AGROFORESTRY BIOMASS AVAILABILITY ASSESSMENT IN UMBRIA REGION, PRELIMINARY RESULTS

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ABSTRACT: Biomass resources vary depending on environmental characteristics, that influence Net Ecosystem Production (NEP), biomass is also dispersed through the territory. Estimating availability of biomass resources is important to assess bioenergy production potential and so bioenergy contribution to annual energy demand.
In this paper residual biomass resources are analyzed, such as agricultural residues (straw, prunings), agroindustry residues (olive husk, vinasse) and forestry residues. Biomasses availability is estimated based on main product production, using correlation indexes. Forestry biomass production can be estimated using annual biomass increment of different forestry typologies. Once availability has been measured, biomass energetic content is used to predict the potentially obtainable energy, depending on best conversion technology. Results are produced for each common of Umbria Region, that represents the ideal basin of agroforestry biomass production.
The obtained data are stored on Geographical Information System (GIS) and can be used for bioenergy chain managing and design.
Keywords: Biomass resources, Geographical Information System

1 BIOMASS ASSESSMENT STATE OF THE ART

1.1 Introduction to biomass assessment

According to European Environment Agency climate change is one of our greatest environmental, social and economic threats. The Intergovernmental Panel on Climate Change (IPCC) has demonstrated how the warming of the climate system is unequivocal.

It is very likely that most of the warming can be attributed to the emissions of greenhouse gases by human activities. So Italy as a member of the UE, who has subscripted Kyoto Protocol, is involved in the greenhouse gases reduction; renewable energies have an important role in this process and in particular biomass could contribute in a significant way.

Biomass could be employed for energy production (bioenergy) by means of different processes, such as biochemical or thermal-chemical ones. The process choice depends on the biomass characteristics; therefore an important step in the conversion systems study is the evaluation of the biomass availability and its energetic, physical and chemical characteristics.

Despite the importance of bioenergy, there is little reliable and detailed information on the consumption and availability of biomass, and no standardized system to measure it. Available methods range from overall estimates of bioenergy for countries or regions to detailed disaggregated local information; most used techniques for biomass assessment are available in [1].

According to [2] estimates of biomass potential depend on the assessment of land availability, of yield levels for biomass production, and on competition between alternative land uses. Four different potentials can be distinguished: the theoretical, the technical, the economic and the expected potential [3-4].

According to [1] biomass can be classified into eight categories: natural forest woodlands, forest plantations, agro-industrial plantations, tree outside forests and woodlands, agricultural crops, crop residues, proceed residues and animal wastes. This work focuses mainly on the assessment of residual biomasses such as forestry residues, agricultural residues, agroindustry residues; the estimation of potential biomass production from energy crops was carried out in previous work [5].

Biomass quantification and assessment is usually made through available agricultural and industry production data or through direct measurements where effective methodologies are available.

Concerning forestry residues production, estimates can be done using harvesting statistics. Roundwood is equal to 60 per cent of total volume of wood actually cut. Potentially harvestable residues include all on-site forestry residues (i.e. 40 per cent of total cut wood) plus all residues arising form industrial roundwood processing at the timber mills. Practically it can be assumed that only 25 per cent of the potentially harvestable residues are recoverable. K. Ericsson [6] indicates that since harvesting of forest residues may cause nutrient depletion in the soil, two harvest indexes can be applied to forestry harvest: the low residue-to-stemwood ratio is assumed to be 0.15 and 0.1, for coniferous and dedicuous trees. The high harvest ratios are set to be twice as large, i.e. 0.3 and 0.2.

With regard to crop residues, since comprehensive global data are only available for crop production, the 'potentially harvestable residue' resource is estimated using residue production coefficients. These allow rough estimates to be made of the amounts of available residues per ton of product. R.A.H. Edwards and others [7] used Eurostat data and Corine Landcover 2000 (CLC 2000) data to map on a GIS basis the production of straw for the EU25+2. Straw yield was expressed as a function of grain yield.

With regard to animal manure the average volumes largely differ from their types and mainly depend on their age and life weight. However average values have been developed by various researchers [8].

To estimate animal wastes production the number of animals is multiplied for dung production coefficients. Due to the disperse nature of dung, it is estimated that only 25 per cent of the dung actually produced is recoverable.

