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CONVERTING THE WASTE GENERATED FROM OLIVE OIL FOOD INDUSTRY AND OTHER SECTORS INTO ENERGY TO BENEFIT THE SMALL SCALE PRODUCERS

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ABSTRACT

The disposal of olive wastes and their wastewater is becoming a serious problem along with an expansion of the olive oil processing industry in Albania. This paper presents the status of research of biomass potential for producing energy for the small scale producers since the energy expenditures comprises ca.20% of the entire production turnover. Biomass potential can be generated by different sources including those of olive oil industry, agriculture sector and fruit processing, wood production sector, etc. So, all types of biomass energy sources are based on dedicated bio-energy crops, agricultural and forestry residues and waste. This research developed an efficient and effective sustainable scenario for production of energy and contributing thus at to the benefits the small scale producers and improving the quality of environment, primarily of aquatic ecosystems. Analysis of the potential biomass resource quantity was based on different approaches as field survey; questionnaire that considered 49 unites of production and calculations following data reports and literature review. Based on the assessment of the biomass potential with a focus on the olive oil sector and other key sectors in Albania, including wood processing, wine production and jam-fruit production, it was found that theoretical, technical and economic potentials for biomass for energy generation are estimated to be about 4.27 Mtoe, with biomass of fruit and olive waste & agricultural production biomass contributing up to 1.52 Mtoe of the theoretical potential and about 1.35 Mtoe to the economic potential.

Keywords: Biomassenergy, environment pollution, olive oil industry, Agro-food industry, waste generation

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1. INTRODUCTION

Increasing energy requirements and other factors associated within sector are leading to daily energy crises caused by the high energy demand throughout the Europe. The need for energy is rapidly increasing to ensure that services can fulfil the needs of society needs and economic development.

Cultivation of olive trees, scientifically known as *Olea europaea*, is one of the oldest processes in the world [1], with an estimated global cultivation area of 9 million hectares [2]. Presently, in Albania the olive tree dominates the country's permanent crops with 10.28 million out of total 13.82 million of fruit trees 74.4% [3-4]. Albania is one of the few countries in Europe and the only country in Central-East Europe that has favorable climatic and geographical conditions for olive cultivation [5]. The demand for olive oil and table olives in the domestic market is very high (Fig.1). Olives are among the most important fruit tree crops grown in Albania, covering an estimated 8% of arable land. 77% of the Olive Oil Sector in Albania is cultivated in organized plantations whereas the remaining 23% is found in a not organized form [5]. Across the Europe there it is ca. 118 to 138 million tons of bio-waste generated annually, of which currently only about 40% (equivalent to 47,5 million tons per year) is effectively recycled into high-quality compost and digestate[6]. As up to 50% of municipal solid waste is organic [6], the bio-waste fraction plays an important role in recycling and the nascent circular economy. In these contexts the agro-food sector and wood processing unites encompasses a broad variety of manufacturing processes that generate considerable quantities of different wastes also in transitional countries like Albania [7].A number of studies in the literature conclude that agro-industrial residues are a suitable source of biomass for electricity production [8, 9, 10, 11-12]; however, its use as an energy source is hindered by several limitations [13], such as for instance the seasonal supply of waste (correlated to the seasonality of the main product) [14-15], or the high investment costs required for waste pre-treatment. Further on it is worth to mention that there are few studies published in the open literature with estimates of energy potential from agro-industrial residues and economic analyses of the electricity generation from them at a country level [15].

The national mitigating the effects of climate change and securing sustainable energy and raw material supplies are two of the key challenges that country face (similarly to the global ones). These elements and issues are taken into consideration in the revised National Strategy for Development and Integration for the period 2014-2020 and other strategic and political documents [16, 17, 18, 19, 20, 21-22]. The strategies are looking on (i) fostering a viable, high quality food production by developing a competitive and innovative agro-food sector, able to sustain the competitive pressure in the domestic and EU markets and meeting EU standards and market requirements; (ii) sustainable management of natural resources and climate adaptation

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actions through smooth management of forests and water and application of environmental-friendly agricultural production methods; (iii) Balanced territorial development of rural areas, promoting diversified economic activity, creation of jobs, social inclusion, and improved living conditions; (iv) Diversify tourism products extended in the whole territory to ensure integrated tourism development.

