Analysis of the potential production and the development of bioenergy in the province of Mendoza – Bio-fuels and biomass – Using geographic information systems

Noelia Flores Marco a,⁎, Jorge Silva Colomer b,1, Renée Alicia Anschauc, Stella Carballo c, Jorge Antonio Hilbert a

a Instituto de Ingeniería Rural, INTA Las Cañitas y Los Reseros s/n, CP: 1712 Castelar, Buenos Aires, Argentina
b INTA EEA Junín Mendoza, Carril Isidoro Busquets s/n CP: 5572, Argentina
c Instituto de Clima y Agua, INTA. Las Cañitas y Los Reseros s/n, CP:1712 Castelar, Buenos Aires, Argentina

Abstract

In this work, the partial results of the potential production of energy, starting from the biomass and the development of the crops, directed to the production of bio-fuels (Colza and Topinamur) in the North irrigation oasis of Mendoza, Argentina within the National Program of Bio-energy developed by INTA is presented.

The study of the potential production and the development of the bio-energetic crops have been carried out with the advising and participation of the experts of INTA of the studied crops.

The province of Mendoza has semi-deserted agro-climatic characteristics. The type of soil and type of weather allows the production of great quality fruits and vegetables in the irrigated areas. The four great currents of water conform three oasis; Northeast, Center and South, which occupy the 3.67% of the surface of Mendoza.

Today, Mendoza has 267,889 irrigated hectares, but the surface that was farmed by irrigation was near to the 400,000 ha. The climate contingencies, froze and hailstorm precipitations, plus the price instability cause great losses in the productive sector, taking it to the forlornness of the exploitations.

The crop setting of these forlornness lands with crops directed to the production of bio-fuels and the utilization of the biomass coming from the agriculture activities and the agro industry (pruning of fruit trees, refuses of olive and vine, remnants of the peach industry, etc.) could assist the access to the energy in the rural areas, stimulating the economical improvement and the development in these communities.

⁎ Corresponding author. Tel.: +54 11 4665 0495.
E-mail addresses: nflores@cnia.inta.gov.ar (N. Flores Marco), jsilvacolomer@correo.inta.gov.ar (J. Silva Colomer).
1 Fax: +54 2623 420296.
0380-3-1199/$ – see front matter © 2010 Professor T. Nejat Veziroglu. Published by Elsevier Ltd. All rights reserved.
1. Introduction

The energy is a basic and necessary component in the development of the communities. The preponderant world model, based on the use of fossil fuels as an energy source, is shown today unsustainable because of its harmful character for the environment and because it is a limited resource.

Today, Argentina’s energetic matrix, is highly dependent on fossil fuels (94%), that places in a manifest the need of implementing a new energetic model based in the diversification of the sources, the energy saving, starting from the rationing of the energy and the energetic efficiency and in the improvement, the care and respect of the environment.

In this context, the Argentine Government has launched several measurements like the rational use of energy program (Resolution 415/2004). The Bio-Fuel Law 26,093, promulgated in fact on May 12, 2006 (Regulation of the Law, Judicial Decree 109/2007, published on February the 13th, 2007) and the law 29,190 that encourages the energy that comes from renewable energies aecic solar, geothermal, sea-moving, hydraulic up to 30 MW, biomass, dumping place gases, gases from depuration plants and biogas, with the exception to those that are considered in the law number 26,093 and the Renewable Energy Program in Rural Markets (PERMER).

The bio-energy, is an autochthonous resource, that has a reduced raw material cost and it is environmentally sustainable, under the parameters of energetic efficiency reached by today’s technological developments, that could play an important role in the valuation of the regional productive chains, with a special incidence in the creation of local jobs positions and in the diversification of the national energetic matrix.

From the National Bio-Energy Program of the National Institute of Agriculture Technology (INTA) of Argentina, the study of the Biomasic resources for the generation of energy, it is carried out, having under consideration all the environmental sustainability, economical and social parameters to a regional scale. All of these parameters are introduced in a Geographic Information System, generating a decision taking tool and the methodical arrangements of the bioenergetic resources of every region of Argentina.

In this present work, we enter upon the study of the biomasic potential for the generation of electrical energy and the farming potential of the colza and topinamur for the obtaining of bio-fuels in the North Oasis of the province of Mendoza, Argentina.

The Province of Mendoza has semi-deserted agro-climatic characteristics. The weight of the economical activity of the primary sector is divided mainly, between the agriculture area (49%) and the mining area (51%) [3], this last one headed by the petroleum extraction and posterior refinement and the petroleum industries located in the provincial territory.

