Gasification of biomass for electricity generation in the Cuban context

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Abstract

The Biomass energy is now accepted as having the potential to provide the major part of the projected renewable energy provisions of the future in order to contribute to the sustainable development of our world. The biomass gasification is one of the most efficiently form to use the energy from biomass. We analyze a Cuban biomass potential for use in the gasification process for the electricity generation as case of study and pay special attention to the technology for electricity production with medium power caloric gas from a new tar free downdraft gasifier.

Key-Words

Biomass. Gasification. Tar. Electricity generation.

Introduction

Renewable energy is of growing importance in satisfying environmental concerns over fossil fuel usage. Wood and other biomass, including energy crops and agricultural and forestry wastes are some of the main renewable energy resources available. These are an important source of renewable liquid, gaseous and solid fuels. Biomass is considered the renewable energy source with the highest potential to contribute to the energy needs of modern society for both, the developed and developing economies world wide [(CONTI; SCANO, 1996); (EUROPEAN COMISSION, 1997)]. The use of renewable raw materials as a fuel for industrial power generation is always a valid option when the process to be supplied already requires renewable raw materials. This is particularly the case in the paper industry, the wood-processing industry as well as in the sugar industry, for long time the most important industry in Cuba. This has been the practice in these fields for some time. However, according to the country-specific subsidies for regenerative energy generation and the biomass source, it can also be profitable to use biomass completely to generate electricity without extraction of process or district heating. This is the case when the electricity revenue is high, and is much higher than the revenues from process steam and district heating. But it is possible to generate electricity in those industries with other biomass, which are not its raw material?

The Cuban Biomass Potential

Cuba has a great energy potential, regarding to biomass resources. The Sugar Industry and the railroad depleted most of Cuba's tropical forests at the beginning of the XXth Century. The remaining forests are subject to severe protection by the government. However, there are huge amounts of waste biomass resulting from the agriculture, or the industries, that do not have yet a proper disposal and a productive use. Among those are the rice husks produced in industrial rice mills, most of the sugar cane straw produced at the sugar factories preprocessing plants, and the sawdust produced in the carpentry workshops. But we are going to give special attention to other source of biomass energy, this is a plant that are polluted a very important part of the cultivation land in Cuba, its name is Dichrostachys Cinerea (Marabú). This thorny, fast growing woody species can invade fields and other disturbed areas and is difficult and expensive to control. Its characteristic is summarized in Table 1.

Table 1 - Dichrostachys Cinerea characteristics (ISSG, 2005)

Taxonomic name: *Dichrostachys cinerea* (L.) Wight & Arn.
Synonyms:
Common names: El Marabú (Cuba), Kalahari-Weihnachtsbaum (German)
Life form: shrub, tree
Description
Bush or tree let 1.5-6 m high. Branches bearing short, thorn ended twigs. Leaves bipinnate, 3-10 cm long, with 5-10 pairs of pinnae, each one with 10-30 pairs of folioles 3-6 mm long. Spikes 3-8 cm long, upper florets sulphur -yellox or yellow, the basal ones neutral, with long lilac pink staminodes. Pods crowded, agglomerate, ondulate and contorted, dark brown. Seeds obovate dark brown, 4 mm long.
Occurs in:
agricultural areas, disturbed areas, natural forest, planted forests, range/grasslands, riparian zones, scrub/shrub lands, urban areas
General impacts
Causes losses in agricultural production. Management involves frequent, heavy and expensive work.
Geographical range
Native to Africa, Dichrostachys Cinerea has been introduced to the West Indies during the 19th century - mainly to Cuba, Hispaniola, Guadeloupe, Marie-Galante, and Martinique. It invades fields, wastelands, road sides, and other disturbed areas.
Management information
Preventative measures: A risk assessment of *Dichrostachys Cinerea* for the Pacific region was prepared by Pacific Island Ecosystems at Risk (PIER) using the Australian risk assessment system (Pheloung, 1995). The result is a score of 16 and a recommendation of: reject the plant for import (Australia) or species likely to be a pest (Pacific).
Physical: Cutting and burning of the plants is not a very efficient control method, since the seeds survive in the soil, and the growth is very fast. Chemical: Use of dangerous herbicides is often necessary.
Reproduction
Seeds, root cuttings, root suckering.
Each plant produces a large number of seeds per year, almost all year long and each seeds can survive by more than 90 years and then can be planted and grow.
Lifecycle stages
Seeds survive long in the soil. The growth of the plants is very fast. Young plants may produce seeds. Adult plants can survive a very long time, producing seeds almost all year long.
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This plant have a very huge invasive potential; that's why the 47.2 % of the arable land in Cuba are polluted with the Marabú tree (more than 14,000 km^2); this are the 10 % of the national territory. In Camagüey province, the land take for the Marabú are more than 5,600 km^2, this is the 52.3 % of the total territory of the province. By other hand the Marabú tree is very good source of energy that's means a calorific power are for a dry wood: 4,250 kcal / kg, for a wet wood: 3,250 kcal / kg and an average of 3,750 kcal /kg. If we compare this value with the calorific power of the biomass that have the most extensive use in Cuba as source of energy, the sugar cane bagasse (1,800 kcal / kg); we obtain that value of the Marabú is more than two times more energetic than the bagasse. We can translate all referenced data before, as the potential for the production of 18,449 GWh of electricity from the Marabú tree with the cogeneration plants installed in the sugar cane factory. According with the IEA, agency of the Energy Department of the United States of America, the total energy consumption of Cuba in the year 2000 was 15,028 GWh. The gasification of Marabú can be a promise way for the generation of energy from biomass in Cuba in most efficiently way.

