Applied Mathematical Sciences Vol. 8, 2014, no. 131, 6577 - 6587
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ams.2014.46442

Estimation of Agroforestry Biomasses Available for Energy Purposes in a Municipality in Central Italy as Instrument for Energy Planning

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Abstract

Biomass used in the production of energy is an important territorial resource, easy to access and capable of supplying new forms of income and promotion for rural economy.
The aim of this work is to give and indicative estimation of agroforestry biomasses (as volumetric mass and energy content), relative to the forest and agricultural sectors (tree and grass cultures) for the Municipality of Bracciano, in central Italy, that can be used as a basis for support for the new territorial politics.

This work shows that the total energetic content could cover the thermal consumption of the 'economy' sector of the Bracciano territory, that includes the agricultural, industrial and tertiary sectors.

Keywords: biomass; renewable energy; energy planning.

1 Introduction

Awareness of the energetic potential for an administrative geographical context is at the base of any energy policy [12]. For this reason, a correct valuation of the amount of biomass for energy production must be done [2, 4, 11].
New and interesting prospective have opened in the last years for agro-forestry lignocellulosic biomass, thanks to new directions in energy and environmental policies. This is due to the necessity to reduce dependence on foreign energy and the need to optimize alternative sources and domestic sources of energy [15].
The European Union has committed to reduce, within the year 2020, its carbon gas emission by 20% as compared to 1990, its energy consumption by 20% and bring renewable fuels to cover 20% of internal energy use [7].
Italy has committed to reduce its carbon gas emissions by 13% in respect to 2005, starting from strategies and EU legislation, increasing renewable fuels production, reaching 17% fulfillment of domestic demand. The National Plan of Action for Renewable Energies (PANER) was prepared, with the Legislative Decree number 28 in the year 2011, relative to the incentive system.
There are various documents at the regional level: regional guidelines for the installation of electrical energy production plants from renewable energy sources;
- air quality recovery plan;
- regional energy plan, that is between two strategic objectives: a) contribute to European objectives of 2020; b) supply economical development without increasing energy consumption

On the provincial level there are many planning instruments, among which:
- Energy plan for the Province of Rome;
- Action Plan for Green Purchases;
- General Territorial Provincial Plan;
- Refuse prevention plan of the Province of Rome;
- Local action plan Agenda 21;
- Sustainable Energy Action Plan.

The Municipality of Bracciano has participated in the European initiative of the Mayors' Pact of May 2010, and has therefore committed to reduce its CO_2 emissions by more than 20% compared to the base year. This is why the Municipality has prepared a Sustainable Energy Action Plan [5], which is coherent with the methodologies given by the European Commission and the Province of Rome. The Municipality Balance Sheet Plan has thus been compiled (adopting as a base year 2004), from which the 2009 results for final energy consumption (final uses are electrical, thermal and combustible for transport) are equal to 242.196 MWh, with the corresponding CO_2 emission into the atmosphere of 73.837 t [5].

From the sectorial analyses relative to the emissions, the residential sector emerges as the second most emissive sector (29% of the total), where energy consumption is mostly due to the use of heat (72% of total thermal energy consumption of the Municipality) [5].
The study has the objective to evaluate how much the agro-forestry biomass, retractable from the Municipality of Bracciano, can positively affect reduction of non-renewable energy consumption and CO_2 emission related to the residential sector thermal energy.
The approach that is used calls for the analysis of the biomass available for energy use for the forest and agricultural sectors, through evaluation of management instruments (Management Forest Plans) and statistics (ISTAT data, ENAMA data).

2Materials and Methods

Biomass includes traditional forest cultures; scraps or by-products from forest or agricultural activities (vineyard pruning, olive orchards, fruit orchards and recovery of seminative residues); dedicated cultures in Short Rotation Forestry (SRF) [15].
The elements influence the choices in the form of use of biomasses for energy in technical terms (choices of the type of plant to use), economical (evaluation of transportation costs and installation size), energy and environmental (evaluation of energy consumption and emission costs, connected to transport and the sustainable resource management). For these reasons, it is important to know the localization, the quality and the quantity of the resources to be used in supplying installations.