1.2 Biomass assessment in Italy

Several institutes have analyzed agroforestry biomass availability in Italy. An interesting study was presented by C. Di Blasi [9], dealing with agricultural residues.

APAT (Environment Protection Agency) has analyzed the national availability of lignocellulosic biomasses in Europe [10]. The National Agency on Energy and Environment (ENEA) has developed together with AIIA (Italian Association of Agricultural Engineering) in 1994 a methodology for the estimate of agricultural by-products, wood and wood by-products, agroindustrial by-products [11] and produced data on the availability of lignocellulosic biomass for every Italian province. Itabia [12-13] has described bioenergy sector trends in 2002 and 2003; while other data about biomass national availability are available in the propaedeutical document for the National Plan on Biomasses and Biofuels, redacted by the Biomass Research Center [14]. Estimates of wood production in forests are made by the INFC (National Inventory of Forests and of Carbon Sinks) [15].

The potential biogas production from animal manure is proposed by Tricase [16]. The number of animals was reported in data of the National Statistic Institute (ISTAT), then the production of effluent was calculated using coefficients enclosed in [17]. The food-industry sector has been analyzed by [18]. Several attempts have been done to estimate biomass availability in different regions at municipality level [19-21].

1.3 Biomass assessment in Umbria Region

Preliminary activity was carried out in the Umbria energy plan [22] and data for the northern part of the region (The Tiber valley) have been proposed in the territorial energy plan redacted by the Biomass Research Centre (CRB) [23].

2 OBJECTIVE OF THE STUDY AND METHODOLOGY

2.1 Objective of the study

The objective of the study is to assess the annual availability of agroforestry biomasses in Umbria Region. These can be classified in different typologies:
- agricultural residues (straw, prunings, animal husbandry residues etc.);
- forestry biomass;
- animal husbandry residues;
- wine, olive oil and dairy industry residues.

The availability will be calculated for every common inside the region, because the common is the ideal basin to achieve a short bioenergy production chain in a distributed energy conversion system.

2.2 Methodology

The methodology approach was different depending on the typology of biomass analyzed.

2.2.1 Woody residues evaluation

For the estimate of forestry biomass production the Regional Forestry Inventory (IFRUM) and the regional Forestry Map can be used as base data. The methodology followed consists of different steps:
- assignment of yearly mean increment to each forestal species (using data taken form IFRUM);
- individuation of the different surfaces present in Umbria Region for each forestal species (using data contained in the Forestry Ma)p;
- individuation of the yearly harvestable surface for each forestal species;
- calculation of the potential harvestable biomass and comparison with effectively harvested according to National Statistic Institute (ISTAT) data.

2.2.2 Agricultural residue

With regard to agricultural residues the adopted methodology is that explained in [9], that is:
- cultivated surfaces evaluation;
- residue production per unit of cultivated area estimate;
- calculation of the total production for the different kinds of residues.

2.2.3 Animal husbandry residues

For the estimate of animal husbandry residues the following methodology was used:
- at first the number of animals was considered for each species;
- then coefficients available in the Literature were used to evaluate effluent production per animal;
- the calculation of animal residue production was done multiplying production for the number of animals.

2.2.4 Agroindustry

Estimates about agroindustry wastes have been done dividing the sector in the following categories:
- wine industry;
- olive oil industry;
- dairy-farming industry;
- etc.

For each of these categories the total residues production was evaluated mainly through questionnaires proposed to different producers and to public agencies that deal with residue displacement.

For olive husk the data were furnished by Agecontrol (national agency for olive oil control) and Umbria Region. Exhausted oils are estimated using a coefficient cited in [24]. Whey production and slaughter residues were declared by Local Health Agency (ASL). Wine industry residues data were declared by a local distillery that collects vinasse from all the region.

3 GROSS BIOMASS AVAILABILITY

3.1 Regional gross biomass availability

Regional agroforestry biomass availability can be divided in 4 categories:
- hearbaceous residues;
- woody residues;
- forestry biomass;
- animal husbandry residues;
- food industry residues.

In the following tables main results are presented and discussed.

