PROSPECTS OF BIOMASS ENERGY USE IN APULIA (ITALY)

VALERIA SPADA (*), MARIA DIPAOLA (**)

Abstract

In light of the European actions implemented in the energy sector Italy, as other European countries, adapting to these, has enacted a policy regarding renewable energy sources, including biomass. Execution thereof has been appointed to both regional and provincial local authorities for various technical, economic and socio-environmental reasons which presuppose a direct and integrated relationship with the territory.

In particular, the present study analyses the situation in the Apulia region, a predominantly agricultural area, in order to estimate the amount of useable residual biomass, highlighting current limitations and prospects of use and recovery, while taking into account other probable uses, land availability and possible interaction with food production. The objective is the production of thermal and/or electric energy through the application of suitable energy conversion technologies.

However, the way the potential offered by agro-industrial residues would be put to use will, apart from availability of appropriate technology, also depend on the ability of economic operators to organize themselves efficiently while respecting environmental sustainability.

(*) Dipartimento di Scienze economico-aziendali, giuridiche, merceologiche e geografiche Università degli Studi di Foggia, Facoltà di Economia, Via R. Caggese, 1, 71100 Foggia (Italy), tel + 39 0881 781706, e-mail: v.spada@unifg.it; m.dipaola@unifg.it

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Riassunto

Alla luce delle azioni europee messe in atto nel settore energetico, e adeguandosi ad esse, l'Italia, come altri paesi della Unione Europea, ha attuato una politica sulle fonti rinnovabili di energia, comprese le biomasse, affidandone l'attuazione alle amministrazioni locali, sia regionali sia provinciali, per varie motivazioni di carattere tecnico, economico e socio-ambientale che presuppongono un rapporto diretto e integrato con il territorio.

Nella presente analisi si esamina, in particolare, la situazione relativa alla regione Puglia, un'area geografica prevalentemente dedita all'agricoltura, al fine di stimare le quantità di biomasse residuali di fatto utilizzabili, evidenziando i limiti attuali e le prospettive di recupero e impiego, tenendo conto di altre eventuali destinazioni delle stesse, della disponibilità dei terreni e delle possibili interazioni con la produzione di alimenti. L'obiettivo è la produzione di energia termica e/o elettrica attraverso l'applicazione di idonee tecnologie di conversione energetica.

Tuttavia la misura in cui si potrà utilizzare al meglio il potenziale offerto dai residui agro-industriali dipenderà, oltre che dalla disponibilità di tecnologie appropriate, anche dalla capacità degli operatori economici di organizzarsi in modo efficace e nel rispetto della sostenibilità ambientale.

Keywords: biomass resources, resource potential, recovery of residues, bio-energy.

Introduction

It is by now common knowledge that agriculture no longer represents the solution to the future energy problems of mankind; it can, however, make a significant contribution during the transitional phase from current use of fossil sources to that of renewable energy, which will hopefully be free of energy and environmental difficulties.

Indeed, agriculture can only play a complementary role, since its main function is to supply food sources which are indispensable to an ever growing population, more so in emerging countries. This is the topic of an increasing worldwide scientific debate involving the main international organisations who express grave concern and dissent over the designation of agricultural products for energy purposes. Such a choice has already determined the current price increase in some food raw materials.

Biomass used for energy, often constituting a main production residue in agriculture, forestry, agro-industry, zootechnics, etc., could contribute to the solution to some of current society's problems, such as the growing need of energy sources as an alternative to fossil fuels, climate change, due mainly to the greenhouse effect and, moreover, the reduction of environmental impact deriving from disposal of such substances.

Every year within the European Union the quantity of biomass collected corresponds to 2.2 billion GJ, of which approximately 1.7 billion GJ is used to generate thermal energy, while 0.5 billion GJ to produce electricity.

In Italy more than 17 million tons of biomass is available per year (90% of which from agricultural and forest residues), amounting to a gross production of electric and/or heat energy currently estimated at approximately 6,745 GWh (Apulian regional data is 485 GWh).

The main types of useable material to produce electric and/or thermal energy include residue from agricultural activity (cereal chaff, branches from pruning, seeds, berries, vine shoots, etc.), wood obtained after tending and maintenance of woods, agro-industrial residues (exhausted olive residue, exhausted vinasse, peel, shells, stones, chaff and husks, etc.) destined for energy and/or fuel production, and lastly, industrial and civil waste, animal waste and the organic fraction of solid urban waste. In these cases biomass is, in effect, available since it is obtained at the same time as the main product, but its direct use for energy purposes often presents real difficulties, such as the possibility of competitive use, wide dispersion throughout the territory and the lack of economic and organisational conditions for collection, storage and transformation. Energy crops (lignocellulosic materials, oils, starches and sugars) play a different role: for the majority of them various problems are beginning to arise on the opportunities for their use.

