large country with various natural benefits including the famous Amazon rain forest. Although electricity and oil products take up a large share, modern sources still make up a low proportion compared to energy consumption standards in developed nations. Biomass accounts for 20% of final consumption as a whole, due to two independent factors: inefficient use of biomass, particularly fuel wood, by poverty-stricken communities, and more modern uses such distilling ethyl alcohol from sugar-cane as an automotive fuel. While fossil fuel sources occupy 38 % of the energy utilized, alcohol occupies about 4 %, cane

Brazil's electric power system is the largest in Latin America, ranking tenth world-wide by capacity. Hydropower accounts for 91.3% of total installed capacity and 96.1% of electric power generation.

Approximately 90% of Brazilian households are connected to the electric power network. However, while urban areas are almost completely covered by these services, much still remains to be done in rural parts of the country, where only 63% of households currently have electric power services. In poorer areas, the problem of supplying rural communities is particularly alarming. For instance, in the Northeast, where villagers and smallholders lack many basic requirements, less than half rural households have access to electricity.

Supplying power to these areas requires facilities that are not economically viable. However, government programs are under way to provide this product so vital to community well being. Public utilities usually lead the expansion of electrification. In 1983, an agreement was signed by two utilities (COPEL and CEMIG) with the World Bank, covering financing for electrification in two states. As a result 123 000 properties in Paraná and 95 000 properties in Minas Gerais were serviced. Some effort was put in to electrify rural habitats using World bank money.

In 1994, Eletrobrás set up the Rural Electrification Priorities Committee to allocate funding from the Global Reversion Fund for rural electrification.. In addition, the Ministry of Agriculture is once again offering grants to underwrite rural electrification. Another important source of investments is the Smallholder Support Program, which offers a line of credit from the World Bank set up to reduce poverty in Northeast Brazil. In addition to federal funds, rural electrification is also backed by ample allocations in state budgets. A number of programs are already firmed up in various areas, particularly Rio Grande do Sul, Minas Gerais and São Paulo States. Based on a pilot project underway in Rio Grande do Sul, the National Bank for Social and

Economic Development (BNDES) opened a line of credit to finance electrification for farmers. This assigns top priority to the implementation of low-cost distribution systems, such as single-line networks. This model is already being implemented in São Paulo and Ceará States, despite some limitations. It is designed to service small farmers located close to established transmission systems.

Existing decentralized systems normally generate electric power from fossil fuels, with low yield and high transportation costs. These are offset by the Fuel Consumption Account (CCC) which subsidizes excess costs incurred through electric power generation.

As generation technologies based on biomass (plant oils and timber gasification, among other possibilities), as well as small-scale electric power plants and solar/wind-power systems, continue to develop, these renewable sources become competitive with those currently in use. In Amazonia, a number of remote communities have only limited electricity supply although they are often close to rich sources of biomass. Renewable use of this biomass could be an economic means of sustainable electricity generation.

Native oil-seeds can also be converted to plant-based diesel oil, which in turn is used to generate electricity. Amazonia is rich in oil-seed plants, particularly babassu and buriti palms. Germany's DMS has developed an engine which runs on unprocessed plant oil, and this model is already in use successfully in Brazil. Three of these engines are currently in operation: one on a ranch in Mato Grosso State which runs on oil pressed from rotten brazilnuts, another at a dendê oil plant in Para State, and the third is owned by the University of Brasilia, which uses it in Rondonia State for a project involving research organisations, the local power concessionaire (CERON), and rural co-operatives in Para State.

Another alternative is power generation based on wood fuel, particularly integrated gasification with combined-cycle gas and steam turbines. This technology is being used by the project known internationally as Brazilian Wood BIG-GT Demonstration Projects/Integrated System for Electric Power Production – WBP/SIGAME. A pilot project is being implemented by the consortium consisting of CHESF, Companhia Vale do Rio Doce and Shell in Bahia, setting up a 32 MW plant. The initial results indicate a total cycle efficiency of 40% – double the rate achieved in traditional woodfuel conversion processes set up to generate electric power. This project has never taken off even though the associated development projects on ambient pressure gasification system at Therminska Power Systems, Sweden and high pressure gasification system at Vernamo, Sweden proved their success albeit some delay on the high pressure system. The reason for non-progress on this project has been related to inability to find local investors in Brazil who must have though this project to be a technical risk. An alternate strategy of using 1 MWe class systems all along the river bank where the eucalyptus plantations are grown would a simpler and non-risky choice even as of today. Coopertaive arrangements with Indian Institute of Science, Bangalore India were made to enable setting up small biomass based power plants in Amazonia. These projects are yet to take off. Also some efforts are being made by the University of Para where Prof. Mrs. Brigida is taking initiative to build systems for Brazil, particularly Amazonia region with a limited technology transfer agreement with Indian Institute of Science, Bangalore, India.

An outstanding institutional initiative is the State and Municipal Electric Power Development Program (PRODEEM) launched by the Ministry of Mines and Energy. This is intended to foster integrated development, while acting as a catalyst for new decentralised power generation projects fuelled by locally available resources. This program introduced acculturation hubs: three projects in each state develop into multiplicatory centres linked to other areas of the Federal Government, normally under the Community Solidarity Program. By mid-1996, the Social Development Sub-Program had provided electric power services to 481 communities.

A whole series of factors drive the dissemination of renewable energy systems: a potential market of some fifteen million people lacking access to electric power; inefficient use of diesel for generation that could be replaced by renewable energy sources; various demonstration projects under way; easy availability of natural resources; and a wide variety of financing sources.

The restructuring of Brazil's electric power sector has prompted appreciable tariff increases. This tends to make renewable energy sources more competitive for electric power generation. Additionally, projects based on renewable energy sources are more likely to obtain financing from international credit agencies. This means that the prospects for using alternative energy sources to supply rural communities with electric power are most favourable.

Mexico

Part of North America, is also the northernmost nation in Latin America. Flanked by the Pacific and Atlantic oceans, it is bordered by the USA. to the north, and Guatemala and Belize to the south. The third largest country in Latin America, Mexico covers some two million square kilometres. It also has the second largest population, with 90 million inhabitants. However, in rural areas biomass still accounts for almost 60 % of energy supplies with most of the energy going for cooking. .

