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BIOENERGY POTENTIAL OF PINE TREE WOOD, CORN AND SORGHUM RESIDUES TO GENERATE ELECTRICITY USING GASIFICATION TECHNOLOGY IN MEXICO.

Hipólito Romero Tehuitzil, Ma. Consolación Medrano Vaca, J. Luis Arvizu Fernández and Jorge M. Huacuz Villamar.

Address:

Reforma 113, Col.Palmira. Cuernavaca, Morelos, Mexico.
http://web.iie.org.mx/Web/intranet.html
hrt@iie.org.mx

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OBJECTIVE:

- **To identify the regions of Mexico with high production of agricultural and forestry residues.**
- **The evaluation of the bioenergy content of the residues produced in each region and,**
- **To outline the schemes of the power plants that could be used for the gasification of the residues**
- **Economic evaluation for the conversion of pine tree wood, corn and sorghum residues to electricity using gasification technology.**

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INTRODUCTION

Bioenergy in Mexico

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- **Bioenergy amounts 8% of total primary energy**
- **The dominants biofuels are fuelwood,mostly used for cooking within rural and peri-urban areas, and bagasse, used to generate heat within sugar mills.**
- **The present contribution of bioenergy can be enlarged to about 30% of Mexico´s primary energy through an integrated approach based on improved technologies and more comprehensive use of biomass resources, including urban wastes, agriculture and animal residues, multipurpose energy plantations and forest residues.**

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- **Despite the lack of government support to bioenergy for more than a decade in Mexico, a growing experienced has accumulated regarding improved woodburning cookstoves and other devices for small rural industries, electricity production from landfills, and biogas digester.**

- **Specific incentives, linked to definite time tables and targets are urgently needed to speed up the process of adoption and dissemination of bioenergy technologies.**

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First step...

- **In June 26 and 28, LAMNET,FAO, CIECO-UNAM, ANES and, the State government of Michoacan,Mexico organized the "International Seminar of Bioenergy and Sustainable Rural Development".**
- **A major outcome from the Seminar was the creation of the Mexican Network on Bioenergy, which will provide a forum to catalize projects,information exchange and activities in the field of bioenergy**
- **All information about the Mexican Network on Bioenergy can be found at the following web sites:**
- **http:www.anes.org/bioenergia/index.html**
- **http:www.bioenergy-lamnet.org**

Research and Development work on Bioenergy in the Electrical Research Institute

- The Non-Conventional Energy Unit of the Electrical Research Institute (GENC-IIE) is promoting the application and development of thermal conversion technologies for the production of energy from solid waste in Mexico, considered to be gasification of agricultural and forest residues for the purpose of this work.

Methodology

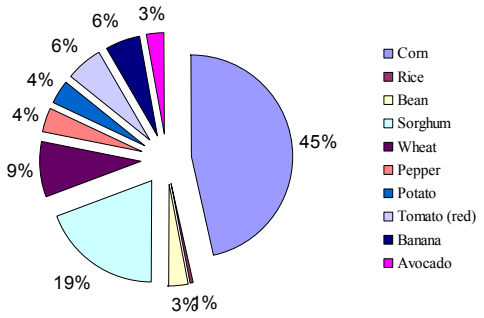
- A bibliographic search was carried out to identify the main agricultural crops and forestry products.
- A statistical model was used to determine the amount of residue from every product and the calorific value thereof
- The THERMOFLEX computer model was used to design the basic schemes of the power plants to be used in the gasification several products, including corn, sorghum and pine tree residues.
- Economic parameters for the gasification power plant was evaluated using the methodology designed in the Electrical Research Institute[11] . For the calculations were considered: standard cost of kW/h installed for gasification plants, net power of the gas turbine and standard cost[2] of the agricultural and forest residues (USD/ton) fed to the gasification system.

RESULTS

Agricultural residues

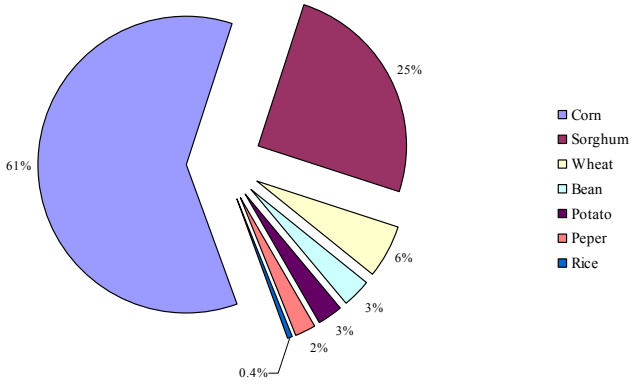
- **According with the National Institute of Statistics, Geography and Informatics (INEGI) , the most important crops in Mexico during 2001 were: corn, sorghum, wheat, rice, bean, pepper, potato, red tomato, banana and avocado (Figure 1).**
- **The total amount of products was 34.5 million tons. Corn, sorghum and wheat are the three main grain products, whose residues could have the main bionergy contribution.**
- **In The total yield of agricultural residues in 2001 was estimated to be 54.6 million tons, equivalent to 82.14 PJ of bioenergy. About 72.5 PJ of this was from residues of corn, sorghum and wheat, which represents 88.3% of the total bioenergy from the crop residues produced in the country (Figure 2). In Figures 3 and 4 the main producers of corn and sorghum in the country are shown.**

