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SEMINAR PROCEEDINGS (Excerpt)

ANES

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WORKING GROUP 4: BIOMASS RESOURCES

International Seminar on Bioenergy and Sustainable Rural Development
- 5th LAMNET Project Workshop – Mexico 2003

BIOMASS RESOURCES OF MEXICO AND THE ELECTRICAL RESEARCH INSTITUTE (IIE) ACTIVITIES ON THIS TOPIC

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ABSTRACT

This article describes the research and development work on biomass to energy conversion performed in the Electrical Research Institute (IIE) with the focus on conversion technologies, biomass resources, and biomass supply in Mexico. The objective of IIE activities is to propose studies and projects that really influence in the national energetic context. Thereby, IIE has great experience and puts great effort in research and development on biomass to energy conversion by developing processes, systems and methodologies focusing on ecological benefits and sustainable development. There are great biomass resources in our country, equivalent to 45% of end energy consumption of the year 2000. In agreement with the energy potential quantified with a methodology developed in the IIE, the following biomass resources can play an important role in Mexico's future energy supply: animal Wastes, Agricultural Wastes, Wood, Bagasse, Forestry Wastes, Waste Waters and Municipal Solid Waste. To identify with more precision their importance, a detailed analysis to consider factors such as technologies, resources and biomass supply has to be performed, which should be supported by national biomass energy conversion programs and linked with ecological protection and sustainable development initiatives.

OBJECTIVE

To show and analyze the research and development work performed on biomass utilization and conversion to energy in the Electrical Research Institute (IIE). This work has the objective to propose studies and projects with high relevance in the national energy context including its impact on environment protection.

INTRODUCTION

Today, the energy contribution (3.6%) of biomass in Mexico is accounted for solely by Wood and sugarcane Bagasse, without considering other important biomass resources such as forestry wastes, wastewaters, municipal solid waste, animal and agricultural wastes. In a recent study made in the IIE, it was found that the energy potential of biomass in our country, is equivalent to 442.1 peta calories or to 45% of the end energy consumption, taken as a reference the National Energy Balance of the year 2000.

There are two important factors, that determine the biomass viability to employ it as a fuel, one is the biomass to energy conversion technologies, and the other is biomass resources inventories.

CONVERSION TECHNOLOGIES

There are basically two types of biomass to energy conversion processes, the thermo-chemical process and the microbiological process. The first one is represented by conventional combustion, pyrolysis, gasification and liquefaction, producing gaseous, solid and liquid fuels, which can be converted to energy by conventional technologies. The second type refers to alcoholic fermentation and anaerobic digestion. By means of the action of microorganisms these processes produce ethanol and biogas. Alcoholic fermentation was used to produce spirit beverages for a very long time, and anaerobic digestion, also called anaerobic fermentation, takes place naturally as part of organic matter decomposition contained in municipal wastes, animal and agricultural wastes and municipal solid wastes.

BIOMASS RESOURCES

Biomass resources can be of two types, natural and artificial. The first one generally refers to wastes, and the second type to materials exclusively generated for the conversion to fuels and later to energy.

The potential biomass resources in Mexico are of a wide variety, and in the same manner information resources are of a wide variety. This implies large efforts to compile information and involve government offices that are concerned with this information such as the National Institute of Geographic and Data (INEGI).

Table 1. Parameters required for the evaluation of the biomass power potential in Mexico.

Source	*1*	*2*	*3*	*4*	*5*
Wood	No of Inhabitants	Fracción de habitantes que usan leña	Consumo per cáp-año	Poder calorífico de la leña	
Bagasse	Superficie de caña de azúcar cosechada (Ha/año)	Rendimiento de cosecha (Ton/Ha)	Fracción de bagazo en caña	Poder calorífico del bagazo	
Forestry Wastes	Producción anual de madera	Producción de residuos de aserradero	Poder calorífico de los residuos		
Agricultural Wates	Superficies cosechadas (maíz...)	Producción de residuos por Ha cosechada	Poder calorífico de los residuos		
Animal Wastes	No de cabezas de bovinos...	Producción de residuos por especie	Producción de biogás por unidad de residuo	Poder calorífico de biogás	
Municipal Solid Waste	No habitantes	Tasa de generación de residuos	Fracción de residuos en Rellenos	Producción de biogás por unidad de residuo	Poder calorífico de biogás
Waste Waters	No habitantes	Tasa de generación de DBO en aguas per cápita	Producción de biogás por unidad de DBO	Fracción de agua tratada anaeróbicamente	Poder calorífico del biogás

For energetic potential evaluation of biomass, IIE has developed a methodology based on the knowledge and definition of 24 basic parameters. Through an adequate analysis of these parameters (summarized in table 1), it was possible to elaborate a methodology for the quantification of potential biomass energy resources.

