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A PROPOSAL FOR SPENT GRAPE MARC EXPLOITATION IN ROMANIA

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The aim of this paper is to find out the opportunities of spent grape marc utilization in Romania as a potential source of renewable energy.

In this paper different scenarios such as centralized and decentralized power plants are being analyzed, underlining the advantage and disadvantage of each solution. In particular this work focuses on electricity production and thermal energy recovery. Additionally the opportunity of the reutilization of spent grape marc for the food and the feed market has been considered, taking into account the separation of grape seeds for oil extraction and of grape skins for cattle feeding.

Keywords: grape marc, combustion, by-product separation, bio-drying.

1. Introduction

In Romania there are 8 wine regions, with a total of 37 vineyards and 171 centers vines.

In Romania, vine is cultivated in specific areas dedicated to viticulture, usually located on hills. Among the 14,700,000 hectares of agricultural surface, 189,000 hectares are cultivated with vines (1.3%).

Grapes production fluctuated in the period 2001-2007. The maximum level of yield is 5991 kilograms per hectare in 2004, and the minimum one is 2603 kilograms per hectare in 2005 (Table 1).

Table 1

Yields of grapes in Romania, in the period 2001-2006

Specification	001	002	003	004	005	006	007
Total bearing vineyards (kilograms/hectare)	568	414	591	991	603	015	561

In 2007, the grapes production decreased by 3.4%, and the yields decreased by 2.4% compared to 2006, which was considered a normal year for grape production [National Institute of Statistics, 2008]. By utilizing 1 kilogram

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of grapes, about 0.8 liters of wine are produced and the solid leftover - grape marc - is about 0.2 kg.

Total production of grapes may be analyzed taking into account the areas cultivated with vineyards and the grape yields. This production is presented in Figure 1.

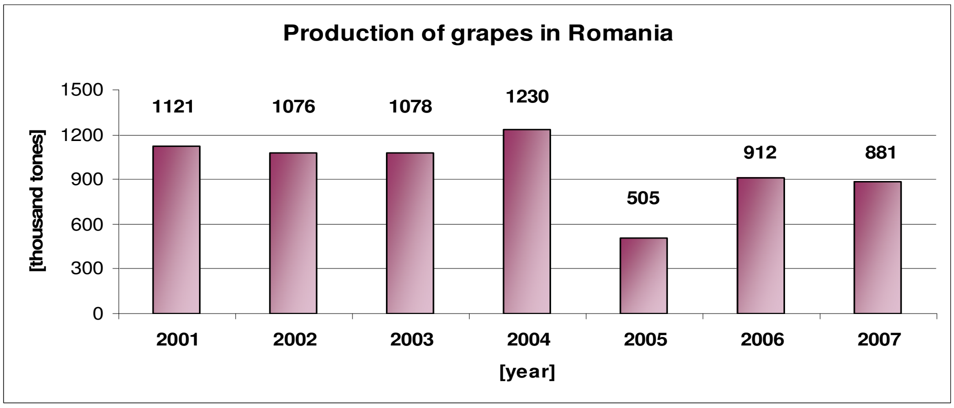

Fig.1. Production of grapes in Romania

In Romania there is no plant using grape marc to produce electrical and thermal energy.

The exploitation scenarios we have analyzed are the following:

1. A process intended to separate the grape marc constituents (skins, seeds and stalks).
2. A combustion process for centralized energy production (electrical and thermal power).
3. A combustion process for decentralized energy production.
4. The combination of bio-drying and combustion process.

The drying of the grape marc is a necessary step before its utilization in a combustor. In the first three scenarios thermal drying is considered and in the fourth one the method used is bio-drying [1].

2. Methods

2.1 By-product recovery process

The first scenario presents the separation of by-products mechanically for reuse, after the drying process, which is sustained by the combustion of a fraction of the material [2].

Considering the case of Romania in 2007, about 880 thousand tons of grapes were produced. Estimating that the quantity of grape pomace is about 20%

of the total volume of grapes processed, it results that Romania produced 170 thousand tons of grape pomace. This grape marc is mainly used by the distillation industry to produce alcohol and alcoholic drinks and significant proportion of the by-product remains in the form of exhausted marc. Because of the above, the amount of grape marc (exhausted and, eventually, fresh) has been estimated in170 thousand tons.