The type of soil and climate, allows the production of fruit and vegetables in the irrigated areas. The four biggest currents way’s of water are: Mendoza, Tunuyán, Atuel and Diamante River. These rivers form the three oasis of the provincial territory; the North, Center and South oasis, which occupy the 3% of the surface of Mendoza.

As in the distribution of its population, a particularity that Mendoza brings forth, falls back on its polarity, in which the 97% of the habitants occupy the three mentioned Oasis, while the rest of the population is located in a dispersed way in the under irrigation areas.

As a base of this productive structure of the primary sector (agriculture) the population is concentrated in the 3% of the total surface of the province and the rest of the economical, manufacture-industry (canned-goods, oils and wines) activities are concentrated.

Regarding the provincial energetic sector, 13,602 homes (3% of the total of homes), don’t have access to electric energy. Considering a media of 4 people by home, a value near to 54,400 people have a lack of electric energy in their homes. The consuming in the province of liquid fuels for the automobile, is of 727,575,523 annual m3 of oil and 192,040 of naphtha [4]. From January the 1st of the year 2010, becomes effective the law that establishes an obligated cutting of oils and naphtha with bio-fuels.

The main crops in the province of Mendoza are the ligenous and horticultural. The fruit sector represents the 27% of the cultivated surface, and the 25% of the provincial agriculture productions value; mean while the horticultural constitutes the third agriculture activity of the province, representing the 11% of the cultivated surface and the 17% of the value of the agriculture production. The horticultural is positioned after the grapevine and fruit bearing activity generating great holdings.

Today, Mendoza has 267,889 irrigated hectares, but the surface that was farmed by irrigation was near to the 400,000 ha. The climate contingencies, froze and hailstorm precipitations, plus the price instability cause great losses in the productive sector, taking it to the forlornness of the exploitations.

The crop setting of these forlornness lands with crops directed to the production of bio-fuels and the utilization of the biomass coming from the agriculture activities and the agro industry (pruning of fruit trees, refuses of olive and vine, remnants of the peach industry, etc.) could assist the access to the energy in the rural areas, stimulating the economical improvement and the development in these communities.

2. Materials and methods

2.1. Materials

For the making of this study, data coming from the Instituto de Desarrollo Rural of Mendoza (IDR) of garlic sheds localization has been used.

Cartographic Bases of wine vaults localization of the Instituto Nacional de Vitivinicultura (INV).

Data base of the atlas of the Instituto de Desarrollo Industrial, Tecnológico y Servicios de Mendoza.


Data bases of the National Census of the year 2001 of INDEC of the number of homes without access to the electrical net by section and number of homes with unsatisfied basic levels.
High resolution satellite images of GoogleEarth, for the making of the map of soil uses by means of a visual classification.

To make the map of physic accessibility to the resource (the legal accessibility was not contemplated, seeing that it doesn’t exist in the study zone, no protected area) radar images of the ASTER-Dem to 30 m of resolution were used. The rustic census of a country map of the study zone were also used, for the obtaining of the route maps, roads a railway net.

2.2. Methods

To enter upon the study, a Geographic Information System has been generated, essential tool to evaluate in a specialized way the potential of the resource. The used software for the digitalization and the geographic analysis of the data, was ArcGis 9.2.

<table>
<thead>
<tr>
<th>Board 1 – Tons of remnants by twig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>North oasis</td>
</tr>
<tr>
<td>Wine industries</td>
</tr>
<tr>
<td>Olive oil industries</td>
</tr>
<tr>
<td>Peach process industry</td>
</tr>
<tr>
<td>Garlic remains</td>
</tr>
<tr>
<td>Sawmills</td>
</tr>
<tr>
<td>Pruning remnants fruit and forest bearing</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

The applied methodology is described in “Análisis del Balance de Energía derivada de Biomasa en Argentina (WISDOM Argentina)” FAO, Departamento Forestal den-droenergía [1].

3. Theory and calculation

The calculation of the remnants for each type of crop, is based on the following formula:

\[ BP = S_j \times o_j \]

In which:

- \( BP \): Is the Potential Biomass, obtained in each field of \( j \) characteristics in Tm year.
- \( S_j \): Is the surface of the field of characteristics \( j \) (ha).
- \( o_j \): Is the superficial potentiality coefficient of production of biomass in a field of \( j \) characteristics. Tm/ha/year. Dry.