Mexico's electric power system has an installed capacity of 34 GW: 69% from thermoelectric plants, 27% from hydroelectric complexes, 2% from geothermal sources and 2% nuclear power. Total electric power generation reaches 136 TWh. The nation-wide power network services close to 95% of the total populace. Urban areas are fully supplied with electricity, while 21% of rural dwellers – some five million people – still lack this basic benefit. In Mexico, access to electricity is a citizen's right, with massive efforts under way to extend transmission lines to even the most remote communities. However, some locations are still not linked to the grid, due largely to their remoteness and distance from main power-lines. Other problems include a widely-scattered populace, mountainous terrain and low electricity consumption levels. For places where connection with the grid is not feasible, decentralized electric power generation systems are the most attractive alternative. Mexico has wide experience of generating electricity using solar photovoltaic cell systems. Early solar projects in the 1970s were expanded to include telecommunications in the subsequent decade. By 1989 the Mexican government was well aware that the electrification of small, remote rural communities was perfectly feasible through photovoltaic systems. The decentralized electrification program based on photovoltaic systems supplements the expansion of the public utility grid, and forms part of the PRONASOL – National Solidarity Program set up to extend infrastructure facilities to less-developed regions. This program is funded by a special budget for the electrification of areas not included in short-term grid expansion plans.

Some of its characteristics are unique:

- This is an endogenous process in which only local authorities participate, avoiding any intervention by foreign institutions.
- Conceptualized on a large scale, its projects are implemented rapidly.
- Both the public and private sectors are involved.
- The program guidelines are basically social, structured to provide services for the poorest communities.

One of the keys to the success of these projects is that public funding is not deployed paternalistically. The counterpart funding requirement – which demands not only financial input but also effort from beneficiaries – creates a commitment within the community that is crucial to the success of this program. Many of the villages actually set up community funds to maintain and expand their domestic solar power systems.

Despite this, rural energy availability in Mexico tops the average for Latin American nations for two reasons. Primarily, the country has ample available energy resources, mainly oil. In addition, another factor making modern energy – particularly electricity – easily available in rural areas is a widespread government priority. The main distribution network has been extended to much of the rural populace and places still without electricity have specific characteristics that undermine the feasibility of further grid extension. For these communities, a highly successful electrification program is being implemented based on the installation of photovoltaic cells supplying solar power to homes.

Honduras

Recent forest biomass studies in a 100 km radius, which includes the states of Francisco Morazán and Olancho, show that 49 sawmills operate and that they generated 86,010 metric tons of residues just in 1997 of which 14,800 metric tons were of sawdust and 71,210 tons of other industrial wood residues. Operations from the forests of Talanga y Guaimaca habe been estimated at 80,000 metric tons. More important is the biomass resulting from the thinning (raleo) of forests, approximately 640,000 tons.

Feasibility studies in the negotiating stage for electric generation from biomass are: Rancho Las Acacias, in San Manuel, Cortés (15-30 MW); between El Progreso and Tela a bamboo project (50 MW); Guaimaca, Francisco Morazán (15 MW); Sabá, Colón (80 MW). Again, high costs of initial investment and the short term marginal cost are hampering efforts to exploit this resource.

A major cooperative initiative with public and private stakeholders was launched in 2002 by the Environment and Energy ministry of the Finnish Government with the support of 60 central American companies and institutions in eight Latin American countries on several renewable energies including biofuels aimed at creating a cache of successful demonstrative projects, removing legal and institutional barriers, catalyzing the market development and capacity building including training in CDM benefits. From the description that can be read from an internet search on the site "session4_markku_nurmi.pdf", the periodic reviews and technical interactions seem to have led to a positive feeling of the progress, Based on a review of these projects costing about 3 million euros, several new projects are being continued through 2009.

Chapter 4 Key Barriers and Issues

[Analyze barriers (technical, economic, institutional and social in particular) and identify key issues that need to be taken into consideration for development of Biomass energy, gasification and bio-fuels, in the Latin American region }

The barriers are a function of the biofuel segment considered. The segments are: Liquid bio-fuels, solid plantation and agro-residues and urban solid waste. The services these fuels provide are also different – liquid biofuels provide the fuel for transportation largely, solid bioresidues aim to provide electricity or heat, industrial or domestic.

Even with respect to liquid biofuels, the issues are different between alcohols and biodiesel. The alcohols are produced by sugar industries that are owned by a select number of owners. This group has some form of an association or an organizational structure that can be approached for evolution or resolution of issues. The technical aspects of alcohol production are well known and widely understood. If the program has any barriers, they are related to prices at which the oil companies buy up the alcohol and the international prices of competing product, namely, sugar. Here again, food vs fuel questions need to be debated and these are strongly country dependent. The only general point that can be made is that the portfolio of alcohol as a fuel should be retained with some flexibility to allow relative production rates of sugar and alcohol. Considerable experience in dealing with these issues in Brazil over the last three decades can be brought in when needed.

Biodiesel is entering into the market in Brazil and there is considerable interest in several other Latin American countries. Nevertheless, even the oil importing countries seem not show serious concerns expected of them in the current volatile pricing structure of crude oil in the international scene. This kind of inelasticity in recognizing the true problems and possible solutions is a property of several developing nations. Further the long term political instability in several nations over decades has contributed to lack of sensitivity to such economic factors. In the case of biodiesel, the issue of lack of awareness does not seem dominant, for Brazil's successful example is splashed over the communication networks and news coverage is substantive. Perhaps much greater awareness of their own problems and possible solutions must occur before penetration becomes significant.