2.1 Environmental Placement

The area which is the object of study (Fig. 1) is located northwest of Rome (about 40 km distance). The Municipality of Bracciano has an extension of 142,52 km^2, of which a 50.44 km^2 surface is occupied by the Natural Regional Park of Bracciano-Martignano (Fig. 3).

Figure 1: localization of the Municipality of Bracciano compared to the Province of Rome [8].

From the phyto-climactic point of view [6], Bracciano is within the Mediterranean Region of transition, particularly in the phyto-climactic unit defined by a mesomediterranean thermotype or thermo-hill. The presence of a lake contributes to curbing internally the thermal extremes and the arid summer conditions.
According to the phyto-climactic classification of Pavari, the Bracciano zone is part of the Lauretum.
The average climactic conditions in the area are described in table 1 with thermo-pluviometric parameters which are available for the Bracciano station (historical series 1980-2000).

Bracciano		
Altitude (MASL)	Annual average T (°C)	Annual average rainfall (mm)
228	**15,2**	**1.002,6**

Table 1: Climatic parameters leading to the Municipality of Bracciano.

The climate as gathered from figure 2, is characterized by a spring and autumn rainfall with a summer water deficit and reduced thermal excursion.

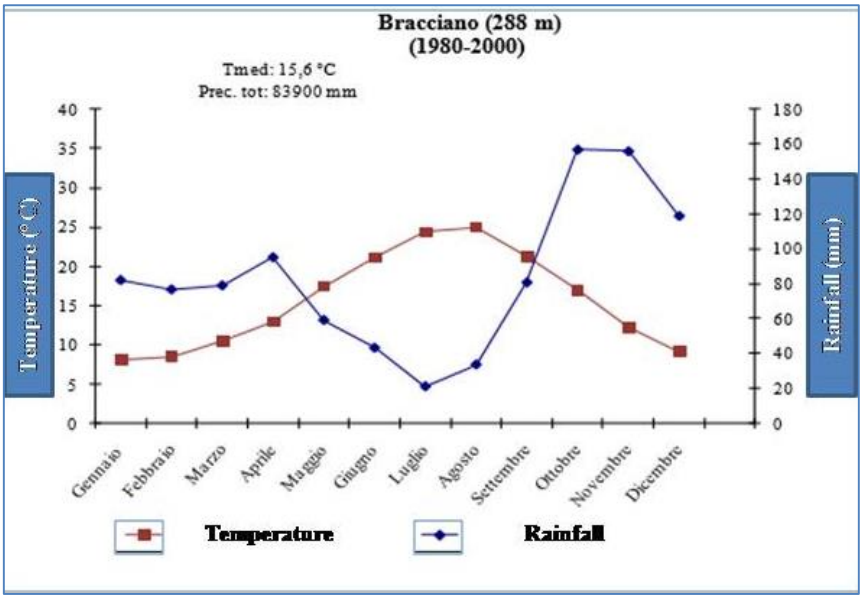

Figure 2: diagram thermo rainfall station of Bracciano (1980-2000 series).

The climactic and pedological characteristics of the area have influenced the presence of species and the habitat with an elevated naturalistic value. In the Municipality of Bracciano, as represented in figure 3, it is possible to identify a Site of Community Interest (SCI) located in Monte Paparano, and a Special Protection Zone (SPZ), denominated 'Bracciano-Martignano District', which is within the boundaries of the Natural Regional Park of Bracciano-Martignano. The presence of these zones of study important for their nature and landscape are subject to limits and restrictions that must be held in account in the sustainable

management of resources. In these areas there are limits and restrictions that are important for the sustainable management of resources.