In Italy, based on decree n. 112 of 31st March 1998, policy on renewable energy sources, including biomass, has for a long time been the competency of both regional and provincial local authorities, for various technical-economic, socio-environmental reasons which presuppose a direct and integrated relationship with the territory. Within this context, the Apulia Regional Administration has, among various initiatives, issued the Regional Environmental Energy Plan 2007, which highlights food processing and forest biomass as fundamentally important sources, and for which suitable interventions aimed at encouraging their promotion for energy purposes will be carried out. In such a context and in application of a recent

law (regional law n. 23 of 3rd August 2007, "Promotion and recognition of production areas"), it has been possible to start procedures relative to the creation of Apulian Production Area for Renewable Energy and Energy Efficiency, with interesting prospects in the sector of integrated management of territorial resources. Among the most important aims is the creation of company networks able to collaborate on development of a new and qualified industrial reference pole for the use of renewable sources, in line with the demands of scientific research, technological innovation and the energy market.

Availability of residual biomass in Apulia for energy

The situation in the Apulia region comes under examination in this study, in order to verify the potential of biomass use in the energy sector. This analysis was carried out by elaborating data on cultivation from Istat (National Statistics Institute) pertaining to the year 2007, while reference is also made to some literature sources specific to the matter in question (1-3); the aim is to assess the theoretical yearly available quantity, in terms of dry substance, agricultural and forest waste and by-products, residue from food processing industry, also with staggered provincial data. In real terms, this data represents the theoretical gross potential for alternative uses to energy, since the fraction of by-products already in use in agriculture or industry is also included. However, it is deemed that less than 50% of total dry biomass thus estimated could be used in the energy sector.

Study of literature has indicated the scarce availability of data regarding the amount of single biomass waste from agricultural, forest and food processing activity. This is essentially due to the lack of detailed analysis on a national level and to the difficulty in carrying out a comparison of the data, often due to lack of homogeneity. Moreover, the aforementioned by-products, though of a significant quantity, are not easy to measure due to their considerable pulverisation in the territory and the difficulty in quantifying that part used within the same farms.

On a local level, cereal cultivation (wheat, barley and oats) and arboreal (vines, olives and fruit) could, in short term, offer considerable availability of residues having suitable characteristics for conversion into energy, even considering just how widespread the aforementioned production is in the region. Other crops, though present, were not taken into account since not regarded significant in terms of quantity produced, areas used and/or characterised by waste which is difficult to recover.

Whereas in the forest sector, potential is modest given low density: in fact, only the minor formations are available (hedges, rows and thickets) which, apart from their prevalent ecological and environmental function, if usefully evaluated, could be used as ligneous biomass source for energy, mainly as wood for fire.

The food processing industry produces waste and by-products deriving from those regional activities considered most important in terms of quantity, oil, wine and preserved food industries, the availability of which and relative energy potential thereof are significant and of interesting use.

A particular problem lies in the evaluation of the rather large quantity of material deriving from the pruning of urban and roadside greenery, rural hedges and rows and the cleaning of riverbeds. Appropriate collection of this could supply considerable quantities of biomass, currently disposed of mainly in landfills by the local authorities which deal with collection. Moreover, maintenance carried out by regular cleaning of river banks limits the risk of flooding due to obstructing detritus and its being destined to the energy sector could require the appointed bodies to regularly carry out the normal procedures required. However, currently no data on the consistency of such a wealth is available (except for some studies carried out locally), nor on the amount of obtainable biomass and its final designated use (2,4).

There are four power stations in Apulia, currently fuelled by the aforementioned types of biomass. One has a capacity of 24.8 MWe, while each of the others has an average net capacity of 3-5 MWe. It is opportune to highlight that in Italy the most important conversion plants are fuelled by lignocellulosic biomass obtained from abroad, with long term supply contracts, and cheaper than local resources; the regional situation, as the national one, is characterised by logistical problems of supply, preparation, transport and storage of raw material (5).

Applying the methods used in previous studies (6,7), the following paper analyses the aforementioned sectors and highlights the theoretical potential of each.