Representative values for grape marc composition are the following: 46% skins, 52% seeds and 2% stalks (dry basis). These values represent the average of measures we performed. The moisture value of the grape marc has been let equal to 60%, value resulting from experimental findings. The grape marc heating value (HHV=21.8 MJ/kg_{dry}) has been obtained by literature.

Scenario 1 starts with the dumping of the wet exhausted grape pomace in a mixing dryer (air and solid) able to reduce the moisture from 60% to 8%. The dried marc then passes through a vibrating screen with an estimated efficiency of 90%. The remaining undifferentiated material is then returned to the screen for rescreening. The process separates the ingoing material into skins, stalks and seeds.

Then the grape seeds could be sent to the market (at €70/ton), while the stalks and a proportion of the skins are sent to burn in the combustor. The remaining skin fraction could be sold to the cattle feed industry (at €40/ton) [3].

2.2 Combustion process for centralized energy production

In the following section the possible solution which is discussed, is a single centralized power plant, which will use the whole amount of spent grape marc from distilleries all over the country.

Combined heat and power generation can increase the efficiency of biomass exploitation to more than 80%. That means lower costs and lower pollution emissions then separated-energy production [4], [5].

The sitting and size of a cogeneration plant must take into consideration the availability of potential heat users, the distance of the plant from the end-user, the possibility and modality of connecting to the electrical grid, the visual impact, and the availability of biomass and the economic and social needs of the area.

We considered a back-pressure steam cycle, which is useful for example for a continuous distillation process that needs constant heat production [6].

Back-pressure steam turbines are often used connected to industrial processes where there is a need for low or medium steam pressure. High pressure steam enters the back-pressure steam turbine and, as the steam expands, a part of its thermal energy is converted into mechanical energy. The mechanical energy is used to run an electric generator or mechanical equipment, such as pumps, fans, compressors, etc. The outlet steam leaves the back-pressure steam turbine at "overpressure" and then the steam is returned to the plant for steam-process applications such as heating or drying.

We have assumed the combustion occurred in a fixed-grid combustor, at a temperature of about 1000°C. With an ingoing grape-pomace stream of 21.25 t/h (for 8000 h/y), it would be possible to obtain about 30.2 MW of thermal energy. About 4% of that would be wasted in unburned material and combustion residues. Another 1.5% would be wasted in heat losses in different parts of the plant. The recoverable heat would be that in the smoke, so we evaluated the unusable enthalpy of the outgoing smoke, about 12.5%.

The useful thermal power for the thermodynamic cycle would be equal to about 24.7 MW. Considering leaks in the electro-mechanical auxiliaries, equal to about 1% of the total power available at the beginning, we obtain 19.6 MW at the turbine outlet (65% of the initial power). The turbine connected to an alternator, would be able to generate 4.2 MW of electricity (14% of the initial power) [7].

2.3 Combustion process for decentralized energy production

The following possible solution which is discussed is that of a number of decentralized power plants, each one placed nearby each main vineyard in Romania.

The scheme, conditions and calculations are analogues to the ones relevant to the previous scenario, only that in this case the quantity of incoming grape marc for each plant is smaller. Therefore the size of the plant will be smaller, and also the quantity of produced energy. Among the advantages of this type of decentralized energy production, the most important one is the reduced cost for transportation, due to the small distance between the vineyard and the plant.

For sake of conciseness, we exemplify this type of scenario for a single wine-growing area of Romania. Hence it was chosen the biggest producer of winemaking products in Romania, which is located in the south-eastern part of the country, called Dobrogea, a perfect area in terms of climate and soil for growing grapes.

This producer is called Murfatlar and it is the largest grower of grapes in Romania, which manages an area of 3,000 hectares of vines. In 2008 the grape harvest was over 30,000 tons and the quantity of wine was about 21 million liters. Hence the grape marc quantity will be estimated at 7,000 tons, with a moisture content of 60%.