Table I: Herbaceous residues

Typology	Availability (kTon/year)
Straw, triticum estivum	152.4
Straw, triticum durum	39.8
Straw, barley	62.3
Straw oat	9.9

Straw, rice	0.0
Stalks, corn	103.7
Stalks and leaves, soybean	0.2
Stalks and leaves, sunflower	117.5
Stalks and leaves, Leguminosae	1.5
Leaves and collar, sugar beet	21.0
Stalks and leaves, potato	1.6
Stalks, tabacco	3.2
Stalks and leaves, tomato	1.5
Stalks and leaves, artichoke	0.1
Stalks and leaves, cauliflower	1.5
Total	**516.2**

Table II: Woody residues

Typology	Availability (kTon/year)
Vine prunings	29.9
Olive tree prunings	36.9
Citrus fruit prunings	0.0
Peach tree prunings	0.8
Apricot tree prunings	0.1
Plum tree prunings	0.1
Apple tree prunings	0.9
Pear tree prunings	0.4
Cherry tree prunings	0.0
Kiwi tree prunings	0.0
Almond tree prunings	0.0
Chestnut tree prunings	0.1
Total	**69.4**

Table III: Forestry biomasses

Typology	Availability (kTon/year)
High forest	75.153
Simple coppice	179.717
Complex coppice	55.808
Out of forest	9.565
Total	**320.243**

Table IV: Animal husbandry residues

Typology	Availability (kTon/year)
Pigs	730
Cattle	460
Ovines and Capridae	219
Equines	66
Chicken	298
Rabbit	28
Total	**1.801**

Table V: Food industry residues

Typology	Availability (solid kton/year)	Availability (liquid kTon/year)
Olive oil industry, olive husk	10	
Olive oil industry, vegetable water		13
Olive oil industry, stone (pits)	1	
Wine industry	4	
Slaughter residues, blood		281
Slaughter residues, carcass and skin		619
Slaughter residues, effluents		147
Slaughter residues, animal residues		34
Milk and cheese industry		42
Exhaused oils		4
Total (solid)	**15**	
Total (liquid)		**1.143**

Both herbaceous residues and woody residues belong to agricultural residues.

These are different from forestry biomasses that are produced by woodlands that in Umbria Region are mostly represented by coppices.

Forestry biomass is mostly used for household heating in traditional devices (i.e. fireplaces).

By the point of view of energy conversion the different typologies of biomasses can be classified in solid biomasses (straw, prunings, forestry biomasses, olive husk, vinasse etc.) and liquid biomasses (vegetable water, animal husbandry wastes etc.).

Dedicated crops can be divided into humid crops and dry crops (poplar, black locust, miscanthus, cardoon etc.). Solid biomasses and dry crops can be used to produce heat or in cogeneration with Rankine cycles, gasification and pyrolysis technologies.

Liquid biomasses and moist crops can be used to produce biogas for CHP applications.

3.2 Straw availability at Common level

Straw availability allocated per common is presented in fig.1.

Straw is usually harvested in bales and used to produce heat or power and heat in cogeneration.

3.3 Prunings availability at Common level

Pruning availability allocated per common is presented in the fig.2.

Prunings can be harvested in bales or directly chipped and then burned to produce heat or heat and power in cogeneration.

3.4 Forestry biomasses availability at common level

Forestry biomasses availability allocated per common is presented in fig.3.