Agricultural biomass

Agricultural waste and by-products constitute a considerable source of biomass which could contribute to improving the energy budget of rural areas without subtracting agricultural land from its main use, that is food production. Moreover, they are already present throughout the ter-

ritory and their disposal, when not re-used, constitutes a real cost for farms.

In Apulia the use of biomass energy could prove interesting, above all thanks to the predominantly agricultural nature of the territory; areas such as Capitanata and Tavoliere, Appenino Dauno and Altopiano delle Murge are of particular importance.

Table 1 illustrates the extent of agricultural residues (and their relative energy content) on a regional level for the year 2007: the high density of cereal crops, above all wheat (mainly concentrated in the province of Foggia) would allow for the recovery of a significant amount of dry substance, having a potential energy content of approximately 6,875 TJ (that is, 81.3%), compared to total potential energy content of approximately 8,461 TJ supplied by cereal residue in the region.

Concerning arboreal growing lands, whose local production in the region is greater than that of herbaceous plants, it ensues that the vine (mainly present in the provinces of Foggia, Bari and Taranto) would yield (in the same year) approximately 455 thousand tds (tons of dry substance), having a theoretical energy content of approximately 7,960 TJ, compared with the total amount deriving from ligneous residues from pruning of trees, equal to approximately 11,231 TJ.

TABLE 1

AGRICULTURAL RESIDUES AND ENERGY RELATIVE CONTENT IN APULIA (YEAR 2007)

Region	Agricultural residues		Total production (t)	Productivity [t/(ha•year)]	Superface areas [ha]	By-product S_1	By-product/main product	Available biomass [t]*	Content d.s.	Total d.s. [tds]	Total energy content [GJ]
Apulia	Plant	Wheat	1,015,815	2,74	370,360	65%	0,70	462,196	85%	392,866	6,875,163
		Barley	95,560	2,81	33,650	65%	0,80	49,691	85%	42,238	739,157
		Oats	125,160	2,81	39,640	65%	0,70	56,948	85%	48,406	847,099
	Tot plant		***1,236,535***		***443,650***			***568,835***		***483,510***	***8,461,418***
	Tree	Vines	2,141,478	15,66	158,025	80%		649,756	70%	454,829	7,959,511
		Olives	1,053,860	2,86	374,596	80%		228,903	70%	160,232	2,804,067
		Almond	31,216	1,06	29,030	60%	1,90	35,586	75%	26,690	467,069
	Tot tree		***3,226,554***		***561,651***			***914,246***		***641,751***	***11,230,648***
	Total							**1,483,081**		**1,125,261**	**19,692,066**

(*) vailable biomass (t) = Total production (t) • By-product S1 • By-product/main product
Source: (8).

Theoretical energy availability deriving from residue from the almond tree would, in the same year, prove to be negligible in almost all the provinces, apart from Bari, the potential there would be approximately 318 TJ.

The energy supply obtainable, should the pruning residue from the peach tree be used, is no less significant. Concerning fruit trees in the region, it proves to be the most representative in terms of quantity produced and from which, according to data relative to 2007, approximately 6 thousand tds, corresponding to approximately 105 TJ of potential energy, could be obtained.

Therefore, the total analysis highlights the agricultural sector in Apulia as being in a position to supply, data from 2007, a rather high and assessable total biomass residual quantity of approximately 1,125 thousand tds, corresponding to a high energy content of 19,692 TJ. In particular, as seen in Figure 1, the province of Foggia has the highest availability of dry biomass within the region (deriving mainly from cereal chaff) equal to 43% of the total, followed by the province of Bari with approximately 28% (mainly from vine shoots rather than cereal chaff); supply in the other provinces is more modest deriving essentially from vine shoots (particularly in Taranto and Brindisi) and residue from the pruning of olive trees (in the province of Lecce).

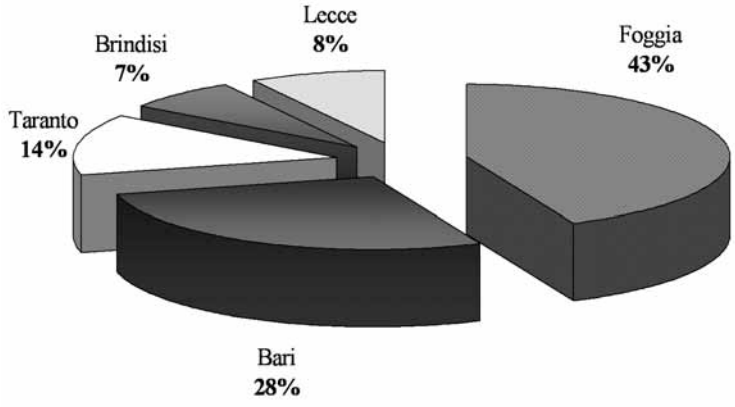

Fig. 1- Distribution of agricultural biomass in Apulian provinces (year 2007). Source: (8).