With an ingoing grape-pomace stream of 0.9 t/h (for 8000 h/y), it would be possible to obtain about 1.23 MW of thermal energy. Considering similar energy losses as for the previous scenario, we obtain 0.8 MW of thermal power at the turbine outlet. The turbine would be able to generate 0.17 MW of electricity corresponding to 1.36 GWh in one year.

2.4 Bio-drying and combustion process

Considering that grape marc presents a high percentage of moisture (about 60%), a pre-drying treatment results necessary before its utilization in combustion plants.

For this reason a new and innovative drying technique to treat grape marc was studied and applied at the University of Trento.

The selected process was the bio-drying. This process was chosen for giving an alternative to the typical grape marc drying approach (thermal drying usually performed in the same site of combustion, in order to exploit the heat of off-gas, how we presented in the first two scenarios).

Bio-drying is an aerobic bioconversion treatment, which is applied generally to Municipal Solid Waste (MSW) with high content of organic fraction. The aim of bio-drying is to generate a material with high lower heating value (LHV) that, after inert separation, can be converted into Refuse Derived Fuel (RDF), suitable for thermal processes in authorized plants.

During the bio-drying process, aeration into the waste mass is adopted. The aim of this aerobic process is the exploitation of the exothermic reactions for the evaporation of the highest part of the water present in the waste, with the lowest conversion of organic carbon.

Taking into account the whole amount of grape marc produced in Romania (170 thousand tons), it was established to have three installations for bio-drying, placed in different regions of the country, close to the wine making regions for limiting the transportation costs. The aim of the process is increasing the low heating value of the grape marc, by decreasing its moisture content and, contemporary, the amount of volatile solids. The bio-drying process is considered lasting 3 weeks. For this specific period of time, the energy consumed for each kilogram of grape marc is 52.5 kWh/t.

After the bio-drying process the remaining grape marc has a higher LHV and a smaller water content (48%), hence we will have a lower cost for transportation and for the initial investment for the plant, because the thermal drying won't be needed or, at least, shortened.

The amount of grape marc (with a moisture content of 60%) entering the bio-drying system is 56.6 thousand tons. The amount of grape marc exiting the bio-drying system (with a moisture content of 48%) results to be 43.5 thousand tons.

The bio-dried grape marc is transported to the cogeneration plant. From this quantity, at a working program of the plant for 8000 h/year, 10.65 MW of thermal power will be obtained. We have to consider the energy necessary for the bio-drying process, 0.8 MW for the whole amount of grape marc entering the process. Hence the net quantity of thermal power produced is 9.85 MW.

The power plant considered resembles to ones already utilized for developing the previous scenario. The useful thermal power for the thermodynamic cycle would be equal to about 8.08 MW. We obtain 6.4 MW at the turbine outlet. The turbine connected to an alternator would be able to generate 1.3 MW of electricity.

Taking into account the stream from also the other two bio-drying plants, the power at the turbine outlet will be equal to 19.2 MW and the generated electricity equal to 3.9 MW. This kind of installation will produce 31.2 GWh of electricity every year.

3. Results

For the previous four scenarios, presented in this paper, it was proposed the following basic economic analysis, which considers the investment costs and the gross return for each system.

3.1 By-product recovery process

We estimated the investment costs and the income from the sale of grape seeds and stalks resulting from the process. Considering a biomass combustor, a vibrating screen and a drying system, the investment cost will be of about 7,150,000 €. The gross return has been calculated equal to 3,500,000 €/year.

3.2 Combustion process for centralized energy production

To calculate the investment costs, we assumed that the cogeneration plant with the designed capacity would cost about 23 million euro. As regarding the thermal drying system, it was considered at 30 €/ton entering the dryer, so the cost of a thermal dryer would be at about 5,100,000 €. The total cost of the plant is about 28 million euro. Beside this cost we have to take into account an additional cost that depends on the initial capital, on an interest rate period and on the duration of operation, expressed in number of years.