The mains crops in Mexico (2001)



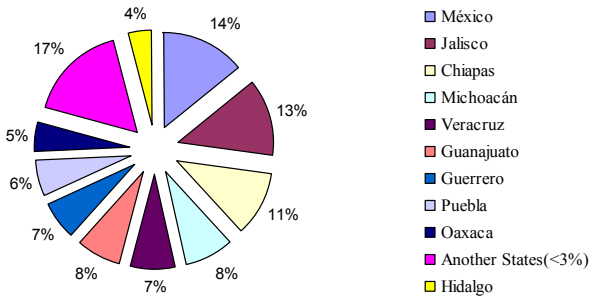
- **Figure 1**

Bioenergy from the mains crop residues in Mexico



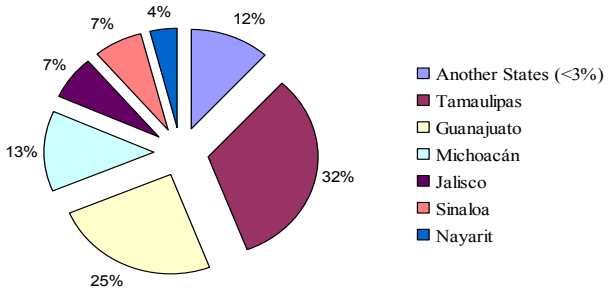
- **FIGURE 2**

Corn



- **FIGURE 3**

Sorghum

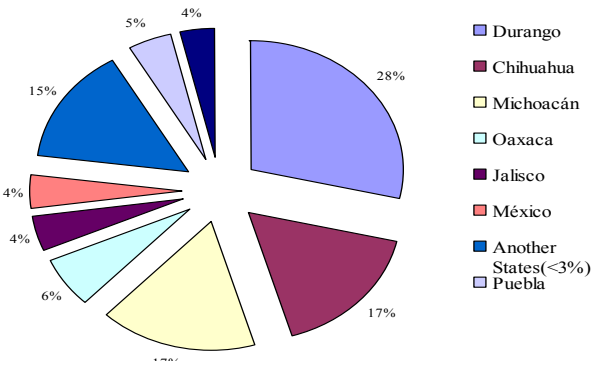


- **FIGURE 4**

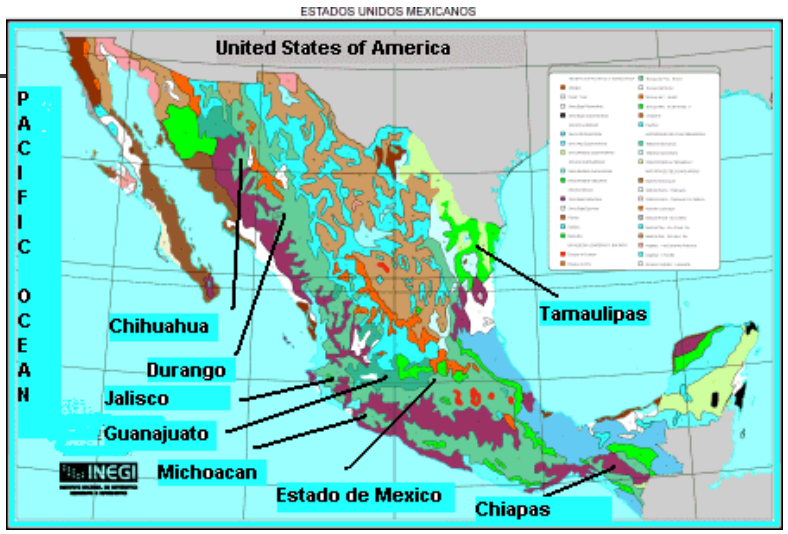
Forest Residues

- **According to official statistical data (INEGI, 2002), the yearly yield of industrial roundwood in 2001 was 2.3 million tons, equivalent to an estimated 4.9 PJ. Figure 5 shows the main producer regions of industrial roundwood and their potential contribution as bioenergy.**

Forest residues (Bioenergy)



- **FIGURE 5**



Biomass Energy Conversion Technology

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- **There are several technologies to convert biomass into convenient and clean energy products. These technologies are classified as: anaerobic digestion, alcohol process, briquetting process, efficient burning furnace, saving fuel stoves and thermal pyrolysis. Thermal pyrolysis includes gasification, liquefaction and carbonisation and can be used for treating crop and /or forest residues, as well as industrial organic waste, to produce gas fuel, biodiesel and coke fuel. In this work gasification technology was selected as an alternative to convert the crop and forest residues into energy.**