The National Strategy of Energy and Plan of Action aims to maximize renewable energy sources and to increase investment in the energy market by international financial institutions. The Power Sector Law requires energy producers with an installed capacity higher than 50 MW to produce a quota of at least 3 percent of their annual electricity output from renewable sources. But since the law was adopted, no thermal power plant has yet been commissioned and the law is yet to be practically implemented. As well as the feed-in tariffs, the new Law on Renewable Energy Sources defines the national target for energy consumption from renewable sources, and aims to attract potential investors in renewable energy through priority grid access.

Other incentives schemes exist for all technologies and all capacity sizes. Electricity from renewable sources is exempt from excise tax. Machinery and equipment used for the construction of renewable energy power plants are exempt from customs duties.

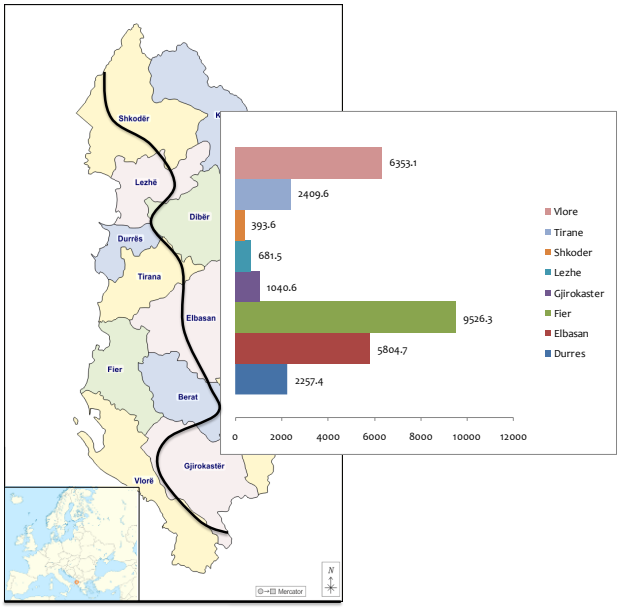

Figure 1: Map of Albania with olive cultivation on western part and generated wastes in tonnes by different regions

The aim of this paper is the assessment of the biomass potential with a focus on the olive oil sector and other key sectors in Albania, including wood processing, wine production and jam-

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fruit production. The survey has been carried out through market surveys related to technical, economic and financial energy potential related to each of these sectors with the potential for respective appropriate technologies to be introduced based on the lowest cost strategy.

2. MATERIAL AND METHODS

In this assessment for the energy potential in wastes generated by agro-industrial waste we use a methodology that estimates the maximum amount of energy available from each source of residues. Generally, the energy potential of a source of residues results from two basic estimations: the amount of residues generated in a given temporal cycle (typically one year) with a certain geographical disaggregation, and the energy content of the material which is transformed into electricity.

Olive-mill residues: There are generated three different residues are generated: olive husk, olive-mill wastewater and sludge. Olive husk is a solid waste containing the pulp, the tegument and the stone of the olive. Traditionally this residue has been used as animal feed but nowadays it is carried to seed-oil factories where the small percentage of residual oil it contains is extracted. As a result an easy-to-burnmaterial is obtained [8-13]. Calculations the energy potential of olive-mill residues was based following [23 -14]. In case of the residue from forest-operation and wood-processing industries the assessment is based Albania [24].

As an integral part of the survey was structured questionnaire that was followed by personal interview, the advantage of which is high credibility in terms of data gathering, ensured by the possibility of asking questions directly related to the items connected to the objectives. Direct contact with the respondent i.e. 49 considered producer, waste generation unite enabled that while asking questions made it possible to deepen specific thematic issues (production capacity, processing, waste generation, type of management, etc), and also gave the respondent the opportunity to develop and justify their statements. The interview was conducted in the places where the surveyed companies have their production unites.