Use of solid plantation fuels and agro-residue utilization is beset with the lack of awareness of successful technology packages that work in appropriate environments – industrial, institutional or domestic, This is perhaps true of decision makers, manufacturers and users and hence, all the stake holders. Unless this is solved, it would be difficult to expect market forces to take over and provide the solutions to the user groups. While many other renewables have the issues of "price distortions from existing subsidies and unequal tax burdens between renewables and other energy sources" and "failure of the market to value the public benefits of renewables" and other market barriers such as lack of access to capital, and high transaction costs for making small purchases, creating a “level playing field” , a cliché in renewable energy technologies, bioresidues based technologies have achieved this already – the cost of installation of a biomass based power package varies from 1000 to 1500 USD per kWe and about a third to a half of this value for heat (300 to 500 USD per kWth). Yet the number of successful installations till now is small and this becomes a key barrier when a large organization like the World bank is trying to create an investment portfolio on this subject. To top this situation, several earlier attempts that have “failed” have led to shying away from this sector. Hence, the key barriers in the introduction of modern biomass technologies – modern combustion systems for cooking, thermal gasifiers for cottage, semi-industrial applications and electrical gasifiers for quality of life electricity as well as rural industrial activity are:

1. A number of earlier failed attempts – example in Costa Rica discussed above and others.
2. Lack of awareness of successful operations.
3. Lack of adequate scientific manpower to understand, appreciate and provide support.

Most projects/programs of important donors and agencies have interests such that they would like to see immediate results, perhaps in a single or select set of projects. Unless the host country has enough technical strength and manpower it would not be possible to find continuity in action. Many failed projects are related to orders being placed on a specific firm with funding form a donor agency with almost no plan to sustain the activity beyond the project. Even if there were a plan, there would be no commitment by the host that could be understood to be reasonable and there would be no monitoring by the donor agency, some times even by definition

The fact that the scientific and technological input required for biomass based devices is much less than what is required for solar photovoltaic devices and the feeling that almost anybody can invent a gasifier has led the world to a disastrous state where there is no confidence in almost any system. Any mention of a successful system brings forth cynical observations that the claims must be truly exaggerated and must be discounted. These problems are not restricted to Latin America alone. Perhaps the lack of awareness makes them not even make observations. They are present in Europe in very significant measure.

These problems are because the developments have largely been undertaken outside academic pursuit and any bright idea of any individual is usually understood to be protected by secrecy and not allowing scientists or engineers to visit the facilities in the fear that they may copy the features and derive commercial benefits completely ignoring the inventor and the invention. This has the prevented many developments from benefiting from outside constructive criticism. This was experienced at the Indian Institute of Science whenever delegations visited them, the team members of the delegation would want all the information, but would not hesitate to keep their knowledge base to themselves. In order to overcome this, a well arranged opportunity to do a rigorous third party test sequence both at the host’s place as well as elsewhere with the involvement of scientists and engineers was gone through. At the time of this writing this is the only rigorous test sequence that has documented all aspects of a gasifier operation – gasification efficiency, energy and mass balance, gas composition and calorific value, particulate and tar analysis both at the hot end as well as the cold end, effluent analysis, all simultaneously determined as a function of the throughput.

Subsequent to this, engine related tests have been done rigorously in cooperation with M/s Cummins India Ltd for over 5000 hours operation at intervals of 1000 hours. Other experiments have been conducted to determine the load following capability of the gasifier – engine – alternator system in field conditions. This magnitude of data is currently unavailable from any other gasifier –engine – alternator packages.

Unless this positive position can be capitalized upon, the field will remain full of barriers – preconceived notions of specific important individuals dominating the decision making process, and perhaps for a long time.

Other barriers related to financial, economic, social and institutional aspects can all be traced to the above observations.

The only way of overcoming them is to get the key individuals on the technical front as well as the financial front be involved in a sequence of activities – awareness, observations of working systems for reasonable duration (of a week to eight weeks to precisely understand what happens in a field operating system) discussions with field operators, investors of successful projects through a route that makes way for transparent dealings – an academic or a research institution. This should happen over a substantial group from each country before it can be stated the ground is ready for introduction of a technology into a specific country. Another way of stating this is that there is no well defined owner of the entire know-how so that this owner can be depended on in times of problems that are subtle and unique to biomass use in thermal systems.

In a paper entitled " Renewable energy investment by the World Bank" in Energy Policy v. 29 (2001) pp. 689 – 699, Eric Martinot, Stockholm Environment Institute~Boston, 11 Arlington St., Boston, MA 02116, USA makes many interesting observations on the subject of investment by World bank, a subject that will immediately throw light on the barriers discussed here. He summarizes it as follows:

"World Bank Group lending for renewable energy accelerated in the 1990s and resulted in 17 approved projects with $700 million in Bank loans and $230 million in grants by the Global Environment Facility. The Bank's 1999 energy-sector strategy *Fuel for Thought* charted new directions for renewable energy investment. Lessons from projects are just emerging, but suggest five areas of support for renewable energy by the Bank in the future: renewable energy Financing, electric power policy frameworks, rural energy enterprises, regulated rural energy concessions, and domestic technology manufacturing. Interviews with the private sector suggest additional forms of support: assist with business plans, finance pre-feasibility studies, reduce commercial risks, support joint ventures, build market volume and stability, and pilot and test innovative business models. The effectiveness of the Bank in following through on its ambitious agenda fundamentally rests on the willingness and commitment of developing countries to pursue these strategies and the degree to which renewable energy applications are seen to serve countries' development priorities."

Issues posed by Martinet (2001)	**Current Observations (2006)**
Energy prices may be too low for renewable energy to compete on economic grounds (perhaps because of explicit or implicit subsidies for conventional energy)	This situation is valid in countries where hydro energy is significant; with fossil fuels, the situation is changing rapidly
Ministries of Finance (the official counterpart for Bank lending) may be conservative, may not understand renewable energy, may be reluctant to provide guarantees, and may not trust new financing arrangements like credit lines;	This is true in almost every country – developing or otherwise; education of successful projects and bankability of projects must be driven home
Countries may be reluctant to borrow for renewables when they are able to receive bilateral grant money for the same thing	This is true with most countries even today.
The "shadow" cast on renewable energy by failures of rural electrification projects in the 1970s and 1980s may dampen enthusiasm for the current	This issue was addressed in section 2.3. The only way of overcoming this problem is to have fully funded

generation of projects;	guaranteed projects by donors, a new portfolio to be opened up.
Private-sector project developers may be unable to absorb financing and conduct projects if the private sector is not strong enough;	This is true for many developing countries. Confidence building measures over a select set of fully funded projects is vital. New methods must be evolved.
Urban utilities may be in poor financial condition and unable to afford work in rural areas	This is truer of urban solid waste projects. Most rural habitats pay for the services when made affordable.
Renewables may be perceived to have an insufficient technological track record.	This is most crucial issue for bioresidues – to – energy technologies.

