**Economic evaluation of sugarcane industry integrated to cogeneration system and bio-oil hydrotreatment for diesel and gasoline production.**

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**Highlights**

* There are some technical obstacles that must be overcomed in order to become pyrolysis of biomass financially viable in front of cogeneration in the sugarcane industry.
* Advances in the area of catalysis may allow the production of diesel and gasoline through catalytic hydrotreatment of bio-oil.
* A new integrated plant concept estimates the production of diesel and gasoline from renewable sources at a very competitive price in the Brazilian market.

**1. Introduction**

Considering its potential for products generation, the pyrolysis of biomass has been shown to be a field of research that arouses and deserves great attention of scientific community. Such process consists of thermochemical decomposition of biomass under reduced atmosphere and results in the synthesis of three main fractions: pyrolysis liquid, biochar and gases (carbon oxides, hydrogen and hydrocarbons) [1, 2].

The chemical composition of bio-oil delimits its physical properties and its quality in the steps of storage, handling and combustion. Thus, to be used as a liquid fuel, bio-oil needs to satisfy several technical and market barriers, complying with constraints and standards of quality, and safety related to their properties (pH, viscosity, homogeneity, water content, calorific potential, acidity, among others) [3]. Therefore, several researches are being developed with proposes of improving deficiencies found in bio-oil, calling attention the process of deoxygenation by hydrogenation and catalytic hydrogenation for hydrocarbons production, which meet the composition range of diesel and gasoline [4, 5].

Nsaful et al. [6] investigated the integration of the cogeneration power system to a rapid pyrolysis process with the possibility of convert biomass energy into bio-oil or electricity. Furthermore, the results showed that it is preferable, from the economic point of view, to allocate all excess of bagasse to the generation of electricity in cogeneration systems. In constrast, it is possible to observe that the research of Dutta et al. [5] show promising results of the economic feasibility of integrating lignocellulosic pyrolysis processes with hydrotreatment and bio-oil catalytic hydrocracking for production of biofuels. Overall, considering what has been exposed, and taking account that in Brazil the sugar and ethanol plants jointly offer more than 186 million tonnes of sugarcane bagasse on the market annualy and the effects of inflation and reduction of non-renewable fuels, this work has been proposed to study the technical and economic viability of integrating systems of energy cogeneration of sugarcane industry to the processes of rapid pyrolysis in fluidized bed coupled to hydrotreatment of bio-oil, aiming the production of diesel and gasoline.

**2. Methods**

The synthesis, simulation and economic evaluation of integration of energy cogeneration system of a sugar and alcohol production plant to the processes of pyrolysis of sugarcane bagasse, hydrotreatment and catalytic hydrocracking of bio-oil for the production of diesel and gasoline, product separation and vapor reforming of non-condensable gases for hydrogen production were performed using Aspen PlusTM software. The effect on financial indicators results was investigated considering the variation of biomass feed division for energy cogeneration and pyrolysis systems. The sensitivity analysis for the results of bagasse split by 50% for cogeneration and 50% for pyrolysis was developed considering variation of financial and operational parameters.

**3. Results and discussion**

In general, the results show that the internal rate of return on capital investment is greater for production of diesel and gasoline than for energy cogeneration. The cogeneration system shows internal rate of return of 6.9% a year while pyrolysis and hydrotreatment transformation demonstrated 12.4%. For the net sales revenues prices of fuels produced, it was possible to estimate $0.64/L (maximum of $0.70/L in sensitivity analysis), while the value practiced in the Brazilian market, in September 2018, was estimated in the range of $0.72/L and $0.88/L.

**4. Conclusions**

The implementation of the new concept of integration requires the commitment of greater financial resources than the current used cogeneration system. Despite this, in view of all the proposals investigated, the highest values of economic viability have been estimated for the production of diesel and gasoline through pyrolysis and catalytic hydrotreatment. The results showed that it is possible to supply these products to the Brazilian market with very competitive prices.

**References**

1. D. Mohan, C. Pittman, P. Steele. Energ. Fuels. 20 (2006) 848-889.
2. E. Gonçalves, C. Teodoro, F. Seixas, E. Canesin, M. Scaliante, M. Gimenes, M. Souza. Can. J. Chem. Eng. 95 (2017) 2249-2257.
3. Y. Solantausta, A. Oasmaa, K. Sipilä, C. Lindfors, J. Lehto, J. Autio, P. Jokela, J. Alin, J. Heiskanen. Energ. Fuels. 26 (2012) 233-240.
4. F. Zheng, J. Chang, Y. Fu. Fuel. 157 (2015) 107-114.
5. A. Dutta, A. Sahir, E. Tan, D. Humbird, L. Snowden-Swan, P. Meyer, J. Ross, D. Sexton, R. Yap, J. Lukas. Process Design and Economics for the Conversion of Lignocellulosic Biomass to Hydrocarbon Fuels: Thermochemical Research Pathways with In Situ and Ex Situ Upgrading of Fast Pyrolysis Vapors. National Renewable Energy Laboratory – Pacific Northwest National Laboratory, 2015.
6. F. NSAFUL, J. GÖRGENS, J. KNOETZE. Energy Convers. Manag. 74 (2013) 524-534.