Data analyses: With a quadratic trend, the values of a time series tend to rise or fall at a rate that is not constant; it changes over time. As a result, the trend is not a straight line. The corresponding regression equation is:

$$y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_t$$

The following data shows a time series with a quadratic trend. In this case, the value of y_t increases at an increasing rate over time. Note that as t increases (such as time

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elapses), *Y* tends to increase at an increasing rate. The trend is curving upward; this type of curve indicates that the *Y* has a positive *quadratic* trend.

A quadratic equation has at least one squared term. In order to overcome the disadvantages of polynomial regression, we used an improved regression technique which, instead of building one model for the entire dataset, divides the dataset into multiple bins and fits each bin with a separate model. **Such a technique is known as Regression spline.** Regression spline is one of the most important nonlinear regression techniques. In polynomial regression, we generated new features by using various *polynomial functions on the existing features* which imposed a global structure on the dataset. To overcome this, we can divide the distribution of the data into separate portions and fit linear or low degree polynomial functions on each of these portions.

3. RESULTS AND DISCUSSIONS

Following our analyses in Albania, due to the appropriate ecological conditions, the olive oil is planted today and grows successfully in large blocks of old and new micro-zones of 17 districts of the Mediterranean area plains and hills that have the largest share of the population [4]. The perennial observations show that in the present area the climate is appropriate and suitable specifically on its elements, such as temperature, solar lighting and air humidity. The height above sea level and the regime of the precipitation, relative air humidity, solar radiation and other factors conditioning the microclimate components, in their entirety are found to be optimal in size, thus allowing growth and regular olive production. After 2000, their number increased considerably and in 2010 their number was almost two time more compared with year 2000 (6.2 million) and in 2015 the number reached 9.2 million or about 3 times more than in 2000 and 2.1 times more than 1990. Olives in production (> 10 years) doubled for the same period (3.2 vs 6.33 million root for 1990 and 2000, respectively). Olive harvesting is variable and varies from 8.6 kg roots (2005) to 25.9 kg / roots (2012) depending on climatic conditions; Progressive increase in productivity in recent years is the result of better technologies and added maintenance services such as irrigation and fertilization. Also, the introduction of new production varieties, from an early age, has improved the variance structure and has reduced the phenomenon of periodicity.

Biomass potential with a focus on wine production and jam-fruit production industry

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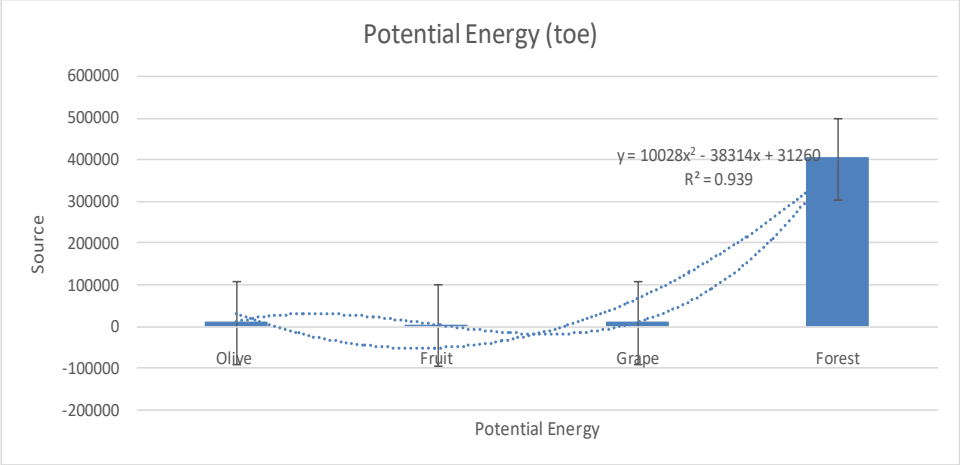

