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Industrial Symbiosis: anaerobic digestion of waste products as mitigation strategy

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Riassunto
La simbiosi industriale è una strategia aziendale con la quale è possibile aumentare la sostenibilità dei processi produttivi. La partnership tra un'azienda vinicola e una società energetica ha consentito un'innovazione di processo che consente il riutilizzo dei rifiuti alimentari dalla produzione del vino. L'azienda vinicola produce 5.200.000 tonnellate di uva. Con un biodigestore è possibile reinserire nel ciclo produttivo circa 220.000 tonnellate di rifiuti alimentari, composti da: rifiuti vegetali, trucioli di legno e rifiuti da potatura. Il riutilizzo degli scarti di produzione genera 105.000 MWh di calore e 81.000 MWh di energia elettrica, con un risparmio di 35.000 tonnellate di CO_2. I risultati ottenuti possono essere ottenuti dalle aziende alimentari che richiedono un elevato fabbisogno energetico e che producono notevoli quantità di rifiuti organici.

Summary
Industrial symbiosis is a business strategy through which it is possible increase the sustainability of production processes. The partnership between a winery and an energy company has enabled the implementation of a production innovation that allows the upgrading by food waste from wine production. The winery produces 5,200,000 tons of grapes. Through the creation of a biodigester it is possible to re-enter in the production cycle about 220,000 tons of food waste, consisting of: vegetable waste, wood chips and waste from pruning. The reuse of production waste can generate 105,000 MWh of heat and 81,000 MWh of electrical energy, allowing savings of 35,000 tons of CO_2. The results obtained could be reached by food manufacturers that require a high energy needs and that produce significant amounts of organic waste.

1. Introduction

The focus on sustainability has become a strategic factor for the development of industrial sustainability, aiming at achieving a particular economic goal with less negative impacts on environmental and social issues [1]. Industrial symbiosis allows implementation of corporate sustainability by the closure of material and energy flows from plants [2]. With the industrial symbiosis it is possible to achieve economic and environmental benefits through industrial synergies [3].

The need to reduce the consumption of fossil fuels and greenhouse gas emissions, has prompted companies to look for alternative ways of production [4]. Green economy in the context of the Common Agricultural Policy (CAP) highlights the priority to mitigate the deterioration of the environment and the development of renewable energy as the main challenges for the agricultural sector. In this sense it is necessary to implement systems which derive energy from waste and improve the profitability of farmers [5]. In the Italian context, biogas production is estimated about 20 Twh in 2015 [6], derived from agricultural biomass, is becoming an attractive sector for companies that are trying to diversify their source of income. In fact, the generation of electricity produced through anaerobic digestion of biomass is also backed by strong public support. The mass of waste resulting from the wine production is estimated at 4.23% [7]. The waste is made of grapes, stems, pressing wines, lees and irrigation mud. The waste by-products often represent a cost for manufacturing enterprises and an difficult environmental problem. The aim of this study is to evaluate the environmental benefits by anaerobic digestion of wine production waste.

2. Methods

The figure 1 describes the production process for biogas fermentation using continuous stirred tank reactor (CSTR). The fermentation process is a mesophilic type.

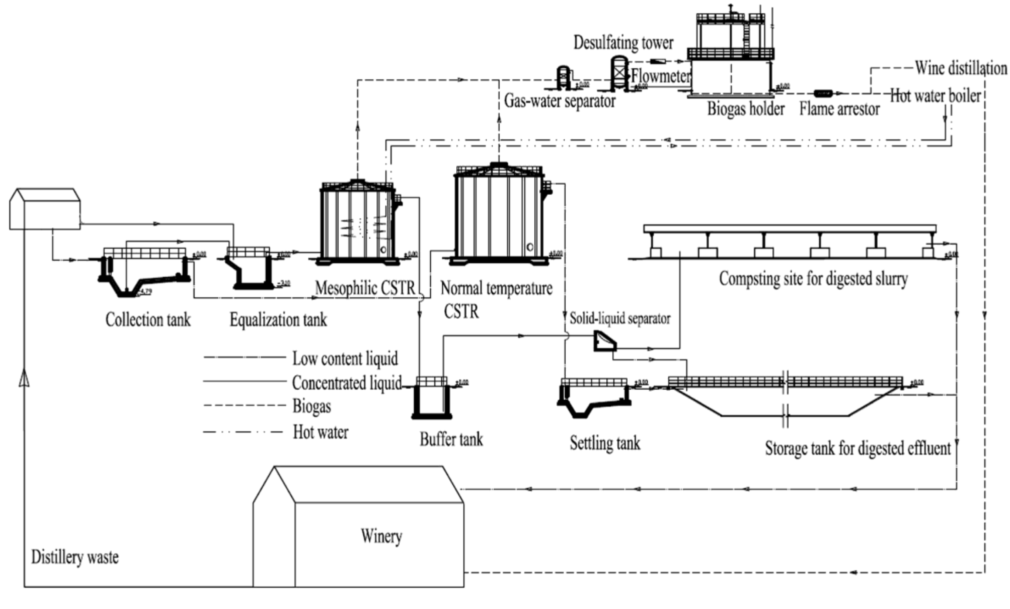

Fig. 1 – *The process flowchart of the biogas plant.*

The fermentation takes place in large tanks of 500 m^3 and the fermentation temperature is kept around 35 ° C with recycled hot water. About 80 tonnes of waste water and part of the biogas produced by the anaerobic digester are used to power the wine distillation process or for heating the boiler.