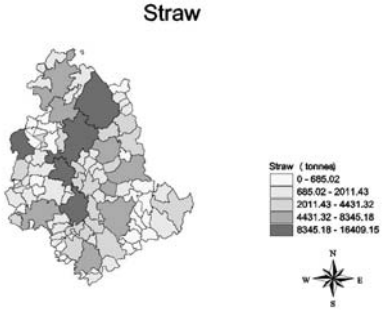

Figure 1: Straw availability in Umbria Region

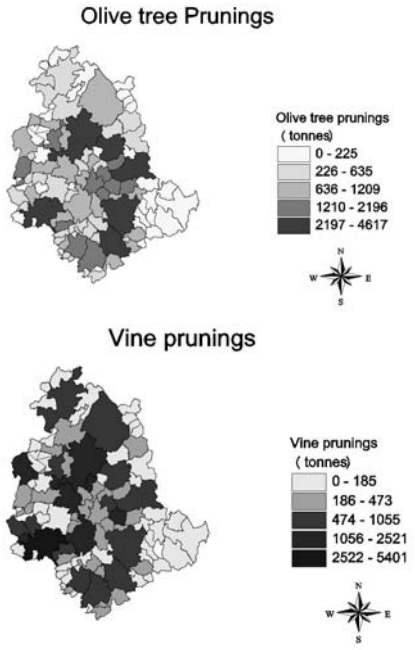

Figure 2: Prunings availability in Umbria Region

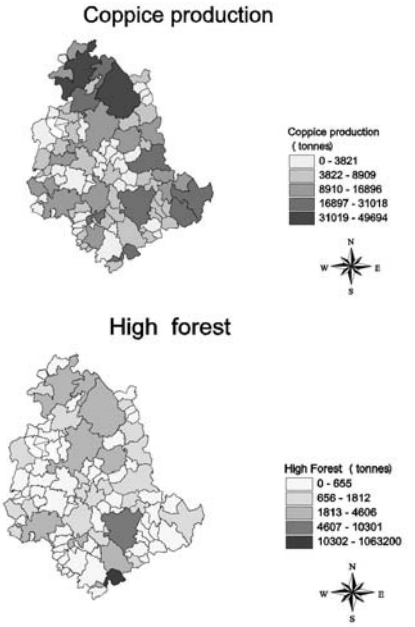

Figure 3: Forestry wood availability in Umbria Region

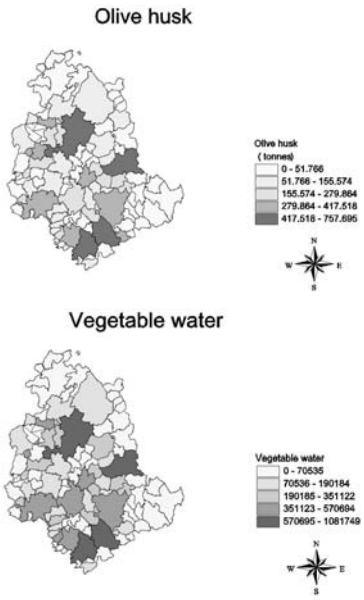

Figure 4: Olive oil industry residues in Umbria Region

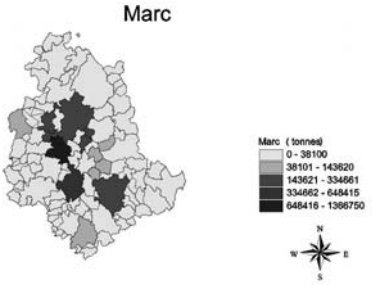

Figure 5: Wine industry residues in Umbria Region

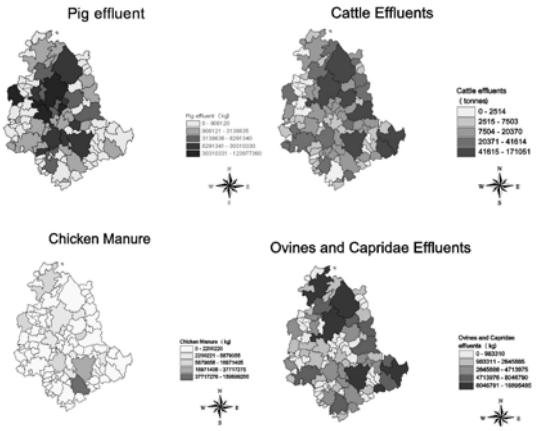

Figure 6: Animal husbandry effluents in Umbria Region

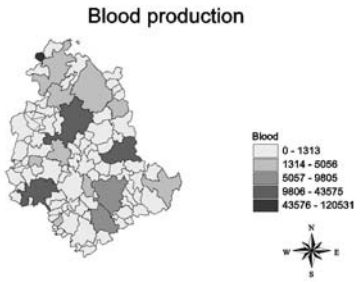

Figure 7: Blood production in Umbria Region

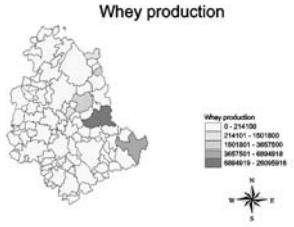

Figure 8: Dairy industry residues in Umbria Region

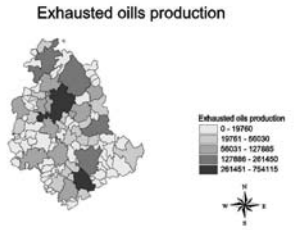

Figure 9: Exhausted oils in Umbria Region

Forestry wood is mainly used in domestical heating devices.

3.5 Olive oil industries residues at Common level

Olive oil industry residues allocated per Common is presented in fig.4.

