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Estimation of energy potential of the main crop residues generated in the state of Hidalgo, Mexico

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Abstract

Hidalgo State is located in the central Mexican plateau, the cultivated area is around of 600,000 Ha, representing the 30% of its total land. The first step for developing the technology based on reneweable resources is analisyng the bioavaliabity of these inputs and the theoretical potential that could be generated by using them.

Many studies have calculated the global energy potential ignoring the possible alternative uses that the residues could have, therefore the net energy value is generally overestimated.In order to describe the energy potential availabi lity of the Crop Residues (CR) generated in the state of Hidalgo, Mexico, one quantitative analyses were performed. According to the cultivated area and amount produced, the maize, oat, bean and barley are the most important crops. The crop residues amount was calculated and classified by irrigation disctrict and season of cultivation p.e., spring-summer and autumn-winter. Sustainability concepts were integrated to the energy potential calculation; soil coverage requirements and livestock feeding were considered.The theoretical and energy potentials were calculated for oat, bean and barley. Since the maize residues are used for feeding the livestock, the technical potential was calculated for the maize residues.The technical energy potentials in average were: 14.5 PJ, 8.5 PJ, 3.3 PJ and 1.0 PJ for maize, oat, barley and bean, respectively.Considering the residues conservation in soil, positive values were obtained for oat and maize cultivars (4 PJ and 2 PJ respectively). Negative values were estimated for barley and bean residues.The technical energy potential charge of maize was negative when the residue is used to feed from the 25% to up of total livestock population (porcine, bovine, ovine).The result of this work allows the establishment of different scenarios for policy makers and crop residues management decisions in Hidalgo by integrating both the energy and food sustainability concepts.

Biomass; Crop Residues; Energy Potential; Sustainability

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Introduction

All societies require energy services to cover basic human needs (lighting, cooking, heating, cooling, mobility, and communication) and for productive processes (IPCC, 2011).

Taking advantage of renewable, non-conventional, sources of energy is a viable and technically feasible alternative to guarantee energy supply (Baxter, 2005).

Among the sources of renewable and non-conventional energy sources we find organic matter or residue from forests and agriculture that is included in the research to contribute to the analysis of sustainability and the environment (Change, 2007).

Some technologies have been developed for taking advantage and generating energy from agricultural residues (AR) (MacKendry, 2002).

In order to determine the energy potential of exploiting available residues generated in the State of Hidalgo, Mexico, it is first imperative to estimate the viability as an alternative source of energy. Due to the volumes of AR generated, as well as the issues related to the final disposal and its management, the employment of these residues appears attractive in terms of energy generation.

Energy Potentials

Energy potential is not just one concept or practice, Angelis-Dimakis and colleagues (2011) classified and defined the different categories of energy potential: Theoretical Energy Potential (ThEP) or available potential energy, Geographic Energy Potential (GEP), defined as the biomass that is generated in spaces dedicated to this pursuit, Technical Energy Potential (TEP), the potential product of extraction of underused or waste biomass in harvesting and processing.

Economic Energy Potential (EEP), this is the result of the economic evaluation of the theoretical potential energy and Implementation Energy Potential (IEP) is a product of political decision making in a geographic region related to economic incentives to exploit biomass.

Crop residues

The State of Hidalgo has a surface area of 2,081,300 ha, of which: 577,000 (30%) is destinated for agricultural practices. (SAGARPA, 2013).

The State of Hidalgo contains 84 municipalities, which are grouped into five agricultural districts, which are Tula, Metztitlán, Tulancingo, Alfajayucan, Ajacuba, (SIAP, 2016).

Materials and Methods

Crop residues selection

The crop residues in Hidalgo were selected and categorized by the volume (ton/year) generated and by irrigation district.

Data collection

The Agro-Food and Fisheries Information Service (SIAP) data were used. The lapse was from 2005 to 2014.

The data were grouped into annual cycles (autumn-winter, and spring-summer), and for irrigation and rain-fed agriculture.

Potential energy calculation of CR

Theoretical potential energy (ThEP)

To estimate the theoretical potential energy of agricultural waste we used equation 1, for each type of residue and for each residue/product relationship (PRP).

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$$ThEP = Y * RPR * A(1 - H) * HHVdm \quad (1)$$

Where,

ThEP: Theoretical Energy Potential (PJ)

Y: Crop yield (Ton/ha)

RPR: Residue-to-Product ratio

A: Production area (ha)

H: Humidity (%)

HHVdm: Highest Heating Value dry mass (PJ/kg)

Sustainable potential energy (SPE)

The sustainable potential energy (SPE) is calculated by using equation 2. This equation is applied according to the soil conditions for each district, and guarantees the conservation of organic material in the soil to avoid erosion or exhaustion of the carbon, and therefore productivity.
If

$$S > E \quad SEP = ThEP - (S * A * HHVdm) \quad (2)$$

$$S < E \quad SEP = ThEP - (E * A * HHVdm)$$

Where,

SEP: Sustainable Energy Potential (PJ)