The applied coefficients for the studied crops are: Olive with a remnant in field of 2.5 Tm/ha/year. Vineyard with 1.8 Tm/ha/year, different species of fruit trees (walnut, apricot, pear, peach and plum orchards) 3 Tm/ha/year and forest plantations mainly composed by poplars 3 Tm/ha/year.

For the incorporation of the remnants derived of the agro and forest industrial activities a point vector format was used. For the calculation of the remnants generated by the agro and saw mill industry, the following parameters were applied;

- Remnants generated by the wine vault (refuse of grapes) 12% of Tm processed, remnants generated the refuse of olive oil 14%, remnants generated by the canned-goods peach industry 27%, remnants generated by the garlic manufacture 50%, Remnants generated and the sawmills 30% [5].
Fig. 2 – Map of the localization of the generator industry of susceptibly remnants to be used in bioenergy.

Fig. 3 – Physical accessibility map.
3.1. Accessibility to the resource

Once the disposable resources have been calculated, an analysis of physical accessibility has been made, obtaining a map of the disposable and accessible biomass resources. The physical accessibility is a special parameter that defines the accessibility of a determined biomass resource in relation to the distance to the nearest place and of an easy access and to a cost factor based on the characteristics of the terrain. For that, the CostDist tool was applied, from the special analysis module of ArcGis 9.2. The physical accessibility map is generated using a Digital Terrain Model (DTM), digital cartography of the road, railway, and population (cities, towns, places) net.

3.2. Deep valley supplies of biomass (bio-deep-valley)

The bio-deep-valley generation plant of energy from the biomass is define as the area that circles the place in which the accumulated sum of the bio-energetic potential, offers the necessary quantity of biomass for the installation of such plant, with an established power.

The estimation procedure to determine the bio-deep-valley of a determined point, consists in expanding the area that surrounds the point of interest considering the accessibility to the resource till accumulated values (sum) of the biomass of each pixel reach necessary values for the installation of the plant without overcoming a radio of 20 km in order to reduce the costs of transport of the raw material, which indicates that inside that territory, the potential offer is sufficient in order to cover the demand of that plant.

3.3. Potential production of bio-fuels

In order to evaluate the potential production of bio-fuels from the colza (bio-diesel) and Topinambur (Bio-ethanol) the landscapes that today are set aside lands were evaluated. In the case of the Colza, the entire surface without farming was counted, because its hydric requirements go against the traditional crop stations of the fruit bearing area and the dedicated surface to winter horticultural crops, seeing that the colza could enter in rotation without cultivating and that have the right of irrigation.

4. Results and discussions

4.1. Biomasic potential for the production of bioelectricity

The total biomasic potential is of 548,605 Tm. The derivate of the agro industries considered in this study is of 308,347 Tm/year. The main generative activity of remnants is the pruning with 298.135. 05 Tm/year followed by the wine Industry with 203,689 Tm/year and the remnants generated in the conditioning of the garlic with 37,913 Tm/year. (See Board 1).

In the Figs. 1 and 2 it is shown the distribution of the biomasic resources and in Fig. 3 the map of physic accessibility to the same.

4.2. Possible localizations. Areas of supply and dimension of generation plants of electrical energy from the biomass in the province of Mendoza. Economical, social and environmental implications

In order to dimension a plant of electric energy from biomass, we should have under consideration several factors, in which it is out lined the securing of the supply of raw material for its functioning during 8000 h a year, which would suppose some 325 days. For this reason an estimation was made of the raw material according to its origin and the month in which it was obtained, considering that the biomass can be conserved in optimum conditions during six months. According to data obtained and considering the examples of standard plants of energy generator by caldron combustion (Board 2) [2] that is presented at following, would be possible the installation of a plant of 25 MW in the nearby of the location of San Martin, considering that every month there are assure the 5500 Tm in less than 20 km during all the year and one plant of 12 MW in