It should be emphasised that availability of biomass residue, both plant and tree, is strongly influenced by climatic conditions, availability of

water and agronomic techniques used in the various Italian areas, which may greatly differ, and thus merit further analysis on a regional level.
As already noted, the quantities and the relative energy content of the agricultural residue illustrated in Table 1 are gross values which also include current alternative uses (in agriculture, industry or as fuel, etc.), which are different from uses in biomass plants to obtain energy and/or heat.

Moreover, excessive collection of agricultural residue from the land should be limited in order to avoid a depletion of organic substance necessary for the productive cycle as an organic amender. In particular cereal chaff, the main residue of plant crops, is currently used as bedding in animal shelters (for the subsequent formation of waste to be used as amender on agricultural lands) for zoo-technical feeding, in the papermaking industry, but it is also often buried or burned in fields: thus net regional availability, theoretically destined for energy, would be approximately 36% of the total plant residue. However, it is necessary to underline that the high C/N ratio of chaff alters the balance of the land, thus rendering the supply of nitrogenous fertilisers necessary which, vice versa, are chemical in origin. In essence, it is a valid practice, though not in an absolute sense. Its application must be carefully assessed based on the specific function of the lands.

On the other hand, concerning pruning residue, vine shoots and wood from uprooting trees, it is estimated that these are currently used as wood to be burned to produce energy or burned on the edges of the fields or buried, with a net availability for energy use of approximately 58% of the total arboreal residue present in Apulia. The advantage of burying the pruning residue, usually done by shredders which shred the biomass and mix it with topsoil, is that it adds organic substance to the soil (with problems similar to those regarding chaff); the disadvantage lies in the eventual chemical substances used in the struggle against parasites, both vegetal and/or animal present in the same pruning residue (9-13).

Forest biomass

Apulia is characterised by a wide variety of plant origin landscape, in relation to is morphological conformation, but it is also one of the Italian regions poorest in forest vegetation due to centuries of agricultural activity throughout the territory.

According to the National Forest Inventory, regional forest surface area is 149 thousand ha, while the most recent forestry statistics (Istat 2000 – National Statistics Institute) indicate wood areas of 116 thousand ha and

characterised by high fragmentation. Thus a rational forest management and reliable estimate of potential wood mass obtainable is difficult due to lack of systematic data on the actual presence. However, both sources denote how the geographic area studied lacks a considerable forest coverage so much so that it proves to be Italian region with the lowest density and the lowest wood/inhabitant ratio (14).

Within the region the situation is not homogeneous: the majority of woodland vegetation is located in the province of Foggia, which represents the most extensive surface area, at 56 thousand ha, corresponding to 48.6% of the regional total; next is the province of Taranto (25.5%), Bari (21.5%) and, with lesser values, Lecce (2.6%) and Brindisi (1.8%). These are woodland areas with a predominance of bole 44%, coppice 43% and 13% Mediterranean bush, evergreens having often taken over destroyed woods, composed of poplars, shrubs aromatic (flowering bushes all insignificant from an energy supply point of view).

Besides climatic conditions, availability of forest residue generally depends on the extent of lopping, type of forest resources, type of management and economic conditions.

Moreover, if the vegetal species, particular conformation of the area, and lack of appropriate data are added, it may be understood how an estimate of actual obtainable forest residue is difficult to carry out. However, Table 2 illustrates, though approximately, wood availability present on regional territory, with reference to 2007. This takes into account the extent of the forest surface area, the lopping periods and the percentage of residue, at 20%, reaching gross theoretical value of dry biomass, at about 38 thousand tds, which could be used for energy.

From processed data it emerges that, in the year in question, total theoretical energy content obtainable from forest waste in Puglia is approximately 661 TJ.

As seen in Figure 2, availability of dry substance potentially obtainable from forest residues proves greater in the province of Foggia with approximately 50.7% of regional total, followed by Bari and Taranto with 25% and 20% respectively, Brindisi and Lecce both supply almost 2% of the total.