3.6 Wine industries residues

Wine industry residues allocated per common are presented in fig.5. According to wine CMO (Common Market Organization), vinasse has to be collected by distilleries to produce alcohol that is sold in the global market. So no vinasse is available in the national market.

3.7 Animal husbandry wastes at Common level

Animal husbandry residues availability allocated per common is presented in fig.6. Pig residues are the most important for quantity, then come cattle effluents followed by poultry and ovines. These are the most important quantity in Umbria Region.

3.8 Slaughter residues at Common level

Among slaughter residues particularly interesting is blood. From Literature it has been proved that most slaughter residue have good biogas production potential.

3.9 Dairy industry residues

Dairy residues allocated per common is presented in fig.8.

3.10 Exhausted oils at Common level

Exhausted oils allocated per common is presented in fig.9.

4 NET BIOMASS AVAILABILITY

4.1 Solid biomass regional net availability

Among solid biomasses the following typologies were considered:

- herbaceous residues;
- woody residues;
- forestry biomasses;
- olive husk;
- vinasse.

Forestry biomasses will not be considered because they are already used for domestic heating. Vinasse is entirely collected by distilleries. So the remaining solid fuels are: herbaceous residues, woody residues and olive husk. According to [9] part of herbaceous residues in not harvested or used in alternative scopes the resulting amount is about 368 kton/year; prunings are supposed to be used in percentage of 10%, the resulting amount is about 62 kton/year, olive husk is supposed to be used completely so the resulting amount is about 10 kton/year. Therefore the remaining quantity of solid biomasses is about 441 ktonnes. Considering solid biomass availability and its LHV, the Energy potential can be estimated assuming 0,9 heat conversion efficiency and 0,15 power production efficiency.

Table VI: Regional solid biomass net availability and energy potential

Typology	Net availability (kTon/year)	Energy Content (TJ)	Heat (MW)	CHP	
				Power (MW)	Heat (MW)
Straw	368	6632	829	39	157
Prunings	62	1949	244	11	44
Olive husk	10	209	26	1	4
Total	**441**	**8791**	**1099**	**51**	**205**

4.2 Solid biomass net availability at Common level

In fig. 10 data about solid biomass availability at Common level showed.

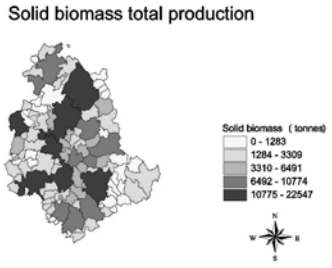

Figure 10: Solid biomass net production, at Common level

Table VII: Regional liquid biomass net availability and energy potential

Typology	Net availability (kTon/year)	Biogas production (m^3/day)	Power (MW)
Vegetable water	3	333	0.02
Slaughter wastes	1081	120000	8.6
Whey	42	4680	0.34
Animal husbandry wastes	1800	199000	14
Total	**2926**	**324013**	**14**

4.3 Liquid biomass regional net availability

Liquid biomasses are represented by: vegetable water, animal husbandry residues, whey, slaughter wastes. Assuming that 25% of the original mass can be collected to produce bioenergy and considering average biogas yield LHV and energy conversion efficiency (about 0,3 for an internal combustion engine) the

obtainable electrical power is calculated (see tab.VII). With regard to heat power, the heat generated in CHP is supposed to be used to furnish process temperature to the biogas reactor.

4.4 Liquid biomass net availability at common level

In fig. 11 data about liquid biomass availability at Common level are showed.

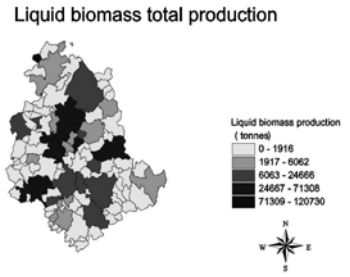

Figure 11: Liquid biomass net production, at Common level

5 CONCLUSIONS

The availability of biomasses in Umbria Region was been evaluated. At first they have been classified into different categories: herbaceous, woody residues, forestry biomasses, animal husbandry residues, food industry residues. For each category the gross availability was calculated using classical methods as well as net availability. Finally the power and heat capacity were estimated both at regional level and Common level and availability maps were drawn.