S: Residues required to maintain 2% organic carbon in soils

E: Covering soils with agricultural residues to avoid at least 10% soil erosion

ThEP: Theoretical Energy Potential (PJ)

A: Production area (ha)

HHVdm: Highest Heating Value dry mass (PJ/kg)

Technical potential energy (TcPE)

The technical potential energy (TcPE) is shown in equation 3, as follows:

$$TcEP = SEP - (DUC * HHVdm) \quad (3)$$

Where,

TcEP: Technical Energy Potential (PJ)

SEP: Sustainable Energy Potential (PJ)

DCU: Demand of residues for competing uses (Ton)

HHVdm: Highest Heating Value dry mass (PJ/kg)

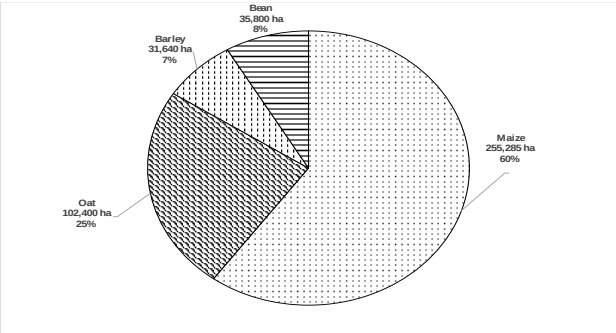
The volume of residues destined to competing uses is estimated considering the use of AR for feeding ovine, bovine, and porcine livestock, therefore we considered the livestock head counts reported by SAGARPA (2014).

Annual requirements for corn and wheat residues were calculated according to the livestock needs (Gallagher et al., 2003).

Results

Cultivated areas and crop production

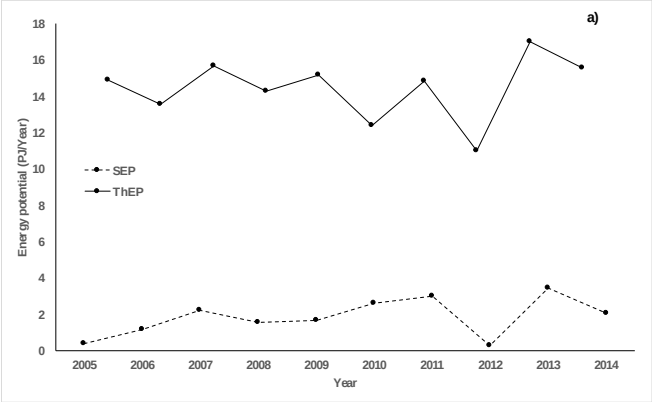
The cultivated area for the crops was estimated (average of ten years). The information is shown in Graphic 1.

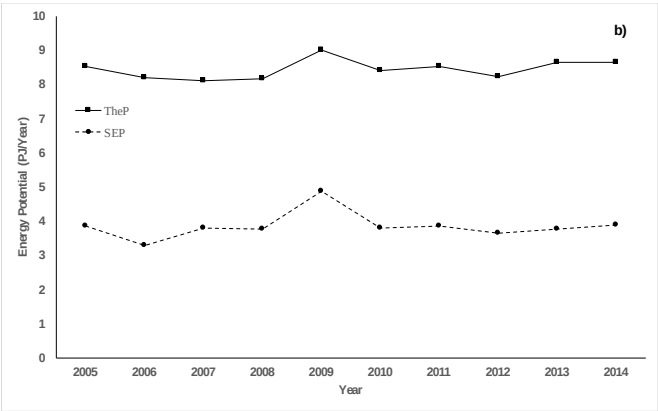


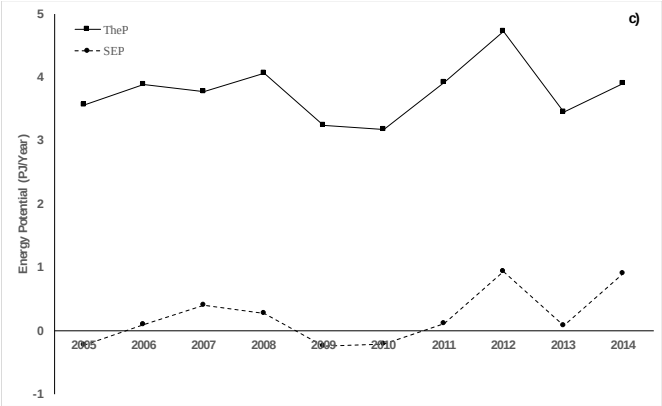
Graphic 1 Production of the four most important cultivars in Hidalgo, Mexico

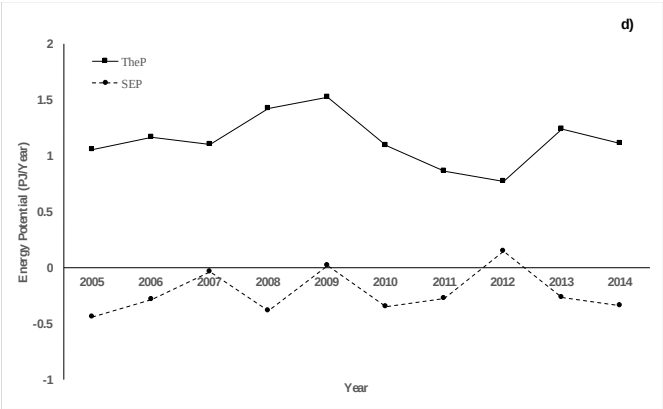
Estimation of the theoretical, sustainable and technical energy potentials.