Figure 2: Potential energy in toe

Agricultural sector is one of the main sectors of residues production which can be used for the production of energy. Thus, based on the evaluations of National Agency of Energy, in the future we will have a considerable quantity of agricultural residues which will increase up to 1.4 MToe/year. These evaluations also suggest that the quantity of energy that can be obtained yearly from the animal remnants is 350 Toe and from the animal manure 25 Toe. The results of these evaluations show that the residues of biomass reach to a total energy of 1 – 1.5 W Toe/year (Fig. 2). The calculation of predictive production trend in short and long term in Albania, was based on actual production trend, potential of available surface area for plantation, the intensification of applied technology of plant production and potential of agricultural farms to increase production and plant yield. A polynomial model of third order was used for calculations of predictive production trend for short term of the year 2020 and for long term of the year 2025.

Thus, the predictive estimation of fruit tree, vine and citrus production in short term (2-5 year) indicate that production in 2020 will be about 310 ton/year fruit tree, 220 ton/year grape and 40 ton/year citrus. The estimation of production in long term (6-10 year) indicate that production in 2020 will be about 370 ton/year fruit tree, 240 ton/year grape and 56 ton/year citrus.

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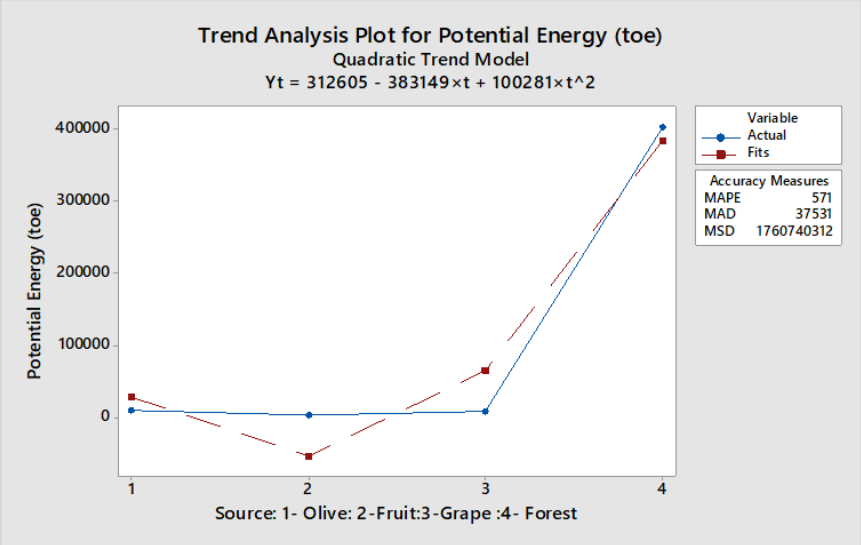

Figure 3: Quadratic trend model for energy projections

Produced fruits can be fresh consumed, exported and processed in agro-industries. The part that is processed varies according to presence of agro processing lines in different regions of Albania and type of fruit species. Actually, a small amount of fruit production is processed in Albania, in amountof 10-20 %. This amount is very low compare to the processing potential and farmer interest for increasing of economic value of fruits. The increase of fruit production will lead to the increase of processing amount; therefore will be increases the amount of formed residues during processing steps. The stone fruits such as plum, cherry and peach are processed more than other fruits in different region of Albania. The processing of stone fruits is related with formation of residues that can be used as biomass for energy production. The citrus fruit are not processed actually in Albania, as the processing lines of citrus fruit do not exist, but the processing of citrus fruit can be developed in the future as the production of citrus will increased up to 85% in the year 2025 compare to the year 2015. Based on scenario of the increase of fruit and grape production will be also increased the amount of processed fruit and grape. Thus, the predictive amount of processed fruit in the year 2020 will be about 75000 ton or 25% of production and in the year will be about 130000 ton or 35% of production. The amount of residues from fruit processing will be about 30000 and 52000 ton, respectively.