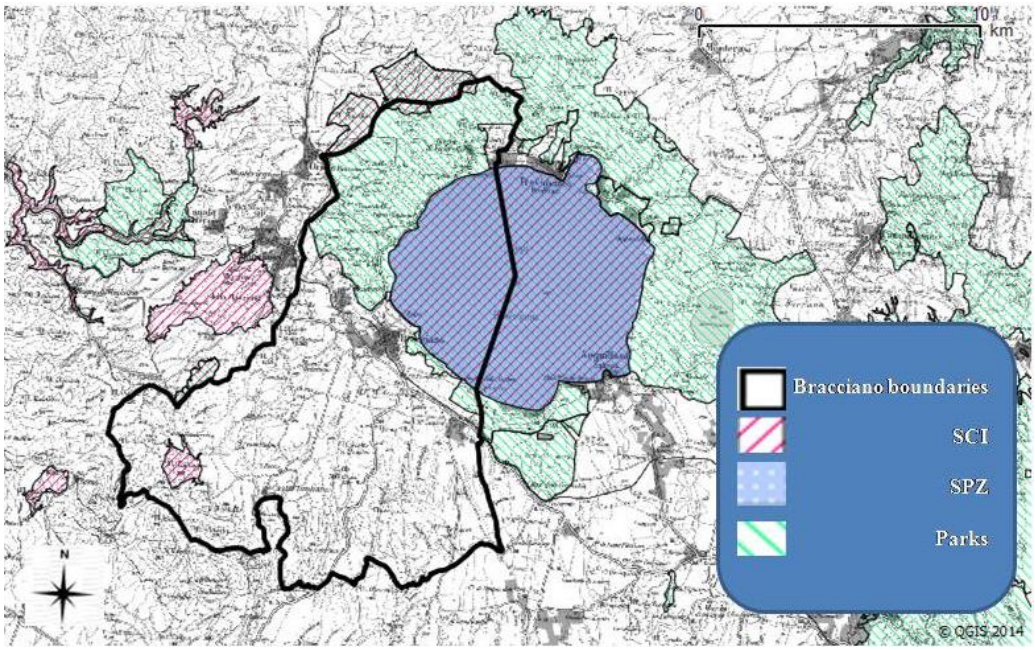

Figure 3: localization, using GIS, the boundaries of the Municipality of Bracciano, with areas SIC, ZPS and the boundaries of the Regional Natural Park of Bracciano-Martignano.

2.2 Use of the surface

The surface of the Municipality of Bracciano, as reported by land cover map [14], is subdivided as represented in figure 4.