The theoretical and sustainable energy potentials for the four cultivars were estimated and plotted for the lapse and are shown in Graphic 2.



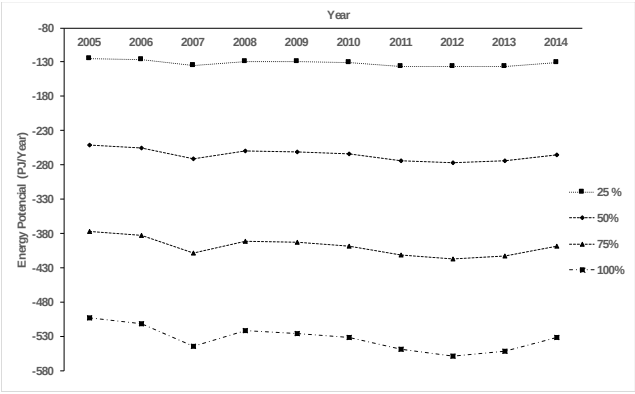






Graphic 2 Theoretical and Sustainable Energy Potentials for a) maize b) barley c) oat and d) bean crop residues generated during 2005 to 2014 in Hidalgo, Mexico

Under the assumption of the livestock food needs, the technical energy potential was calculated for the maize residues for the same lapse, it was plotted and is shown in Graphic 3.



Graphic 3 TcEP Corn. Behavior according to the percentage of competing with feed for cattle

Discussion

The potential calculated considering the statistical and historical data generates important information in technical, technological and policies areas.

The consideration of factors related with the crops e.g., higher heating value, humidity of the resiude, residuo-to-product ratio and yield, could give us a better scenario for interpreting the information; is important to determine these factors of the resiudes in field for better approximation.

The amount of cultivated crops are shown in Graphic 1. The maize crop has the higher volume of production in Hidalgo state, on the other hand the barley crop has the lowest volume production but its energy potential occupies the second place, only behind the maize, and followed by the oat and bean energy potentials (Graphic 2 a, b, c and d).

Employing this residue for feeding 25%, 50%, 75% and 100% of the livestock population were negative from 2005 to 2014 (Graphic 3). These results are important given that the employment of this residue may contribute in aspects beyond generating energy.

Conclusion

Agricultural residues generated in the state of Hidalgo, represent a sustainable source or energy, however, the implementation and development of appropriate technology for taking advantage of the biomass should be done after the inclusion of sustaible development, e.g. use of residues for house building, livestock feeding, carbon sequestration, erosion of soil and loss of fertility in cultivation land.

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References

Angelis-Dimakis, A., Biberacher, M., Dominguez, J., Fiorese, G., Gadocha, S., Gnansounou, E., & Robba, M. (2011). Methods and tools to evaluate the availability of renewable energy sources. Renewable and Sustainable Energy Reviews, 15(2), 1182-1200.

Baxter, L. (2005). Biomass-coal co-combustion: opportunity for affordable renewable energy. Fuel, 84(10), 1295-1302.

Change, I. C. (2007). Mitigation of climate change. Contribution of working group III to the fourth assessment report of the Intergovernmental Panel on Climate Change.

Edenhofer, O., Pichs-Madruga, R., Sokona, Y., (2011). Fuentes de Energía renovables y mitigación del cambio climático., IPCC. ISBN #978-92-9169-331-3

Gallagher, P. W., Dikeman, M., Fritz, J., Wailes, E., Gauthier, W., & Shapouri, H. (2003). Supply and social cost estimates for biomass from crop residues in the United States. Environmental and Resource Economics, 24(4), 335-358.

McKendry, P. (2002). Energy production from biomass (part 2): conversion technologies. Bioresource technology, 83(1), 47-54.

SAGARPA, 2013 [online] México. [accessed: 14 de mayo de 2016] Base de datos con información sobre generación de residuos agrícolas, available at: http://www.gob.mx/sagarpa.

SAGARPA, 2014 [online] México. [accessed: 14 de mayo de 2016] Base de datos con información sobre uso de de residuos agrícolas, también disponible en: http://www.gob.mx/sagarpa.

SIAP, 2016 [online] México. [accessed: 15 de mayo de 2016] Base de datos con información sobre productividad agrícola en México, available at: http://www.siap.gob.mx/

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