TABLE 2

FOREST RESIDUE AND ENERGY RELATIVE CONTENT IN APULIA (YEAR 2007)

	Wood type	Surface [ha]	Lopping period [years]	Yield [m^3/ha]	Forest residues [%]	Available biomass [t]	Content d. s.	Total d.s. [tds]	Total energy content [GJ]
Apulia	Bole	51,087	80	215	20%	24,713	60%	14,828	259,490
	Coppice	50,010	20	85	20%	38,258	60%	22,955	401,705
	Mediterranean Bush	15,112							
	TOTAL	**116,209**				**62,971**		**37,783**	**661,195**

Source: (11).

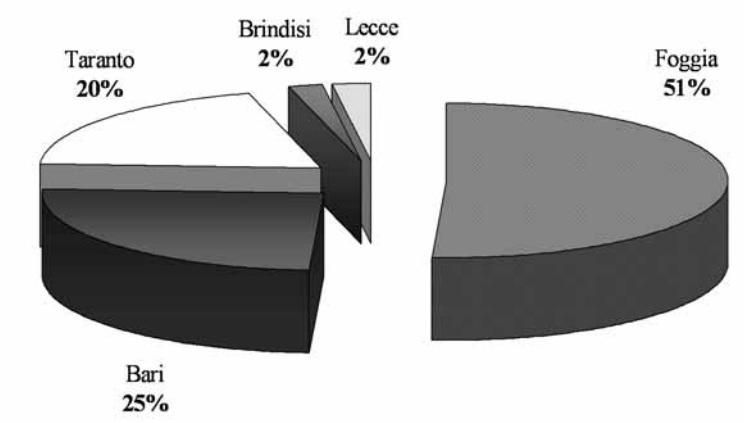

Fig. 2 - Distribution of forest residue in the Apulian provinces (2007).
Source: (8).

It is important to underline that 80% of dry wood mass is currently used as fuel (wood to be burned) and to a lesser degree as wood for carving, a sector which already saturates the market.

Consequently, biomass actually available for energy purposes, that is to fuel biomass plants in order to produce electricity and heat, would exclusively derive from by-products such as dead branches and lop, equal to 15-35% of total forest residue available in the region, depending on the woodland type. Therefore, it seems evident that the role played by Apulian forest residues, given the modest amount, is essentially for ecology, landscape and environmental protection (2,15).

Agro-industrial biomass

The food processing industry generates a variety of residues which are particularly suitable for conversion into energy since, in the majority of cases, they are vegetal with limited contamination levels, as far as harmful substances are concerned, and a humidity rate compatible with combustion in cogeneration plants within the same said industries.

These residues include those of the oil industry (virgin and exhausted olive residues, vegetation liquid), alcohol industries (fresh and exhausted vinasse, distillery lees), rice industry (husk, chaff, etc.), preserved food industry (fresh fruit stones, dry fruit shells, seeds and peels of

fruits and vegetables).

Within the Apulian context, energy assessment of vinasse and exhausted olive residues prove of particular interest given the significant presence of wine and oil industries. Other types of agro-industrial by-products can be deemed of limited interest for the purpose of this study, since they are of little importance above all from a quantitative and qualitative point of view.

In the processing of olives, the oil industry has to carry out burdensome disposal procedures for the residues produced (olive residue and vegetation liquid), highly polluting due to high organic and fat content. As a consequence, the main proposals for alternative use of olive residue concern its use as a food supplement in the zoo-technical sector (thanks to the high level of natural antioxidants and fat substances having balanced acidic composition; extraction of compounds for cosmetic and pharmaceutical products; fertilization of land. In this case, due to the high content of organic substance and nutritive elements, it could constitute the raw material from which to obtain high value amender (given the low carbon/nitrogen ratio) useful to the enhancement of chemical-physical properties of the soil. However, over the last years, the current norm (M.C.P.D. 08/10/2004) no longer classifies exhausted olive residue (by-product from the extraction of olive oil residue from virgin residue) as "special waste" (as such it had to be pre-treated before being used as an agricultural amender or deposited in landfills), but as fuel with certain chemical-physical characteristics: high inferior heat power 14.6÷18.8 MJ/kg and a granulometry, allowing it to be easily used in loose measure and possibility of collection and stockpiling within the same extraction plant. Therefore, exhausted olive residue assumes an important role also from an ecological-environmental point of view, since in this way pollution of aquifers would be avoided. In fact, it is a low cost fuel available in sufficient quantities and having excellent characteristics for combustion in boilers. Furthermore, olive residue from continuous two-phase plants, having high water content, and the vegetation liquid are substances with excellent possibilities of being designated for bio-digestion process in the production of gas.