The increase of grape production will lead to the increase of processed amount of grape and production of grape pomace. Thus, the predictive amount of processed grape in the year 2020 and 2025 will be about 135000 and 155000 ton, respectively. Thus, the amount of produced grape pomace will be about 27000 and 31000 ton for the year 2020 and 2025.

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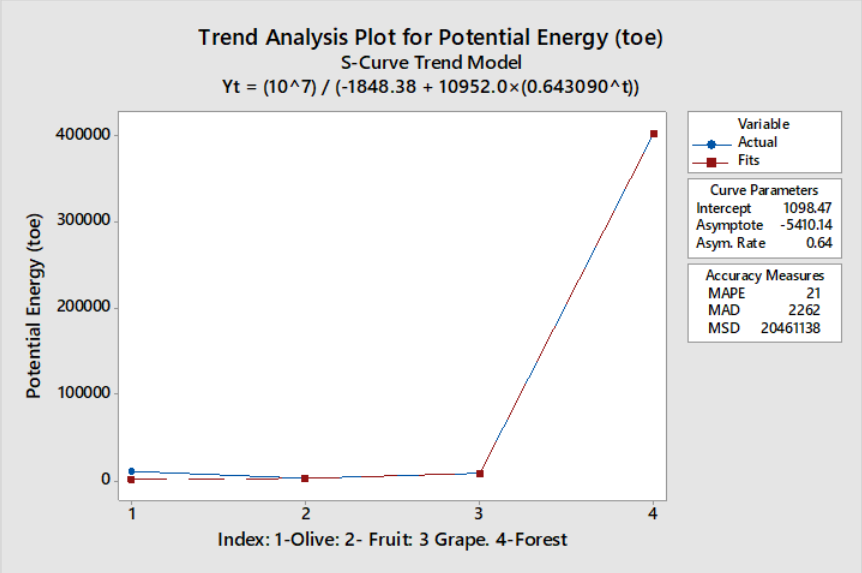

Figure 4: S-Curve trend model

The heating value of forest biomass was set to 16.6 MJ/kg [25] when it is dried in ambient condition which is the case of Albanian forest biomass [4]. Theoretical energy content was estimated from biomass production multiplied by heating value. A conversion efficiency of 30% was used for estimating technical electrical energy generation [4].

CONCLUSION

This article presents an extensive analysis of the biomass renewable energy potential in Albania based on the current energy scenario and future evaluation of biomass potential in energy generation. There is emphasized the fact that there is a need of Substantial development of bio-energy technologies in Albania, mainly to improve the rate of production, efficiency, reliability and sustainability of bio-energy chains. In the energy sector, improvement would lead to cleaner, more reliable systems linked to higher quality fuel supplies. In the electricity sector, the development of smaller and more cost-effective electricity systems could better match local resource availability. Following the sectors assessment of the biomass potential with a focus on the olive oil sector and other key sectors in Albania, including wood processing, wine production and jam-fruit production, it can be concluded that theoretical, technical and economic potentials for biomass for energy generation are estimated to be about 4.27 Mtoe, with biomass of fruit and olive waste & agricultural production biomass contributing up to 1.52 Mtoe of the theoretical potential and about 1.35 Mtoe to the economic potential.

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REFERENCES

[1] Uddin M.A., Siddiki S.Y.A., Ahmed S.F., Rony Z.I., Chowdhury M.A.K., Mofijur M., Estimation of Sustainable Bioenergy Production from Olive Mill Solid Waste. Energies, vol. 14, 2021. 7654. https://doi.org/10.3390/en14227654

[2] Espeso J., Isaza A., Lee J.Y., Sörensen P.M., Jurado P., Avena-Bustillos R.D.J., Olaizola, M.; Arboleya, J.C. Olive Leaf Waste Management. Frontiers in Sustainable Food Systetms, vol. 5, 2021, 162. https://doi.org/10.3389/fsufs.2021.660582

[3] INSTAT., Agriculture Statistical Yearbook, 2020. Source of information Ministry of Agriculture and Rural Development, 2020. http://instat.gov.al/media/3658/statistical-yearbook-2020.pdf