Doing a simple calculation, the final capital cost is about 47,800,000 euro. To this capital it would be added also the operational costs (OC). We estimated the final investment costs for this solution at about 48,000,000 euro, including a biomass steam boiler, heat exchangers, smoke cleaning systems, a turbo–alternator group, and control systems, yearly costs covering staff salaries, maintenance and debt servicing.

A yearly profit would be assured by the sale of electrical and thermal power. Only the sale of electrical power and green-certificates, which are energy bonds with certificate renewable energy, were evaluated. The annual production would be equal to 33.6 GWh. By selling the electricity at a price of 0.125 €/KWh and the sale of the green-certificates at a price of 40 €/MWh, it would gross about 5,544,000 €/year.

3.3 Combustion process for decentralized energy production

This system does is not advantageous form an economic point of view, because the quantity of electrical energy produced is lower than 1 MW, which is the minimum value for a proper operating of the turbine [8]. So a possible solution of this scenario it will be a bigger plant, using grape marc from many more important regions, than only from the Murfatlar vineyards.

3.4 Bio-drying and combustion process

From the economic point of view, by selling the electrical energy for a price of 0.125 €/kWh and the price for green certificates in Romania considered 40 €/MWh, it would gross about 5,140,000 €/year.

For the investment cost we estimated that the cost for the bio-dying system is about 25 €/ton_{in}, meaning that the three systems placed in the country will cost about 4,250,000 €. Adding the cost for the cogeneration plant, the initial cost will be 26,500,000 €. Taking into account the accrued interest and the operational costs, the final capital will be about 55,000,000 €. The calculations were made analogous to the second scenario for the centralized energy production.

4. Conclusions

The purpose of this work was to analyze some opportunities for the exploitation of the spent grape marc produced in Romania. We have considered four scenarios from an energetic and economic point of view.

In the first scenario the method used for the drying of the grape marc was thermal drying, followed by a separation of the grape marc constituents: seeds, skins and stalks. This scenario sounds very promising, because according to the new laws in Romania, the grape pomace must be valorized in different industries. The grape seed oil industry is an industry extending in our country, hence the market for selling grape seeds is also a good market, obtaining favorable prices for this by-product. The grape seeds are also very used in cosmetics industries, because of their benefits for the skin and body. The investment was assumed to be 7,150,000 € and considering the gross return of 3,500,000 €/year, that means in 2 years the investment will be covered (for 6000 h/year of functioning).

The second scenario uses the same method for drying the grape marc, thermal drying. This kind of plant will process the whole amount of grape marc produced in the country (170 thousand tons) and will generate a large amount of electricity, 33.6 GWe in one year. For 8000 h/year as we assumed at the beginning of the analysis, we can affirm that the investment cost will be covered in about 9 years.

The third scenario analyzed is analogous to the second one; the only difference is in the quantity which enters the plant. We considered for this scenario a decentralized energy production, many smaller plants placed near the wine-production regions. The results observed were that a smaller plant means a lower cost for the investment, but also a lower production of energy. A big advantage of the decentralized energy production is the lower cost for transportation. The minimum value for a proper operating of a turbine is at least 1 MW, so this scenario is not advantageous for our country, only if it is applied not for one region (Dobrogea), but for two or three regions, which will produce obviously a bigger quantity of grape marc, hence a bigger energy at the turbine outlet.

The last scenario is based on the bio-drying process. The advantages of this process are the following: bio-drying could be performed at small scale where grape marc is produced, the transportation costs decrease thanks to the mass loss obtained by bio-drying, the management of the drying process doesn't affect the management of the combustor as the two stages are uncoupled, the area necessary for the construction of the centralized burner is smaller as no space is needed for an integrated thermal drying and the centralized combustor could be in reality a plant aimed to receiving many kinds of fuels/waste. The investment of the system is about 55,000,000 € and the gross return for about 5,140,000 €/year. So the investment will be covered in more than 10 years.

The conclusion of this research is that for by-product separation it will be a viable solution for Romania, but also for energy production, the centralized and the bio-drying processes look very promising. It is important to realize that Romania has a valuable source of this biomass, grape marc, and indifferently of the method there are possibilities to exploit it.

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