Generally speaking, in the extraction plants there are thermal systems serving the production cycle and fuelled by exhausted olive residue (approximately 30-35%) to function the boiler during the process of exsiccation of humid olive residue and for the extraction of oil, whereas the remaining part (approximately 70%) is sold as fuel, though it also has a marginal use in the manufacturing of bricks, production of furfural and in

cabinet-making. Over the last twenty years the number of olive residue extraction plants in Apulia has greatly reduced and currently only eight are operative (Bari, Brindisi and Lecce). Three produce electric energy, both from the exhausted olive residue from its own production process and from that bought from nearby area, also using other types of bio-fuels (wood chip, animal meal, Waste Derived Fuel - WDF). The integration of energy conversion systems in olive residue extraction plants requires great quantities of biomass to fuel medium-sized power stations (approximately 70,000t/year of exhausted residue to fuel a 5 MW capacity plant). Consequently, it is necessary to diversify supply, making use of other types of bio-fuel or developing consortiums among the operators in the sector to increase the quantity of available biomass (16).

Bearing in mind that the percentage rate of exhausted olive residue compared to that total olive for oil production (about 1,054 thousand t in 2007) is 26.8%, the total energy potential in the same year is equal to 3,502 TJ, as illustrated in Table 3.

TABELLA 3

EXHAUSTED OLIVE RESIDUE AND VINASSE
AND ENERGY RELATIVE POTENTIAL IN APULIA (YEAR 2007)

	By-product typology	Raw material production [t]	Available biomass [t]	Content d. s.	Total d. s. [tds]	Total energy content [GJ]
Apulia	Olive residues	1,053,860	282,434	80%	225,948	3,502,188
	Vinasse	1,084,478	162,672	40%	65,069	488,015
	TOTAL	**2,138,338**	**445,106**		**291,017**	**3,990,203**

Source: (8).

Greater theoretical availability of exhausted olive residue in Apulia is registered in the provinces of Bari and Lecce (respectively, about 37% and 29% of the regional total): followed by the provinces of Brindisi and Foggia (with respective values of about 16% and 13% of the total) and Taranto, with lesser values (about 5% of the total), (Figure 3).

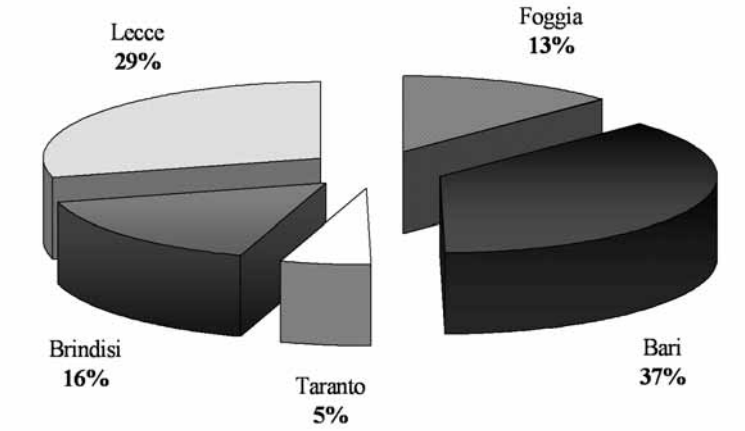

Fig. 3 - Distribution of exhausted olive residue in the Apulian provinces (year 2007).
Source: (8).

The wine industry also holds a prominent position in regional agro-industrial sector. Within the wine industry, vinasse is the residue from the pressing and squeezing of grapes. It represents 15-25% of the grape (about 1.084 thousand t in 2007) and is made up of skin (10-20%), grape stalks (3-8%) and seed (1-6%). Vinasse is used in distillation or production of "light wine" and residues, distilled and exhausted vinasse respectively, may be used, after appropriate exsiccation, as fuel to produce energy (inferior heat power approximately 12.5 MJ/kg).

Energy may be produced through using different technologies, the most traditional of which being direct combustion in specific water-tube boilers, or the production of biogas. In the latter case, technologies exist and are experimental, even if the energy yields are less compared to the previous one.

There is no market for exhausted vinasse, it is available at a low cost from the wine industries that use its energy potential only for the requirements of the production process. It is estimated that only 60% of residue is useable for energy purposes, while the remainder is in part sent to landfills (approx. 20%) and the rest used to recover nobler components (tartaric acid) within the production cycle (approx. 20%) (3,10).