6 REFERENCES

[1] F. Rosillo-Calle, P. de Groot, S. L.Hemstock, J.Woods; The biomasa assessment handbook ISBN-10: 1-84407-285-1;

[2] A.Fallot, P.Girard, Spatial assessment of biomass potential for energy scenarios, 14th European Biomass Conference, 17-21 October 2005, Paris, France;

[3] G. Thek, I. Obernberger, J. Hirtenfellner, Investigation of woody biomass potentials in selected european countries and their allocation to potential applications for thermal utilization;

[4] J. Neubarth, "Erneuerbare Energien in Österreich, 2000, Springer. Vienna Austria; Nikolau, A., Biomass Availablity in Europe, 2003, Brussels Belgium;

[5] G. Bidini, F. Fantozzi, C.Buratti, P. Bartocci, Most suitable areas for the cultivation of herbaceous energy crops in Umbria region (Italy) and biomass production evaluation, 15th European Biomass Conference & Exhibition, 7-11 May 2007, Berlin, Germany

[6] K. Ericsson and L.J. Nilsson, Assessment of the potential biomass supply in Europe using a resource-focused approach, 2nd World Conference on Biomassfor Energy, Industry and Climate Protection, 10-14 May, 2004, Rome, Italy;

[7] R. A. H. Edwards, M.Šúri, T.A. Huld and J.F. Dallemand, Gis based assessment of cereal straw energy resource in the European Union, 14th European Biomass Conference, 17-21 October 2005, Paris, France;

[8] N. Szarka, J.Wolfbauer, A.Bezama, G.Azócar, Agriculture and forest origin biomass potential at regional scale, 15th European Biomass Conference & Exhibition, 7-11 May, 2007, Berlin, Germany;

[9] C. Di Blasi, V. Tanzi, M. Lanzett, "A study on the production of agricultural residues in Italy", Biomass and Bioenergy vol.12, No. 5, pp.321-331, 1997;

[10] APAT, "Le biomasse legnose – Un'indagine sulle potenzialità del settore forestale italiano nell'offerta di fonti di energia", 2003;

[11] E.Scoditti, F.Reale, F.Lucia; Assessment of solid biofuel in the Italian provinces: methodology and potentiality, 14th European Biomass Conference 17-21 October 2005, Paris, France;

[12] Rapporto sullo stato della bioenergia in Italia al 2002; In Italian

[13] Le biomasse per l'energia e l'ambiente, rapporto 2003; In Italian

[14] Propaedeutical document for the National Plan on Biomasses and Biofuels, Biomass Research Centre (CRB, Italy), 2007, In Italian

[15] G.Tabacchi, F. De Natale, P. Gasparini, Italian forest resources assessment: rationale, methods and first results of the National Forest Inventory, CRA-ISAFA (Italy);

[16] C. Tricase, M.Lombardi, Potential supply of biogas from animal manure in Italy, 15th European Biomass Conference & Exhibition, 7-11 May 2007, Berlin Germany;

[17] Regione Campania, Guida alla compilazione del Modello di comunicazione LZ versione 2.a.2, (2006);

[18] I rifiuti del comparto agroalimentare, Studio di settore, Rapporti 11/2001, ANPA – Unità Normativa Tecnica, ISBN 88-448-0242;

[19] V.Motola, M. Cardinale, D.A. Matera, A.D'Alessandro, N. Cardinale, G. Braccio, Biomass availability and its energetic use in Basilicata (italy), 14th European Biomass Conference, 17-21 October, 2005, Paris France;

[20] L.Pari, Agricultural waste energy exploitation in the Lazio region, 2nd World Conference on Biomass for Energy, Industry and Climate Protection, 10-14 May 2004, Rome, Italy;

[21] R.Villani, E.Piccioni, G. Ragaglini, T. Sabbatici, E.Bonari, Gis based land suitability evaluation for bioenergy chains: a multidisciplinary approach applied to mediterranean reions, 15th European Biomass Conference & Exhibition, 7-11 May Berlin, Germany;

[22] Umbria Region Energety Master Plan 17th March 2004;

[23] G. Bidini, S. Servili, Piano Energetico Comprensoriale alto Tevere umbro sezione energia rinnovabile, 62° Congresso Nazionale ATI, Salerno 11-14 settembre 2007; In Italian

[24] ''Waste grease resources in 30 US metropolitan areas'' Gorge Wiltsee; Bioenergy'98: Expanding Bioenergy Partnerships;