[4] Topi D., Guclu G., Kelbek H., Selli S., Olive Oil Production in Albania, Chemical Characterization, and Authenticity. In: Olive Oil-New Perspectives and Applications, Ed. M. Akram. 2022. http://doi. 0.5772/intechopen.96861

[5] MoEI/KBN., National Action Plan for Renewable Energy Resources in Albania 2015-2020. Approved in January 2016

[6] ECN., ECN Status report 2019 – European Bio-waste Management: Overview of Bio-waste Collection, Treatment & Markets across Europe, 2019. (https://www.compostnetwork.info/policy/biowaste-in-europe/)

[7] Karaj A., Rehl T., Müller J., Analysis of biomass residues potential for electrical energy generation in Albania. Renewable and Sustainable Energy Reviews, vol. 14, 2010, pp: 493–499. http:// doi:10.1016/j.rser.2009.07.026

[8] Caputo A., Scacchia F., Pelagagge P., Disposal of by-products on olive oil industry: waste-to-energy solutions. Applied Thermal Engineering, vol. 23(2), 2003, pp: 197–214.

[9] Kuiper L., Sikkema R., Stolp J., Establishment needs for short rotation forestry in the EU to meet the goals of the commission's White Paper on renewable energy. Biomass Bioenergy, Vol. 15(6), 1998, pp: 451–6. http://doi: 10.1016/S0961-9534(98)00058-0

[10] Boateng A., Walawender W., Fan L., Chee C., Fluidized-bed steam gasification of rice hull. Bioresources Technology, vol.40, 1992, pp: 235–249.

[11] Malaspina F., Cellamare M., Stante L., Tilche, A., Anaerobic treatment of cheese whey with a downflow-upflow hybrid reactor. Bioresources Technology, vol. 55, 1996, pp: 131–139.

[12] Mussatto S., Dragone G., Roberto I., Brewers' spent grain: generation, characteristics and potential applications. Journal of Cereal Sciences, vol. 43(1), 2006, pp: 1–14. https://doi.org/10.1016/j.jcs..06.001

[13] Klass DL.. Waste biomass resource abundance, energy potential, and availability. Biomass for Renewable Energy Fuels and Chemicals, vol.23, 1998, pp: 137–158.

ISSN: 2456-1851

Volume: 07, Issue: 02 "March-April 2022"

[14] Celma A., Rojas S., López Rodríguez F., Waste-to-energy possibilities for industrial olive and grape by-products in Extremadura. Biomass Bio-energy, vol. 31(7), 2007, pp: 522–534. https://doi.org/10.1016/j.biombioe.2006.08.007

[15] Gómez A., Zubizarreta J., Rodrigues M., Dopazo C., Fueyo N., An estimation of the energy potential of agro-industrial residues in Spain. Resources, Conservation and Recycling, vol, 54, 2010, pp: 972–984. http://dx.doi.org/10.1016/j.resconrec.2010.02.004

[16] MoEI/AKBN., National Strategy of Energy Tirana, 2003, pp. 136.

[17] MoEI., The National Strategy of Energy and Plan of Action Tirana, June 2003 (updated on April 2005)

[18] MoEI., Strategy of Non-Food Industry, 2005b.

[19] MoEI/AKBN., Updated Draft Strategy Energy (August 2009)

[20] MoEI/AKBN., Albanian Government Energy EU Integration Questionnaire (approved March 2010)

[21] MoEI/AKBN., National Energy Efficiency Action Plan (approved in September 2011)

[22] MoE & UNEP., National Action Plan to Phase-out Ozone Depleting Substances, 2003-2010, 2003.

[23] IDAE., Spanish Renewable Energy Plan 2005–2010. Tech. rep., Institute for Diversification and Saving of Energy, 2005. See also: http://www.idae.es/

[24] Albania ANFIGo., Management Unit of the Forestry Project. Ministry of Agriculture & Food: Tirane, 2004.

[25] Bossel U., Well-to-wheel studies, heating values, and the energy conservation principle. European Fuel Cell Forum, 2003.