As illustrated in Table 3, potential energy of vinasse on a regional level is approximately 488 TJ, much less than energy obtained from exhausted olive residue. Supposing the whole production of vinasse is car-

ried out industrially, it is evaluated that the highest yearly average availability (in 2007) is to be found in the province of Foggia (approx. 52% of the total), followed by Bari, Taranto and Brindisi (each having 14%, 13% and 12% respectively); of lesser importance is the contribution of Lecce (approx. 9% totally) (Figure 4).

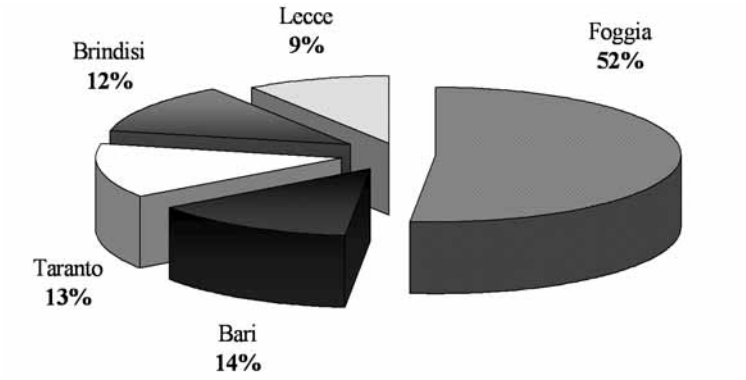

Fig. 4 - Distribution of exhausted vinasse in the Apulian provinces (2007). Source: (8).

Concerning the preserved food industry producing fruit juices, jams, fruit in syrup or shelled dry fruits etc., production residues such as shells, stones, are obtained which could be used for energy purposes. Indeed, they constitute excellent fuel (the same industries use them to generate heat) both due to their energy characteristics (on average approximately 18.8 MJ/kg) and to the ease with which they are obtained, transported and stored. Although these have no consolidated market, increasing interest has been noted, above all regarding shells (almond, hazelnut and pine nut, etc.) to be used for combustion in domestic boilers. In fact, the amount of waste products compared to original raw material is 15-20% for peach stones, 65-70% almond shells and 50-60% hazelnut shells (10).

Almond shells are a particularly important by-product of the dry fruit production industry and represent in their original state an excellent fuel for traditional use in areas dedicated to almond production. Raw material collected from various sources undergoes grinding, calibration and homogenization, in order to make it compatible for the technological needs of bio-fuel small-sized boilers, while preserving the excellent heat and functional characteristics of the original product.

In Apulia, having a yearly almond production of approximately 31 thousand tons in 2007, 17 thousand tons of shells could be obtained, having a theoretical energy content of approximately 318 TJ.

Moreover, a significant energy contribution could come from vegetal residue from processing and preservation of vegetables. This hypotheses should be appropriately assessed since, on a national level, Apulia is the leading region in the production of vegetables, which in 2007 amounted to approximately 2,974 thousand tons. Given this, and accounting for the fact that total obtainable waste represents between 20 and 36% of raw material manipulated weight, it would prove possible to obtain, on a regional level, from 595 thousand to 1,071 thousand tons of biomass, corresponding to a quantity of dry biomass of about 119-214 thousand tds, with an energy content ranging from 73 to 129 TJ. In particular, the main food industries able to supply biomass suitable for energy production are tomato and sugar beet processing plants (5). Regarding the latter, based on the Common organisations of the market (COM) reform on sugar, in force as of 1 July 2006, it is no longer processed; recent data from Istat (National Statistics Institute) relative to regional production, referring to 2005. Until some years ago, production in the province of Foggia was carried out in the facility located in Incoronata, but the sugar refinery is included among those likely to be converted into power stations to produce energy (electric and/or thermal) from lignocellulosic biomass.

Another useable local resource lies in the tomato industry, widespread in Apulia, particularly so in Foggia which has a far greater annual production compared to the other provinces. However, at present, processing is carried out in other regions, particularly in Campania, thus residue is not available locally. However, since regional production in 2007 was approximately 1,897 thousand tons (the province of Foggia totalling 89%) biomass availability could be approximately 84,000 tos (tons of organic substance) for a theoretical energy potential of approximately 67 TJ.

Dedicated energy crops

The present study must also make brief reference to energy crops which present a series of problems different from those relative to residual biomass use. Together with the need to occupy land which would inevitably be subtracted from food crops for human consumption, energy crops require availability of water which is rather limited , in southern regions of Italy, since rainfall is scarce particularly in summer. The nega-

tive impact on crop biodiversity is no less important. However, with opportune adjustments within the context of regional cultivation and favouring those more resistant to lack of water, they could prove to be an interesting energy prospect regardless of the fact that both regionally and nationally, their diffusion has not yet "taken off". In fact, these crops could occupy land designated for surplus crops or areas made available by "set aside", subject of productive reconversion or marginal areas, original cultivation having been abandoned due to economic, environmental or social causes. Most of these kinds of plants are still in the experimental phase; however, in the short term, they could be introduced and spread as a form of integrated income for the farm.