- **Figure 6, illustrate the schematic process to generate electricity by gasification of pine tree wood, corn, and sorghum residues, respectively. Table 1 shows the technical parameters for each of the power plants studied.**

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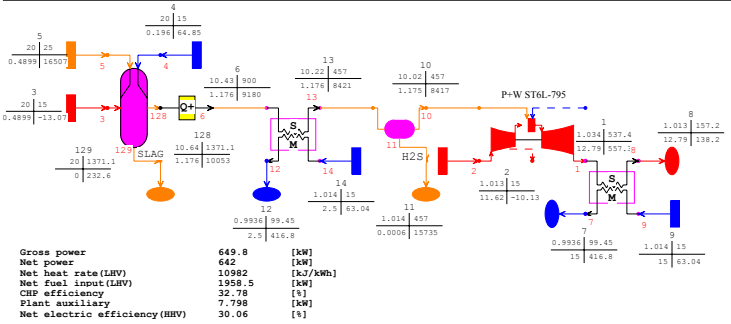
Gasification of corn residues in a CHP plant (simulation with the Thermoflex software)



- FIGURE 6

THERMOFLEX Version 11.0 pc1 privada
272 File = C:\CONSUELO\GASIFICACION\gasificador-maiz01.tfx 21/06/2003 10:00:38 p.m.

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Table 1. Summary of the main technical parameters from simulations

Biofuel (residues)	Fuel Consumption (Kg/hr)	Net Power (KW)	Cost of Electrical Generation (USD /kWh)	Net electrical efficiency (%)
Pine	342.5	642	0.046	30.0
Corn	489.9	642	0.049	30.0
Sorghum	505.6	642	0.050	30.0

Table 2. Summary of the main economical parameters to convert biomass to energy using gasification technology

ECONOMICAL PARAMETERS				
Sort of Biomass (residues)	*Sorghum*	*Corn*	*Pine*	*Units*
Total Capital Requirement	963000	963000	963000	USD
O & M	48150	48150	48150	USD / year
Biomass consumption	3986	3862	2700	Ton/ year
Biomass Cost	13	13	13	USD / ton
Plant Factor	90	90	90	%
Average Generation	5061528	5061528	5061528	KWh / year
Project Discount rate	15	15	15	%
Project Lifetime	20	20	20	Year
Surrender value	10	10	10	%
Investment (USD/kWe)	1500	1500	1500	USD/ kWe
Electricity price	0.05	0.049	0.046	USD / kWh

- **Table 2 summarizes the economic parameters to convert pine tree wood, corn and sorghum residues to electricity by gasification. It were considered for the calculation the following standard costs: 1500 USD /kWh installed[5,6], the net power for the gas turbine was estimated in 642 kW, the sort of fuel fed to the gasification system (corn, sorghum or pine tree wood residues) and, was assumed an average cost of 13 USD/ ton fuel [2] .**

- According with the Table 2, the electricity cost was evaluated in 0.050 USD/ kWh, the biomass consumption for pine tree wood , corn and sorghum residues was estimated in 2700 tons/ year, 3862 tons/ year and 3986 tons/ year respectively; and the average generation of electricity was estimated in 5061528 kWh/ year.

- Therefore the implementation of a project to convert these forestry and agricultural residues could be economically feasible, if we consider that in Mexico the electricity cost is around 0.090 USD/kWh, and the biomass could be provided easily from any of the main regions identified in this study (Figure 2,5).

Conclusion

- In this work the main regions of Mexico with agricultural and forest resources were identified. The regions with the largest agricultural bioenergy potential are, in decreasing order: the state of Mexico, Jalisco, Chiapas, Tamaulipas, Guanajuato, and Michoacan mainly. The largest potential from forest residues is found in the following regions: Durango, Chihuahua, Michoacan, and Jalisco.

- New technologies are available to convert biomass into energy. This work was focused on the possibilities of gasification technologies because of their higher conversion efficiencies to electricity. In this analysis only medium-scale processes were simulated, for which sensitivity of the model was good.

- According to our economical and technical evaluation conversion of pine tree wood, corn and sorghum residues could be a good alternative to generate electricity using gasification technology into the main regions identified in this work.

Acknowledgements

- The authors wish to thank the Coordinator Dr. Rainer Janssen and Dr. Omar Masera from LAMNET-Latin America Thematic Network on Bioenergy (Coordination WIP Germany), and the Center for Ecosystem Research (UNAM Mexico) respectively, for the financing to attend the International Conference on Bioenergy Utilisation and Environment Protection Technology - 6th LAMNET Workshop - in Dalian, China. Dr. Masera is also coordinator of the Mexican Network on Bionergy created to provide a forum to catalize projects, information exchange and activities in the field of bioenergy.