In table 2 the theoretical contribution from the most important biomass resources determined by the IIE methodology is summarized. These results emphasize the importance of biomass as an energy resource in Mexico, today contributing with 3.6% to the total energy supply. Therefore, good opportunities exist to propose well supported projects in order to realise major biomass contributions to the Energy National Inventory.

Table 2. Energy Potential of Biomass in Mexico.

Biomass Resource	*Biomass Energy Content Petacal/year*
Wood	58.7
Bagasse	16.7
Forestry Wastes	1.4
Agricultural Wates	144.6
Animal Wastes	219.7
Municipal Solid Waste	0.02
Waste Water	1.0
Totals	442.1

Note: 1 petacal = 10^{15} cal

BIOMASS RESOURCES AVAILABILITY

Biomass resources for energy conversion are in competition with other traditional uses:

Wood is used mainly for food preparation and cooking, home and water heating, and lighting. This competing use is prevalent in rural areas, 25 million mexicans consume 17 million tonnes of wood per year.

Sugar cane bagasse is generated in 63 sugar cane factories located in 15 states in the national territory, with an average sugar production of 4,668,500 tonnes (1996-1997). Sugar cane bagasse content is between 24 to 30% in weigh. Bagasse is also used by paper companies in our country making it impossible to convert all the bagasse to energy .

Forestry Wastes. In agreement with the National Institute of Geography and Data (INEGI), there are 63.7 million ha tropical and conifer forest in Mexico, 80 % of which is communal and social property, 15% private property and 5% federal property. 54% of this land corresponds to cool and temperate weather forest, and 46% to warm weather tropical forest. In 1995, 85% of the wood production was carried out in five states. The wood industry used 75% of national wood production, paper industry used 19%, and 6% of wood production was used for fuel and railroad construction.

Agricultural Wastes. Crop production in Mexico on 14 million ha produces more than 31 million tonnes of crop products. Agricultural wastes with energy potential considered in this article are: rice, coffee, cereal straws and leguminosas like barley, wheat, rice, oats, lentil, peanut, rye, cotton, and maize. Many of this crop wastes are used as forage and animal food. Traditional practices make their collection, handling, and use as fuel for energy production difficult.

Animal Wastes. 107.8 million hectares are used for animal production in Mexico. Bovine production uses 84 million hectares for pasture. In 1995, 3,685,000 tones of meat, 1,412,000 tones of bovines, 1,283,000 tones of chicken meat and 922,000 tones of pig meat have been produced. Meat from lambs and similar species amounts to 1.8% of the total national meat production. 90% of the national chicken meat production takes place at 1,500 farms with an average capacity production of 60 thousend/cycle, whereas 10% takes place in 5,000 farms with an average capacity of 25 thousands of chickens/cycle. The production of pig meat concentrates in the states of Jalisco, Sonora, Guanajuato, Yucatan, Puebla and Michoacan, comprising 71% of the national total. Pig production is performed with three different production processes: technified (30%); semitechnified (30%), and family or backhouse production (40%). Today, there are about 50 thousand specialised facilities engaged in pig production activities and 400 thousand family operations.

Municipal Solid Waste (MSW). The national generation of wastes in 1997 was considered to be 82,680 tons daily. Only 35% (28.900 tons per day) are deposited at controlled sites, whereas the rest (53.700 ton/d) is taken to open dumps, noncontrolled or clandestine. In all the country 22 landfills operate satisfactorily; the other sites do not fulfill the minimum norms. MSW can be taken advantage of for the generation of energy by means of two processes, by combustion and recovery of biogas. The incineration processes are expensive and the organic matter content and the waste moisture make their use difficult.

The production of biogas seems to be the most viable option, but until now no municipality has taken advantage of biogas as power plant fuel.

Waste Waters. In agreement with the national Hydro-Program (1995-2000), annually 7,3 km3 of municipal waters (231 m3/seg) are generated, of which the public sewage system only collects 5,5 km3 (174 m3/seg). This means that of 1,8 million tons of organic matteronly 0,15 million tons are treated suitably.

IIE BIOMASS PROJECTS

Biomass to energy conversion projects started in the second half of the seventies with the IIE operation, focusing on biogas generation from cattle dung in anaerobic digesters, as a part of the Integrated Energy Systems Project for Mexican Rural Application.

Early in the eighties, IIE performed an evaluation of wood consumption as a fuel in the Mexican rural areas.