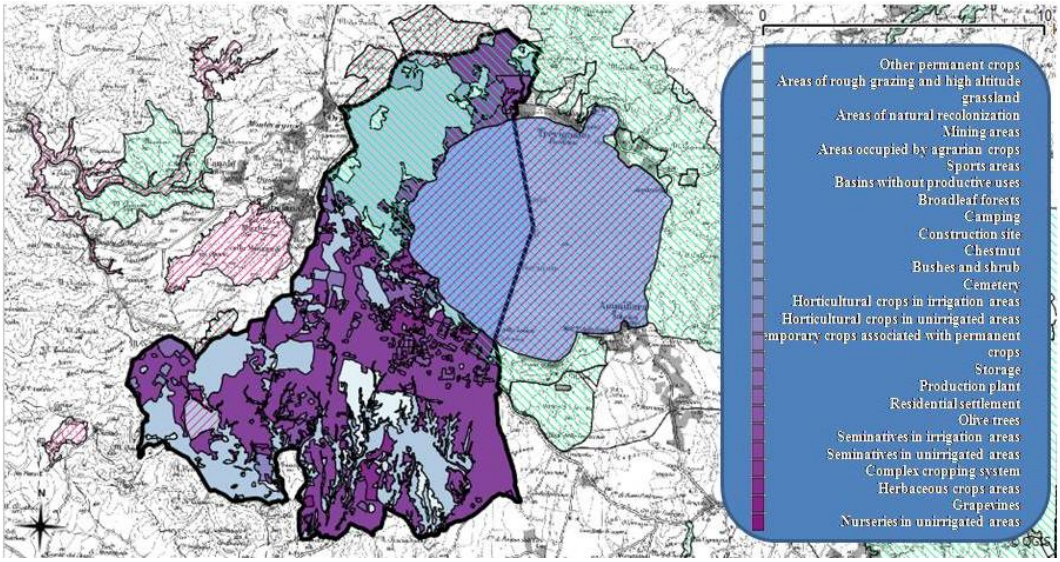

Figure 4: land cover map [14] on the Bracciano area.

The boundaries of Bracciano include in the northern area, a part of the Park with the relative SPZ (Fig. 3). In this area (Fig. 4) there are especially woods of broad leaves, used as described in the management forest plan, approved by the Park Authority and taken into consideration in this study for the estimation of the forest biomass available for energy production.

The data found in the map of land cover [14] have been integrated with those of the last census of Italian Institute of Statistics [9]; the following surface use destinations are determined:

Bracciano	**ha**
Total Agricultural Area	**8.282,71**
Utilized Agricultural Area	**5.711,58**
Seminative	**2.966,37**
Grapevine	**14,54**
Woody agricultural crops	**280,88**
Kitchen gardens	**7,67**
Permanent grassland and grazing	**2.442,12**
Arboriculture annexed to farms	**458,26**
Forest annexed to farms	**1.956,51**
Unutilized agricultural area	**156,36**

Table 2: intended of surface use for the Municipality of Bracciano [9].

2.3 Evaluation of forest biomass potential

The parameters used to evaluate the forest biomass potential are extracted from the study conducted for the Tuscia - Romana area [3], data is listed in tables 3.

The biomass for energy use is calculated by:

$$(B * VMic * 0.18)/1000$$

B = biomass.
VM_{ic} = volumetric mass as a function of volumetric water content.
0,18 = the amount of biomass (18 %) allocable to energy use.

The total energy content is calculated by:

$$(Beu * VMic * Lcv)/3{,}6$$

B_{eu} = biomass for Energy use
VM_{ic} = volumetric mass as a function of volumetric water content
Lcv = lower calorific value

Forest species	***Quercus cerris* L.**	***Quercus cerris* L.**	***Castanea sativa* Miller**
Type of government	Copse	Mixed copse	Copse
Biomass (m^3) (B)	**15.828,70**	**3.003,90**	**14.281,40**
IC (%)	**33**	**33**	**33**
U (%)	**50**	**50**	**50**
Volumetric mass as a function of I. C. (kg/m^3) (VM_{ic})	**900**	**900**	**780**
Biomass for Energy use (t) (18% of total biomass) (B_{eu})	**2.564**	**487**	**2.005**
Cv (MJ/kg)	**18,12**	**18,12**	**19,80**
Lcv (MJ/kg)	**11,74**	**11,74**	**19,80**
Total energy content (kWh_{th})	**7.526.072**	**1.428.264**	**5.434.847**

Table 3: amount of biomass for forest species and type of government, with relative water content (IC) and moisture (U) [3]; in relation to forest biomass, are reported the mass as a function of volumetric water content (IC); the amount of biomass (18 % of total biomass) allocable to energy use; the calorific value (Cv); the lower calorific value (Lcv); the total energy content [3].

2.4 Evaluation of agricultural biomass potential

Evaluation of the agricultural potential is done by referring to the methodology applied in the study AIGR-ENEA (2009) [1]. Starting from the farmed surfaces and the harvest gathered, the availability of byproducts from grass and tree cultures have been defined; the yearly residual biomass quantity obtained is calculated in a given territory. An estimated quota of reused product is subtracted from this amount (fig. 5) which is on the farm or market sales level, so as to obtain the net potential.