According to some analyses the soil climatic conditions features of the Apulia region are oriented towards the implementation of wood species (poplar, willow), which can be lopped at short intervals (SRF) and are considered better than herbaceous ones for the quality of biomass produced and fast re-growth thereafter.

Some herbaceous crops which adapt well to the regional territory and mainly designated as food, such as sunflowers, rape, soya and sugar beet, could be converted into no food production and destined to the liquid biofuel chain. Recently some experiments have started up concerning other types of energy presenting water requirements, not so compatible with the hydrologic, hydrographic and climatic characteristics of the region. These experiments deal with three herbaceous types, sorghum, switchgrass, and Brassica carinata and a type of arboreal and shrub growth form, the black locust, for which the provinces of Foggia and Bari seem more predisposed, both in terms of total surface area suited to conversion and surface areas adaptable to cultivation. This is due to the greater presence of non irrigated cultivated and sown land areas and their suitability to the physical characteristics of the territory (11).

Conclusions

The present study has made it possible, through examining literature and available statistics, to determine the theoretical potential of residual biomass (present in the Apulian area) from agriculture, forests, food processing sector, while highlighting their current use. Form the study it has emerged that the yearly amount of obtainable energy from the use of dry biomass in Apulia, approximately 24,867 TJ, would only be able to meet the requirements of approx. 7% of regional energy consumption with

reference to 2004, corresponding to approximately 374,460 TJ. To complete this analysis, the values thus determined, will need to be integrated with those obtained in a similar analysis on zoo-technical waste, of which there is a significant amount in the region, with an energy potential, for 2007, of approximately 964 TJ (17).

Moreover, a non negligible energy supply on a local level could come from the implementing and optimising those technologies used for other renewable sources, solar, thermal, photovoltaic and particularly wind (the latter contributing approximately 25% to national production).

Examined in its entirety, the enhancement of local biomass for energy proves to be advantageous since it would favour processes of environmental and socio-economic improvement such as diversification of crops, restoring abandoned land and recovery of rural areas, maintenance of woods; all this may lead to an increase in employment and the emergence of a new figure of agricultural entrepreneur.

However, bio-energy chain crops is rather complex, due to the difficulty in both the rational planning of supply of residues and establishing a solid interaction between the agro-forest sector and industry. Moreover, as already highlighted, actual availability and possibility of collection and supply of residual biomass are less than the theoretical value, since part of the material is already destined to alternative uses and the remainder those same operations seem difficult and burdensome. Therefore, it is necessary to rationalize the handling of residue within the territory; in this case mechanization of the various collection, packing and transport of biomass residue is essential to improving economic yield of agricultural activities and facilitate a more rational use of energy. An interesting project proposal could consist in the development of a computer platform where regional and extra-regional offers of purchase and sale may be directed.

Therefore, it is necessary to reduce the aforementioned biomass imports which, apart from strongly limiting the possibility of local upgrading activities, constitute expensive long distance transport costs causing significant consumption of fossil fuels and inevitable environmental impact. Unfortunately, in Italy the most important energy conversion plants are currently fuelled by imported biomass with long term supply contracts, costing less compared to local resources.

It would be desirable to favour collection, storage and direct use of biomass on a local level using small and medium-sized plants, in order to profit from both simplification of the process, deriving from reduced scale of the facility, and reducing distance from the supplier having low energy

conversion yield and high specific costs, relative to production of electricity and liquid and solid fuel.

The introduction of residual biomass on the market depends on the various support mechanisms to be adopted, political, legal, administrative and financial in nature. In general, the countries in which long term use of biomass is assumed, a series of tools are foreseen to guarantee both technological and scientific development, such as favourable legislation (through issuing a single document of norms) for the highly compatible with the production facilities in our country.

Moreover, aiming to promote the agro-forest sector, Local Authorities could, moreover, finance forest maintenance operations, from which a significant availability of biomass may be obtained, then directed towards energy enhancement in mountain communities or district heating plants in residential facilities, or incentives for the development of collection and transport systems through service companies.

In this context, a greater collaboration between public administration and the business sector together with essential support from the research field is needed.

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