During 28 years, IIE has carried out successfully development projects, such as processes, systems and methodologies for biogas production from biomass by anaerobic digestion, with applications in the rural, municipal and industrial context, as:

- Family Digesters.
- Small Farm Digesters.
- Anaerobic Treatment of Market Waste.

- Acidogenic/Methanogenic Anaerobic Treatment of Waste Water From Citric acid Industry.
- Anaerobic/Aerobic/Anoxic Treatment of Municipal Waste Waters.
- Laboratory Methanogenic Assays of Municipal Solid Waste Samples in Landfills.
- Feasibility Studies of Electricity Generation in Sanitary Landfills and Open Dumps.
- National Inventory of Methane Emissions from Wastes as a Green House Gas.
- Projects of Electricity Generation from Biogas Production in Sanitary Landfills.

Some important results of these projects are:

- Anaerobic digester prototypes for rural and small scale farms waste treatment, including contamination control and self supply energy generation for farms
- Development of Anaerobic/Aerobic municipal wastewater treatment process, with 50 – 60% less energy consumption and with the same magnitude of sludge waste reduction.
- Development and laboratory tests of Acidogenoc/Methanogeic Fluidized Bed Anaerobic Treatment of Citric Acid Industry Wastewater. This treatment reduces the organic contamination of this wastewater by over 95%, and leads to the additional benefit of a biogas generation with a very high methane content.

In the nineties, IIE started to work in projects on electricity generation from biogas produced in landfills. In 1991, a Feasibility Study for Electricity Generation With Biogas Produced in Mexico City Landfills was performed.

To cappy out these projects, it was necessary to develop methodologies and laboratory methanogenic test with municipal solid waste deposited and sampled in the landfills. In the same way, the Potential Energy Landfills Evaluation Methodology was developed to predict biogas and energy production of landfills, including an economic and financial analysis.

In 1991, IIE put in operation a biogas pilot plant installed in Mexico City Santa Cruz Meyehualco landfill, in cooperation with the Federal Electricity Commission, Light and Power Company and the Mexico City Government. In 1995 a study was performed titled Biogas Emissions Evaluation and Characterization of Electric Power of the Prados de la Montaña Landfill, as a response to the National Commission of Energy and a petition of the Mexico City Government.

In the last three years, following a opetition of the Mexican Energy Minister, the IIE carried out the project 'Demonstration Plant of Electricity Generation With Biogas Produced in a Sanitary Landfill'. The objective project was to look for the main barriers against the development and implementation of this technology in our country. One of the main goals of the project was the realization of the *First International Colloquium on Landfill Gas Conversion to Electricity in Mexico* in October of year 2002 in Aguascalientes City.

The results of this project indicating existing barriers can be summarized as follows:

- Short and limited time administration of municipal authorities.
- The law in this matter, enclosed these projects in the Energy Self Supply Scheme. This implies that private investors and municipal authorities form a complicated association by 15 to 20 years partnership.
- Lack of financing to carry out feasibility field assessment studies.
- Resistance to the projects by landfill operator companies.
- Slow processing of generation permissions, interconnection contracts and expensive electricity transportation.
- Lack of real incentives for environmental protection for private investors, and lack of legal rules for Carbon Bonds negotiation.
- Private investors uncertainty, lack of guarantees.
- Lack of investors incentives, innovation funds, etc.
- Little interest of first level government authorities to promote this projects.
- Lack of information on waste landfills and open dumps.

A result of the *First International Colloquium on Landfill Gas Conversion to Electricity in Mexico* was to stimulate the interest of some municipal authorities to apply this technology in their cities, giving a good future of these projects for the conversion of biomass to energy, with the additional benefit of methane emissions mitigation.

CONCLUSIONS.

- IIE has made concerted efforts in the field of the investigation and development of biomass, developed processes, systems and methodologies for power conversion and investigated their impact on the environment and on sustainable development.
- There are a lot of biomass sources available in Mexico (mainly wastes) with the potential to cover 45% of the total energy consumption (2000).
- Being an oil producing country, the potential of biomass has been purposely underestimated in Mexico.
- No long term National Program for biomass use as an energy source exists in Mexico.
- Advantages of biomass comprise energy supplies as well as socio-economic, political, economic and ecological aspects, such as the conservation and rational operation of the forests, control of greenhouse gas emissions, civil security, deforestation, etc.
- According to the methodology developed by IIE the following biomass resources can play a significant role in Mexico: Cattle or animal wastes, Agricultural wastes, Wood, sugar cane Bagasse, Waste Waters and Urban Solid Wastes.

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