The data for the evaluation of products harvested and the technical characteristics of the biomasses are referred to as reported by ENAMA (2008) [13]. For data on grapevines and olive trees, no product residue reuse percentage was subtracted because in the territory of Bracciano, these residues are burned in the field; recent regulations forbid this type of practice and it was decided that all residue products are to be destined for energy purposes.

The total energy content is calculated by:

$$Btq * Lcv * 10^3$$

B_{tq} = total quantity of biomass
Lcv = lower calorific value

Crop	Use	Residual	% Used
***Triticum* L.**	Straw	-Bedding	40-50
		-Animal feed	5-10
		-Industry	5-10
		-Burning in field	30-40
***Hordeum* L.**	Straw	-Bedding	40-50
		-Burning in field	50-60
***Avena* L.**	Straw	-Bedding	40-60
		-Burning in field	40-60
***Zea* L.**	Stalks	-Bedding	40-50
		-Animal feed	10-20
***Vitis* L.**	Prunings	-Bedding	70-80
		-Animal feed	30-40
		-Landfill	30-40
***Olea* L.**	Wood, branches	-Energy	20-40
		-Burning in field	90-100
Fruit-bearing	Branches	- Landfill	90-100
		-Burning in field	10-20
Fruit-bearing with shell	Branches	-Burning in field	80-90
			90-100

Figure 5: locations of residues of agricultural crops [10].

	Tot. quantity (t s.s.)	**Energy use** (%)	**Lcv** (MJ/kg)	**Tot. energy content** (MWh_{th})
Grapevine	**20,64**	**100**	**17**	**97,466**
Olive tree	**384,80**	**100**	**18**	**1.924**
Straws	**5.042,2**	**50**	**18**	**12.605,5**

Table 4: The table shows the quantities of residual biomass estimated for the olive tree, the grapevine and cereal straw (wheat, barley, oats, rye); the percentage of the distributable biomass for energy use; the lower calorific value (Lcv); the total energy content.

3 Results

In table 5 the retractable energy from forest, agricultural and grass biomass values are listed. In table 6 there are the thermal consumption data relative to the Municipality of Bracciano, as an average consumption for the years 2005 – 2008.

Forest MWh_{th}	**Grapevine** MWh_{th}	**Olive tree** MWh_{th}	**Straws** MWh_{th}	**Total** MWh_{th}
14.389,2	**97,466**	**1.924**	**12.605,5**	**26.994,7**

Table 5: Total energy content for the sectors considered (forest, grapevine, olive tree, straws), expressed in MWhth.

Consumption	Range	Average years 2005-2008
Thermal En.	Economy	**23.431,8** MWh_{th}
Thermal En.	Family	**51.522,4** MWh_{th}
Total	Thermal En.	**74.933,7** MWh_{th}

Table 6: thermal consumption estimated for the Bracciano territory [5].

In the territory of the Municipality of Bracciano there is a considerable amount of biomass, usable for energy purposes. As in table 6, the area that supplies the most quantities of biomass is the forest (woods), followed by grass cultures (hay). The total energetic content could cover the thermal consumption of the 'economy' sector of the Bracciano territory (tab. 6), that includes the agricultural, industrial and tertiary sectors.

4 Conclusions

The evaluation of biomass available for energy purposes represents a necessary instrument for energy planning. The evaluation is useful to estimate which typologies are correct and plants dimensions, for using these biomasses that are effectively realizable in the territory. The work conducted considers only a portion of the retractable biomass for energy purposes and is bases on the evaluation of statistical data.
A Territorial Information System could be used to further this study, so as to punctually highlight the available residual biomasses, by putting them in relation to other functional parameters, such as roads, acclivities, cultivation density. In this way defining the costs and the logistics for the biomass (evaluation of the organic substance of the surface, using forest machinery, evaluation of the use of a deforestation chain, application of the Life Cycle Assessment - LCA value). An instrument of this type could be particularly useful to the municipality administrations that should have the guidelines to aim their energy policies in a better way.

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Received: June 1, 2014