Table 9 Martinet's issues (2001) and current observations (2006)

Martinet further analyzes the possible reasons for the difficulties in World bank lending through interviews with World bank staff at several levels. Specifically, he has identified the factors as follows.

"(a) Pressure on project preparation resources – Task managers and investment officers are under pressure to deliver projects in the shortest possible timeframe, and often lack the resources, knowledge, and time to pursue renewable energy projects. Preparation time and expense for renewable energy projects can be substantially more than for conventional projects (one manager estimated 30/60% more), which makes them unattractive to a manager with fixed resources and time pressures. Managers under pressure to deliver new investments in the shortest possible time will tend to avoid renewable energy projects, all else being equal.
(b) Nontraditional project risks – In additional to traditional project risks (procurement, construction, future energy prices, and cost overruns), renewable energy projects often require new technology experience, new institutional development, new financing/contractual mechanisms, and technology acceptance by financiers and stakeholders. Building new institutions in projects is often an expensive, difficult and time-intensive activity. Many project features could be considered `experimental' because an accepted set of best practices for the kinds of project interventions needed to develop renewable energy markets simply does not exist. These nontraditional project risks require a risk-taking mentality and incentives that do not penalize managers when parts of projects do not turn out as expected.
(c) Lack of appropriate skills – Renewable energy projects can be quite different from traditional energy-sector investment projects. Task managers in the energy sector and their normal set of consultants may not possess the necessary skills or knowledge. Relevant lessons and `best practices' must be identified and incorporated into project design, for example institutional development, test activities, and social surveys. Task managers, as engineers and economists, may not be trained or skilled in institution building. They may have to hire consultants outside of the normal skill set or qualifications to which they are accustomed…
(d) Lack of attention in country assistance strategies – Rural and renewable energy are not often explicitly called out in the Bank's formal country assistance strategies. Consequently, country directors – who control preparation and manpower budgets and assignments – have no mandates or strong managerial incentives to devote their resources to renewable energy projects.
(e) Limited experience and interest in the social and rural development sectors –

Renewable energy is still seen as primarily an energy-sector activity. The social and rural development sectors still have limited experience with renewable energy, despite being in a good position to implement rural energy projects and utilize community-based institutions. As an indication of how far the social sectors have to go, a 1999 Bank review of current thinking on rural infrastructure issues did not mention solar home systems or renewable energy ….

(f) GEF project preparation burden – All Bank renewable energy projects in the 1990s were facilitated by GEF grants (many said none of these projects would have happened without the GEF). Yet additional burden comes from the need to prepare separate GEF documentation and get GEF Council approval for these grants. Even though special GEF project preparation resources are available, the process can be burdensome for Bank managers. They generally do not want the added complexity, and, if unfamiliar with GEF procedures, do not want to have to learn another set of rules.

(g) Corporate reorganization – During the 1990s, renewable energy expertise accumulated within the Bank's central Energy Department. During the period 1998}1999, as part of a corporate-wide reorganization, most of the Bank's renewable energy experts not in ASTAE were moved from the central Energy Department to Africa, Latin America/Caribbean, and South Asia operating regions. Although these experts became tied together through a Bank-wide `Rural and Renewable Energy Thematic Groupa, the success of these new groupings remained to be seen. Perhaps the ASTAE concept can be replicated in each region through this process, but the potential downside is the dilution of a previously existing core group of expertise".

It is believed that some or many factors valid for the World bank as seen by Martinet are valid for other donor agencies as well. In the experience of the present authors when they worked on the conceptualization and implementation of UNDP projects, it must be emphasized that the bureaucracy has difficulty in constructing new management structures to overcome problems. It is perhaps vital that the aspects identified in item (g) be given thought to.

Chapter 5 Linkages with Productive Uses

The linkages with productive uses are not always evident to start with, for several reasons. The communities that are living under subsistence conditions some times with no access to electricity (hard electricity, not the solar photovoltaic variety that only provides quality of life electricity) that can make a difference to the economic well being of their lives or with unsure access that could be worse have little to think of the various possibilities. The planning of power projects in such an environment should be such that initially a small capacity system must be built and reliable service provided. Slowly, people begin to think of other possibilities of the use of electricity for job opportunity creation. This can be helped with the support of other NGO's in touch with the wider world. The project can then enhance the power generation capacity and provide the needed electricity. This experience has been obtained by the authors at a field station called Hosahalli, an initially un-electrified village in Karnataka about 100 km from Bangalore. Initially a 3.7 kWe system was established with grid lines taken through the village of 50 house-holds and electricity provided for six hours a day (from 5 to 11 pm every day) as expressed by the village council. After two years of operation other services were demanded – drinking water supply to taps near the houses, and a flour mill to grind the grains. This service needed a larger capacity system. After some experiments, a 25 kWe system was established. Then they wanted irrigation water supply on demand so that their economic well being could be bettered. This service was also provided for some years. During this period of thirteen years the net tariff collection exceeded 80 % with promises from the defaulters to make good their dues in better times. Such a condition is wanting in urban scenarios. It is this learning experience of the response of the community to the new intervention that has given confidence that independent small power producers can also function provided the community wishes to have the service.

Subsequently, they got grid electricity and this service has currently stopped. It is therefore very important to have a long enough project schedule to account for these variations till the community can take over and run the operations through a suitable self-help group with some authority or a state-involved authority to direct the operations of providing the services as well collection of tariffs.