<table>
<thead>
<tr>
<th>Power (MW)</th>
<th>Fuel PCI = 4 ter/kg (4 tm)</th>
<th>Relation Tm/MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>40,000</td>
<td>8000</td>
</tr>
<tr>
<td>12</td>
<td>78,000</td>
<td>6500</td>
</tr>
<tr>
<td>25</td>
<td>135,000</td>
<td>5400</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pruning</th>
<th>Refuse of grapes</th>
<th>Refuse of olives</th>
<th>Peach Ind.</th>
<th>Sawmills</th>
<th>Garlic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2000</td>
<td>1180</td>
<td>3647</td>
<td>6827</td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>2000</td>
<td>1180</td>
<td>3647</td>
<td>6827</td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>12,726</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>12,726</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>12,726</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>12,726</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>5535</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>1180</td>
<td>12,726</td>
</tr>
<tr>
<td>August</td>
<td>5535</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>1180</td>
<td>1180</td>
</tr>
<tr>
<td>September</td>
<td>5535</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>1180</td>
<td>1180</td>
</tr>
<tr>
<td>October</td>
<td>5535</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>1180</td>
<td>1180</td>
</tr>
<tr>
<td>November</td>
<td>5535</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>1180</td>
<td>1180</td>
</tr>
<tr>
<td>December</td>
<td>5535</td>
<td>4828</td>
<td>1184</td>
<td>1180</td>
<td>1180</td>
<td>1180</td>
</tr>
<tr>
<td>Total</td>
<td>33,208</td>
<td>28,965</td>
<td>7104</td>
<td>12,000</td>
<td>14,157</td>
<td>21,892</td>
</tr>
</tbody>
</table>
Maipú: As an example it is shown Board 3 that corresponds to the Department of Maipú and the Fig. 4 and Board 4 that corresponds to the Bio-Deep-Valley of San Martin.

The definition of the area of sustainable offers is made progressively adding the values of the balance of the rings (isolines of the same access difficulty) starting from the central point (the city, location or place) until the balance of biomass accumulated adquires enough value for the installation of the plant and that will not exceed the 20 km. of transfer for the same to the plant Board 4.

4.3. Potential for the generation of bio fuels

The placing under farming of lands that today are not farmed the North Oasis of the province of Mendoza with Colza and the rotation with winter horticultural crops would provide 43,878 m³ of biodiesel and with Topinambur 438,780 m³ of bioethanol. If we have under consideration that the volume of sales in 2008 in the province of Mendoza of gas oil was of 723,068 m³ and the naphtha was of 192,040 m³, the necessary demands for the 5% of obligated cutting with bio-fuels will be covered, which would suppose a great opportunity to increase the incomes not only by the sales of bio-fuels, at also and the incomes of the by-products such as protein flour.

4.3. Potential for the generation of bio fuels

The placing under farming of lands that today are not farmed the North Oasis of the province of Mendoza with Colza and the rotation with winter horticultural crops would provide 43,878 m³ of biodiesel and with Topinambur 438,780 m³ of bioethanol. If we have under consideration that the volume of sales in 2008 in the province of Mendoza of gas oil was of 723,068 m³ and the naphtha was of 192,040 m³, the necessary demands for the 5% of obligated cutting with bio-fuels will be covered, which would suppose a great opportunity to increase the incomes not only by the sales of bio-fuels, at also and the incomes of the by-products such as protein flour.

4.3. Potential for the generation of bio fuels

The placing under farming of lands that today are not farmed the North Oasis of the province of Mendoza with Colza and the rotation with winter horticultural crops would provide 43,878 m³ of biodiesel and with Topinambur 438,780 m³ of bioethanol. If we have under consideration that the volume of sales in 2008 in the province of Mendoza of gas oil was of 723,068 m³ and the naphtha was of 192,040 m³, the necessary demands for the 5% of obligated cutting with bio-fuels will be covered, which would suppose a great opportunity to increase the incomes not only by the sales of bio-fuels, at also and the incomes of the by-products such as protein flour.

**References**


---

Maipú: As an example it is shown Board 3 that corresponds to the Department of Maipú and the Fig. 4 and Board 4 that corresponds to the Bio-Deep-Valley of San Martin.

The definition of the area of sustainable offers is made progressively adding the values of the balance of the rings (isolines of the same access difficulty) starting from the central point (the city, location or place) until the balance of biomass accumulated adquires enough value for the installation of the plant and that will not exceed the 20 km. of transfer for the same to the plant Board 4.

4.3. Potential for the generation of bio fuels

The placing under farming of lands that today are not farmed the North Oasis of the province of Mendoza with Colza and the rotation with winter horticultural crops would provide 43,878 m³ of biodiesel and with Topinambur 438,780 m³ of bioethanol. If we have under consideration that the volume of sales in 2008 in the province of Mendoza of gas oil was of 723,068 m³ and the naphtha was of 192,040 m³, the necessary demands for the 5% of obligated cutting with bio-fuels will be covered, which would suppose a great opportunity to increase the incomes not only by the sales of bio-fuels, at also and the incomes of the by-products such as protein flour.

References