The Gasification Potential for the Electricity Generation in Cuba

The most efficient way to produce electricity from the biomasses is the gasification and the use of the gas produced in an Otto cycle motor gas (CONTI; SCANO; 1996). The conversion of the organic carbon in the gasification is greater of 95% while energetic efficiencies can be reached between 70% and 90% in dependence of the type of technology of adopted gasification. Feeding a gas motor with the gasifier gas can be gotten in total an electric efficiency superior to 26%, in comparison to the initial energetic content of the biomass. The principal problem that presents the system gasifier-engine-generator is the quantity of tar in the gas produced in the gasifier. A solution to this problem have been suggested recently (PEDROSO *et al*, 2005).

In the figure 1 is represented schematically a balance of the process. The energetic losses usually coincide with the heat not used.

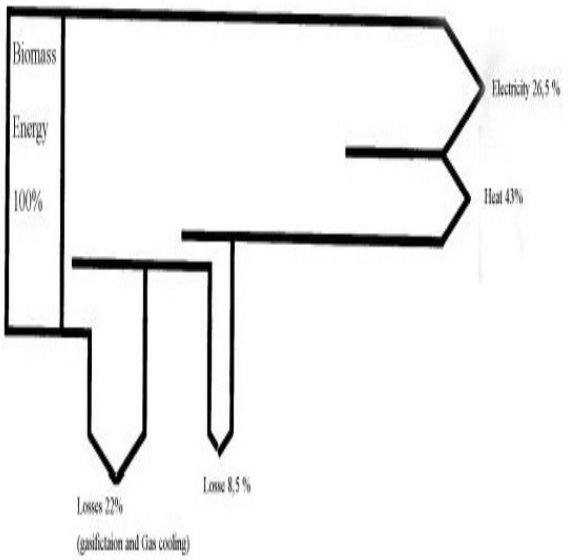

Figure 1 - Balance of the process of conversion of biomasses in energy

For this are surely more rational systems of thermodynamic conversion, that contemporarily furnish heat and mechanical energy used for production of electric energy (cogeneration). The energetic requirement of a plant of cogeneration is inferior of over a bystander in comparison to the production separate of electric and thermal energy, while the total output grazes 90%. Usually the plants are building in proximity of the user, that's why the losses of distribution are inferior in comparison to the centralized systems. A possible alternative can be the use of a gas turbine. In comparison to the turbines the gases motors clearly offer a more elevated electric output (see figure 2) with costs of investment sensitively inferior.

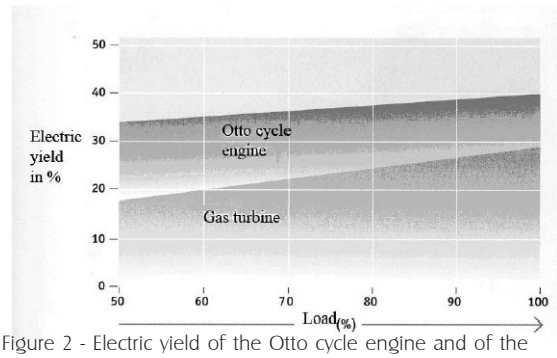

Figure 2 - Electric yield of the Otto cycle engine and of the turbines (CONTI; SCANO; 1996)

A plant of cogeneration consists in a motor (or turbine) coupled to a generator in an only unity with heat exchanger for the exploitation of the thermal energy from the intercooler, from the water of

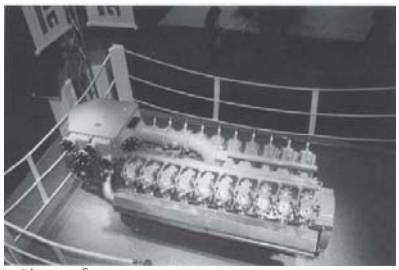

Figure 3 – Plant of cogeneration

The total energetic surrenders are reported to the inferior calorific power of the gases of feeding and they also reach for the gas motor 90%. The losses of energetic conversion, around 10%, are from the generator, from the cooling system, from the heat exchanger and from the heat not recovered on the gases of unloading. Over the gas cycle motor Otto is possible to use as mean of driving a Diesel motor or a gas-diesel (dual-fuel), with the principal disadvantage of sensitively more elevated polluting emission. In many plants the gases motors are supercharged increasing the pressure of the mixture gas air in the turbo compressor. It increases so the energetic density in the cylinders and therefore the power disbursed towards the motors inhaled in analogous dimension. The motors studied for employment in cogenerations reach times of operation from 40,000 to 100,000 hours.

Conclusion

The most important source of biomass for energy production in Cuba has been for a long time the sugar cane bagasse. But now has been developed another important biomass source, which can be used alternatively for energy production, the *Dichrostachys Cinerea*. Our country, work for make efficiently use of the energy potential hidden in this plant, that "pollute" the arable land. The gasification of the *Dichrostachys Cinerea* has the potential of being imposed in the energy sector as important source of clean energy; able to produce more than 18,000 GWh of electricity with a low cost of maintaining and with especial impact in zone far away of the distribution grid.

Gaseificação da biomassa para geração de eletricidade no contexto cubano

Resumo

A energia da biomassa é agora aceita como tendo o potencial para prover a maior parte da projeção das provisões de energia renovável do futuro de forma a contribuir com o desenvolvimento sustentável de nosso mundo. A gaseificação da biomassa é uma das formas mais eficientes para usar a energia da biomassa. Nós analisamos um potencial da biomassa em Cuba para uso em processos de gaseificação para geração de eletricidade como um estudo de caso e especial atenção à tecnologia para produção de eletricidade com gás de poder calórico médio de um novo gaseificador de leito fixo livre de alcatrão.

Palavras-Chave

Biomassa. Gaseificação. Leito fixo. Geração de eletricidade.

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