One might ask: what purpose has this project served in view of the fact that grid electricity has been made available. The role of the project for all the operational period has been to understand the issues involved in running an energy package in a rural environment: it was learnt that the demands of the group will slowly move from the minimal quality of life services to those with productive uses. The design of the package must be of a low peak power to start with and expand slowly on demand. .This expansion might occur in a few years or may take several more years. Even though the services would be paid for particularly when a major part of the energy is provided for productive purposes so that the paying capacity of the community is enhanced, the fact that the power package should be capable of expansion over a period has led to the conceptualization of a mini0grid that is capable of being connected to or disconnected from a main grid nearby. The advantages of such a system are multi-fold. The energy service package can be made to run at high plant load factors because when the energy consumed by the community is low, the energy generated can be pumped into the grid and at other times the power package can be servicing the demands of the community. All these call for innovation along way and the project objectives must be flexible enough to accommodate these. It also helps solve another major issue in developing countries. Many electric transmission agencies are unwilling to accept grid linking of power generators at capacities lesser than a MWe because the transactional costs will be high. By combing a few communities into a mini-grid, but linking on to a main grid at some switching station, one can set the power generation capacities to be high – typically half a MWe or better and the comfort level of transmission agencies fulfilled..

Chapter 6 Regulatory / Policy Framework

If bio-liquid fuels have to be made available to the community, clearly the well understood techniques followed for fossil fuels must be followed. The fuel belongs to a large agency as it happens now. In many countries, the state agency is one of them. Several multi-national companies can also own large stocks of oils and these are made available in dispensing stations. The dispensing stations must add at least two more dispensers – one for alcohol and one for biodiesel. If national standards are followed, blends can be dispensed as cleared by national authorities on the subject. In the Latin American region, Brazil has a very long experience of dealing with these issues. While alcohol based fuels – neat alcohol or 25 % alcohol – gasoline mix have been dispensed separately for a long time, new regulations on biodiesel have been introduced in recent times.

Federal Law # 11.097, January 13, 2005: definition of biodiesel as a fuel, authorization of a 2% blend of biodiesel (B2) until 2008, when a blend will be mandatory, increased to up 5% until 2013. To determine competence for regulation the market to Biofuels, Gas and Petroleum National Agency - ANP.

Federal Law # 11.116, May 18, 2005: tax exemption and reduction over the biodiesel production chain. Tax incentives according kind of raw material; size of producer and region of raw material production.

These have been followed by executive orders:

Executive Order # 5.297/2004: establishes the "*Social Fuel Stamp*" for biodiesel.
Executive Order # 5.298/2004: establishes the IPI (manufactured product tax) exemption on biodiesel.
Executive Order # 5.448/2005: authorizes upper biodiesel blends in power engines, captive fleets, locomotives and boats.
Executive Order # 5.457/2005: establishes the rules for biodiesel fuel tax exemption and reduction.

It has also brought in regulations and financing arrangements with banks.

20 ANP regulations: biodiesel production, distribution and fiscalization.
BNDES (Social and Economic Development Bank) rule # 1.135/2005: biodiesel financing and investment support.

Specifically on Biodiesel it has provided subsidies through tax exemptions to family agriculture in the north, northeast and semi-arid regions with castor or palm plantations, family agriculture in general, agricultural businesses in various regions.

In so far as solid wastes are concerned, they can be used for generating off-grid electricity for scattered small sized habitats or high grade heat for industries or even cooking heat for the poorer sections of the society. In order to sensitize their growth, suitable regulatory framework is necessary; this is different in different countries in the LA region. Some have been progressive, have unbundled the electrical sector to generation, transmission and distribution to make each efficient and allow private competition in the delivery of electrical services. We will examine these features for a few other countries.

Argentina restructured its electric power sector earlier this decade. From 1992 onwards, this reform was rapid and radical, following guidelines that reshaped this industry in the U.K. Its regulatory framework was laid down by Law N° 24,065/91 which stipulated vertical segmentation of the generation, transmission and distribution segments and set up the national regulatory agency (ENRE – Ente Nacional Regulador Energético), in addition to reorganising the electric power market and introducing the wholesale segment, together with a new pricing system and an administration agency for this market – CAMMESA.

This restructuring also involved the privatization of state-owned assets. The participation of private enterprise is modifying the driving forces in this sector. As rural electrification offers lower returns due to its intrinsic characteristics – mainly a widely-scattered market – it is not attractive to private capital. Keenly aware of this, the Argentinian government is subsidizing rural electrification through the National Electric Power Fund, which evens out tariff differences.

In order to define the concession areas, this restructuring distinguished between concentrated markets and scattered markets. The former already provide electric power supplies, or offer easy connections to either centralized or individual systems, while the latter still lack access to these services. This distinction is justified by the widely varying objectives for each concession: in the concentrated area, concerns should focus on the quality of the power, while in the dispersed area, more attention should be given to quantity, through expanding supplies. While the concentrated market can operate under the usual rules, activities on the dispersed market must still be subsidized. Splitting up services for concentrated and dispersed areas between different companies avoids any possibility of cross-subsidies.

Due to this subsidies policy, electricity services have been extended to a large proportion of the population. However, solutions based on connections with the central system are still given high priority, even when this may not be the most efficient alternative. Areas that still lack electricity supplies are normally located in remote regions, as communities closer to the nation-wide network are already electrified. The most economic way of providing services for these remote locations is through decentralized systems powered by energy sources available locally.

The regulatory framework is different in different countries in the LA region. Some nave been progressive, have unbundled the electrical sector to generation, transmission and distribution to make each efficient and allow private competition in the delivery of electrical services..

Honduras: The overall reforms to the electricity sector approved by the National Congress in 1994 were aimed at the privatization of the distribution system, while leaving generation and transmission to ENEE. The process to introduce and implement these reforms has been very slow with no particular attention paid to rural electrification. Since 1994, there have been other political and legal attempts to promote the development of renewable sources of energy, especially Law 267-98 and 85-98 enacted by the Congress in 1998 that promotes the development of small scale renewable energy projects (Hydro up to 50 MW) by offering a set of incentives including energy pricing, duty free on imports of equipment and machinery, and “zero” income tax during the first five years after the project’s commissioning.

Chapter 7 Funding / Investment Opportunities

Every Latin American country is abound with opportunities where the biomass waste can contribute to economic power supply on a local basis. For example, in Honduras, there are more than 7,000 communities off the grid where rural electrification by conventional grid extension may not be cost-effective as these rural centers are small, dispersed, and low-intensive power consumers. Small and mini (less than 10 MW) and micro hydro (less than 100 kW) sites have been identified and some of them have been developed up to the investment stage. These type of investments “match” the needs of particular end users, like the significant existing market for productive uses of electricity made up by 5,000 small coffee processing facilities.

The new financial instrument required in a new technology area should be different from is traditionally practiced when donor agencies participate in the development and introduction of these technologies. One principal way of judging the success of major projects taken by countries with help of donor agencies is the extent of finances being brought from private sector or the government into each project. Larger the extent of private finance in each project, better would be grade awarded to such project in the minds of evaluators. A different approach needs to be adopted in the case of new technologies like the biomass gasification. The entire project must be financed and executed by a manufacturer with a sequence of deliverables. These could be monitored periodically with a review team consisting of technical people from the host country, the donor agency and the performance assessed. If the performance has met with expectations completely or with a defined shortfall, then the project can be transferred to a local agency for continued operation with the recovery of finances as clear from the performance assessment. Most donor agencies do not want to get to this degree of detail and leave most actions to a high power committee of the government. These committees treat these small projects with neglect associated with small projects without realizing the importance that they may have to their country and invariably the matter is lost sight of over a period of time.

ESMAP Report 300’05, Advanced Bioenergy for sustainable development, Guidelines for policy makers and investors. Volumes I, II, and III

Chapter 8   Information Dissemination

The institutional networking works well only when all the principal actors recognize the value for this networking. The fundamental condition for this to occur is to be together for a period in an institution that can resolve all questions to a level of detail and confidence that the concerned people se value in connecting themselves to such an entity. After this part is achieved with one/two people from each country, modern techniques of information dissemination through News letters and electronic communication should be adequate.

Chapter 9   Concluding Remarks

1. Biofuels imply a wide range – liquid biofuels, solid biofuels and urban solid wastes. The strategies for their utilization are different.
2. Alcohols are produced in the most effective manner in sugar industries. These are well understood and adoption requires the study of successful models.
3. Biodiesel is being actively pursued more recently in LAC.
4. Some European countries, Germany, Italy have considerable experience in this area. The feed stock in European scene may be different from that in LAC. Yet the processes of

production, quality certification and distribution have commonalities and successful models can be built by example.

5. Sold biofuels are not easy to manage as liquid fuels. Technology intervention via gasification provides excellent prospects. Gasification technology is however, not a well understood aspect in LAC or perhaps even in Europe where a large number of developments are currently taking place with commercialization still far away.

6. The Indian subcontinent holds the knowledge of new technological developments that are fuel-flexible and the projects have been practiced in a commercial mode. More visible commercialization may need to take place before large scale acceptance much like several other technologies.

7. The Latin American land mass is blessed by nature in several ways – rich land and water are its principal assets.

8. The oil importing countries will face the oil shock through substantial rise of international oil prices very significantly. Fortunately, they are all blessed with bio-fuels significantly.

9. There is very little awareness of modern use of biomass in most countries. Where there is awareness, the negative experiences make them doubly shy in looking at biomass conversion technologies, particularly for electricity generation.

10. The issues of mindset among donor agencies, lack of awareness among decision makers in the LAC combine to prevent a new technological path provide benefits in terms of distributed electricity generation and more modern cooking technologies.

11. There is compulsive need to bring this awareness to individuals and institutions – both donor agencies, administrators, industrial outfits and academia in these countries. This is first and foremost activity that should be undertaken by all donor agencies before investing money into thermo-chemical conversion of biomass.

12. Each country should have demonstration projects awarded in such a style that it must be incumbent on the concerned to take responsibility for the operation and maintenance for a reasonable period of time, typically a year.

13. Each country should have at least a few members who can own the technology after this period so that all further demands on confidence building can be dealt with locally.

14. Manufacturing must be made country-centric. This can easily be facilitated through the support of UN agencies or others after identifying competent manufacturing outfits in each of the countries.

15. It is strongly recommended that projects be initiated only after the capacity building – intellectual and manufacture are strengthened to avoid spreading of “failures”.

16. It is vital that this be done since the trust of people should no longer be taken for granted as has been the case all these decades, no matter how much money is invested in projects

References

1. IEA fact sheet entitled Renewables in global energy supply, CIA – Factbook and FAO Websites
2. Joachim Heller, Physic nut, Jatropha Curcus L, IPGRI, Rome
3. A survey of biomass gasification 2001, 2001 (one can get this from the website http://www.woodgas.com/tombio.htm
4. Stassen, H.E.M., 1993. ‘‘UNDP/WB small-scale biomass gasifier monitoring report, Volume 1 – Findings also appearing in the Journal of Energy and Sustainable Development, pp 41 – 48, Vol II, May 1995
5. Debyani Ghosh, Ambuj Sagar and V V N Kishore, Scaling up biomass gasifier use: applications, barriers, and interventions, November 2003, World Bank report posted on the internet.
6. Biomass-to-Energy, The science and technology of the IISc Bio-energy systems, ABETS. Indian Institute of Science, Bangalore, December 2003
7. Eric Martinot, Renewable energy investment by the World Bank, Energy Policy v. 29 (2001) pp. 689 – 699, , Stockholm Environment Institute~Boston, 11 Arlington St., Boston, MA 02116, USA

Appendix

AC Country Wise Residues – The crop residue information from the team on NBRAP, India (IISc)

CRR = Crop to residue ratio calibrated at the laboratory and determined from field studies

Data on crops (2004) from FAOSTAT © FAO Statistics 30 July 2006										
Country	**Crop**	**Productn MT**	**Area MHa**	**Yield T/Ha**	**Residue 1**	**CRR Res.**	**Res. 1 Mill. T**	**Residue 2**	**CRR Res 2**	**Res 2 Mill. T**
Argentina	Sugar crops	19.30	0.31	63.30	Trash	0.05	0.97			
Argentina	Sorghum	2.16	0.48	4.60	Stalks	0.50	1.08			
Argentina	Oats	0.35	0.23	1.50	Stalks	0.50	0.18			
Argentina	Barley	1.00	0.33	3.00	Stalks	1.30	1.30			
Argentina	Cottonseed	0.19	0.25	0.80	Stalks	2.00	0.38			
Argentina	Maize	15.00	2.33	6.40	Stalks	2.00	30.00	Cobs	0.50	7.50
Argentina	Rice,paddy	1.06	0.17	6.30	Stalks	1.50	1.59	Husk	0.20	0.21
Argentina	Soyabeans	31.50	8.48	3.70	Stalks	1.70	53.55			
Argentina	Sunflower seed	3.10	1.82	1.70	Stalks	2.00	6.20			
Argentina	Wheat	14.56	5.74	2.50	Stalks	1.50	21.84	Pod	0.90	13.10
Bolivia	Sugar crops	4.80	0.11	45.70	Trash	0.05	0.24			
Bolivia	Maize	0.69	0.31	2.20	Stalks	2.00	1.38	Cobs	0.50	0.35
Bolivia	Rice, Paddy	0.30	0.14	2.20	Stalks	1.50	0.45	Husk	0.20	0.06
Bolivia	Soyabeans	1.67	0.89	1.90	Stalks	1.70	2.84			
Bolivia	Sunflower,Seed	0.17	0.16	1.00	Stalks	2.00	0.34			
Bolivia	Wheat	0.11	0.12	0.90	Stalks	1.50	0.17	Pod	0.90	0.10
Brazil	Sugar crops	416.26	5.63	73.90	Trash	0.05	20.81			
Brazil	Cassava	23.93	1.75	13.60	Stalks	0.50	11.97			
Brazil	Oranges	18.27	0.82	22.20	Waste	0.30	0.30			
Brazil	Bananas	6.58	0.49	13.40	Residue	3.00	19.74			
Brazil	Coconuts	2.94	0.29	10.30	Shell	0.17	0.50	Fronds	0.75	2.21
Brazil	Cottonseed	2.47	1.15	2.20	Stalks	2.00	4.94			
Brazil	Maize	41.81	12.41	3.40	Stalks	2.00	83.62	Cobs	0.50	20.91
Brazil	Rice, paddy	13.28	3.73	3.60	Stalks	1.50	19.92	Husk	0.20	2.66
Brazil	Soyabeans	49.79	21.53	2.30	Stalks	1.70	84.64			
Brazil	Wheat	5.73	2.81	2.00	Stalks	1.50	8.60	Pod	0.90	5.16
Chile	Maize	1.32	0.12	11.10	Stalks	2.00	2.64	Cobs	0.50	0.66
Chile	Rice, paddy	0.12	0.02	4.80	Stalks	1.50	0.18	Husk	0.20	0.02
Chile	Wheat	1.92	0.42	4.60	Stalks	1.50	2.88	Pod	0.90	1.73

Colombia	Sugar crops	40.02	0.43	92.70	Trash	0.05	2.00			
Colombia	Maize	1.40	0.61	2.30	Stalks	2.00	2.80	Cobs	0.50	0.70
Colombia	Rice, paddy	2.72	0.51	5.30	Stalks	1.50	4.08	Husk	0.20	0.54
Costa Rica	Sugar crops	3.80	0.05	77.30	Trash	0.05	0.19			
Costa Rica	Rice, paddy	0.25	0.05	4.70	Stalks	1.50	0.38	Husk	0.20	0.05
Country	**Crop**	**Production MT**	**Area MHa**	**Yield (T/Ha)**	**Residue 1**	**CRR Res. 1**	**Res. 1 Mill. T**	**Residue 2**	**CRR Res 2**	**Res 2 Mill. T**
Cuba	Sugar crops	24.00	0.70	34.30	Trash	0.05	1.20			
Cuba	Coconuts	0.12	0.03	4.70	Shell	0.17	0.02	Fronds	0.75	0.09
Cuba	Maize	0.40	0.15	2.80	Stalks	2.00	0.80	Cobs	0.50	0.20
Cuba	Rice, paddy	0.49	0.16	3.10	Stalks	1.50	0.74	Husk	0.20	0.10
Dominican R	Sugar crops	5.55	0.14	40.80	Trash	0.05	0.28			
Dominican R	Coconuts	0.18	0.04	4.80	Shell	0.17	0.03	Fronds	0.75	0.14
Dominican R	Rice, paddy	0.58	0.12	4.90	Stalks	1.50	0.87	Husk	0.20	0.12
Ecuador	Sugar crops	6.59	0.08	83.70	Trash	0.05	0.33			
Ecuador	Cassava	0.12	0.02	4.70	Stalks	0.50	0.06			
Ecuador	Cocoa beans	0.12	0.25	0.50	Stalks	0.50	0.06			
Ecuador	Bananas	6.04	0.22	27.90	Residue	3.00	2.19			
Ecuador	Maize	0.73	0.41	1.80	Stalks	2.00	2.70	Cobs	0.50	0.37
Ecuador	Rice, paddy	1.35	0.33	4.10	Stalks	1.50	0.17	Husk	0.20	0.27
Ecuador	Soybeans	0.11	0.06	1.70	Stalks	1.70	8.98			
ElSalvador	Sugar crops	5.28	0.06	92.50	Trash	0.05	0.26			
ElSalvador	Sorghum	0.15	0.09	1.60	Stalks	0.50	0.08			
ElSalvador	Coconuts	0.11	0.01	14.20	Shell	0.17	0.02	Fronds	0.75	0.08
ElSalvador	Maize	0.65	0.23	2.80	Stalks	2.00	1.30	Cobs	0.50	0.33
Guatemala	Sugar crops	18.00	0.19	96.80	Trash	0.05	0.90			
Guatemala	Oil Palm Fruit eq.	0.58	0.02	30.40	Waste	1.50	0.87	Fronds	1.19	0.69
Guatemala	Bananas	1.00	0.02	52.50	Reisdue	3.00	3.00			
Guatemala	Maize	1.07	0.60	1.80	Stalks	2.00	2.14	Cobs	0.50	0.54
Haiti	Sugar crops	1.08	0.02	60.00	Trash	0.05	0.05			
Haiti	Plantains	0.28	0.04	6.40	Residue	3.00	0.84			
Haiti	Cassava	0.33	0.08	4.30	Stalks	0.50	0.17			
Haiti	Bananas	0.29	0.05	6.40	Residue	3.00	0.87			
Haiti	Paddy	0.06	0.04	1.5	Stalks	1.50	0.09	Husk	0.20	0.012
Haiti	Corn	0.35	0.25	1.3	Stalks	2.00	0.70	Cobs		

									0.50	0.18
Honduras	Sugar crops	5.47	0.08	72.40	Trash	0.05	0.27			
Honduras	Oil Palm Fruit eq.	1.14	0.05	25.20	Waste	2.50	2.85	Fronds	2.19	2.50
Honduras	Bananas	0.81	0.02	42.20	Residue	3.00	2.43			
Honduras	Maize	0.50	0.25	2.00	Stalks	2.00	1.00	Cobs	0.50	0.25
Jamaica	Sugar crops	2.10	0.05	43.80	Trash	0.05	0.11			
Jamaica	Coconuts	0.17	0.05	3.30	Shell	0.17	0.03	Fronds	0.75	0.13
Mexico	Sugar crops	48.37	0.64	75.60	Trash	0.05	2.42			
Mexico	Sorghum	7.00	1.83	3.80	Stalks	0.50	3.50			
Mexico	Oil Palm Fruit eq.	0.22	0.01	15.80	Waste	0.50	0.11	Fronds	0.19	0.04
Mexico	Bananas	2.10	0.07	29.20	Residue	3.00	6.30			
Mexico	Cottonseed	0.21	0.11	1.90	Stalks	2.00	0.42			
Mexico	Maize	21.67	7.69	2.80	Stalks	2.00	43.34	Cobs	0.50	10.84
Mexico	Oilseeds	0.21	0.21	1.00	Stalks	2.00	0.42			
Country	**Crop**	**Production MT**	**Area MHa**	**Yield (T/Ha)**	**Residue 1**	**CRR Res. 1**	**Res. 1 MT**	**Residue 2**	**CRR Res 2**	**Res 2 MT**
Mexico	Potatoes	1.73	0.07	25.20	Stalks	0.05	0.09	Leaves	0.76	1.31
Mexico	Rice, paddy	0.28	0.06	4.50	Stalks	1.50	0.42	Husk	0.20	0.06
Mexico	Soybeans	0.13	0.09	1.50	Stalks	1.70	0.22			
Mexico	Wheat	2.32	0.52	4.50	Stalks	1.50	3.48	Pod	0.90	2.09
Nicaragua	Sugar crops	4.03	0.05	88.90	Trash	0.05	0.20			
Nicaragua	Beans, dry	0.17	0.23	0.80	Stalks	0.50	0.09			
Nicaragua	Maize	0.44	0.32	1.40	Stalks	2.00	0.88	Cobs	0.50	0.22
Nicaragua	Rice, paddy	0.23	0.07	3.20	Stalks	1.50	0.35	Husk	0.20	0.05
Panama	Sugar crops	1.65	0.04	47.10	Trash	0.05	0.08			
Panama	Plantains	0.12	0.01	11.30	Residue	3.00	0.36			
Panama	Bananas	0.53	0.01	44.80	Residue	3.00	1.59			
Panama	Maize	0.08	0.07	1.20	Stalks	2.00	0.16	Cobs	0.50	0.04
Panama	Rice, paddy	0.32	0.14	2.40	Stalks	1.50	0.48	Husk	0.20	0.06
Paraguay	Sugar crops	3.64	0.07	55.10	Trash	0.05	0.18			
Paraguay	Cassava	5.50	0.31	18.00	Stalks	0.50	2.75			
Paraguay	Oil Palm Fruit eq.	0.13	0.01	9.60	Waste	3.50	0.46	Fronds	3.19	0.41
Paraguay	Cottonseed	0.19	0.32	0.60	Stalks	2.00	0.38			
Paraguay	Maize	1.12	0.44	2.60	Stalks	2.00	2.24	Cobs	0.50	0.56
Paraguay	Rice, paddy	0.13	0.03	4.00	Stalks	1.50	0.20	Husk	0.20	0.03
Paraguay	Soybeans	3.58	1.87	1.90	Stalks	1.70	6.09			
Paraguay	Wheat	0.72	0.33	2.20	Stalks	1.50	1.08	Pod	0.90	0.65
Peru	Sugar crops	9.68	0.08	120.70	Trash	0.05	0.48			
Peru	Plantains	1.66	0.13	12.50	Residue	3.00	4.98			
Peru	Cassava	0.96	0.09	11.00	Stalks	0.50	0.48			
Peru	Cottonseed	0.10	0.08	1.20	Stalks	2.00	0.20			
Peru	Maize	1.18	0.45	2.60	Stalks	2.00	2.36	Cobs	0.50	0.59

Peru	Potatoes	3.00	0.25	12.00	Stalks	0.05	0.15	Leaves	0.76	2.28
Peru	Rice, paddy	1.82	0.30	6.10	Stalks	1.50	2.73	Husk	0.20	0.36
Trinidad + Tobago	Sugar crops	0.58	0.01	48.30	Trash	0.05	0.03			
Uruguay	Sugar crops	0.15	0.00	46.70	Trash	0.05	0.01			
Uruguay	Barley	0.41	0.14	2.90	Stalks	1.30	0.53			
Uruguay	Maize	0.22	0.04	5.00	Stalks	2.00	0.44	Cobs	0.50	0.11
Uruguay	Rice, paddy	1.26	0.19	6.80	Stalks	1.50	1.89	Husk	0.20	0.25
Uruguay	Soybeans	0.38	0.23	1.60	Stalks	1.70	0.65			
Uruguay	Sunflower seed	0.18	0.13	1.40	Stalks	2.00	0.36			
Uruguay	Wheat	0.53	0.18	3.00	Stalks	1.50	0.80	Pod	0.90	0.48
Venezuel a	Sugar crops	8.81	0.13	70.30	Trash	0.05	0.44			
Venezuel a	Sorghum	0.56	0.27	2.10	Stalks	0.50	0.28			
Venezuel a	Coconuts	0.16	0.02	8.30	Shell	0.17	0.03	Fronds	0.75	0.12
Venezuel a	Maize	2.18	0.62	3.50	Stalks	2.00	4.36	Cobs	0.50	1.09
Venezuel a	Rice, paddy	0.97	0.20	4.90	Stalks	1.50	1.46	Husk	0.20	0.19