Most of the waste to be composted are derived from a winery in northern Italy [8]. The winery has embarked on a partnership with an energy company, with which it works in symbiosis. The energy company produces biogas resulting from the waste processing of the wineries. The energy requirements of the winery is totally satisfied by the production of electricity resulting from the biodigester.

In Table 1, the energy requirements are listed.

Equipment	Electricity Consumption (KWh)
Screw pump for mesophili CSTR	12.946.500
Recycle stirring pump	12.946.500
Hot water recycle pump	3.528.000
Submerged pumps	37.663.500
Overhead stirrer	17.650.500
Submerged mixer for equalization tank	7.056.000
Solid liquid separator	12.946.500
Illumination	262.500

Tab. 1 – *Main electric equipment used in the biogas plant and power consumption.*

2.1. Energy balance

To calculate the energy balance, energy and biogas have been converted into electricity (kwh). The total production of 5,200,000 tons of grapes produces 220,000 tonnes of waste that are destined to the biodigester. Through the anaerobic digestion process the energy company can produce 105,000,000 kwh of biogas and 81 million kwh of electric energy. The use of renewable fuels allows an annual saving of about 35,000 tons of CO_2. The energy produced satisfy the energy needs of the winery that produces food waste.

2.2. Economic Analysis

An economic analysis was conducted for the biogas plant. The biodigestion plant was built in 2009 and has an estimated life span of 20 years. The installation cost was 1,250,000 €. The annual revenue is calculated by adding up the sale of energy produced and the savings resulting from the production of energy from the biodigester. The annual costs include the cost of labor and equipment maintenance fee. The annual income is calculated from the difference between the annual operating costs and revenues. The payback period has been identified by dividing the costs for the installation of the biodigester and annual income (1).

$$Payback\ period = \frac{investment\ cost}{annual\ income} \qquad (1)$$

Net present value (NPV) is calculated as shown in equation (2).

$$\text{NPV} = -C0 + \sum_{i=1}^{n} \frac{C1}{(1+r)^i} \qquad (2)$$

- C0: installation cost of biodigester
- C1: annual income
- *r*: rate of interest
- *n*: number of years
- *i*: discount factor at time

Table 2 shows how the payback period and npv returns positive results. Domestic production of electricity and biogas saves in a year: 3.726 € million from electricity costs and 2,195, 545.54 € from gas costs.

Type	Value
Installation cost	1.250.000,00 €
Annual income	5.921.545,54 €
Annual costs or equipment maintenance	4.830.000,00 €
Payback period (months)	2,56
Net present value	5.529.082,99 €

Tab. 2 – *Economic analysis of the biogas plant.*

As a source of renewable energy, biogas and other renewable energy, not only bring environmental benefits but can be economically competitive in order to attract new investments.
The most important benefit resulting from the anaerobic digestion is the production of biogas, which can be used to generate electricity or heat as a renewable energy source. The use of renewable energy sources has a positive impact on environment [9]. Even if the production of renewable energy may have higher costs for the production of heat or electricity [10].
It is a great challenge for the future conduct business strategies and bioenergy projects in a sustainable manner.

3. Conclusions

This study can be concluded observing how the production of thermal energy generated through the anaerobic digestion process satisfies the energy needs of the wine factory. Overall, the main role of the biogas plant has been the treatment and reuse of waste, saving energy sources for future generations, and the circular economy implementation.
Economic analysis has shown that a more sustainable production involves a greater economic effort for initial investments but the effects in the long run are beneficial to the environment, the economy and society.

References

1) **Boons F., Baas L.,** "*Industrial symbiosis in a social science perspective*" Discussion Proposal for the Third Industrial Symbiosis Research Symposium, Birmingham, UK (2006).
2) **Dong L., Gu F., Fujita T.,** *"Uncovering opportunity of low-carbon city promotion with industrial system innovation: Case study on industrial symbiosis projects in China"* Energy Policy 65, 388–397, (2014).
3) **Desrochers, P.,** "*Industrial symbiosis: the case for market coordination*"
Journal of Cleaner Production 12, 1099–1110, (2004).
4) **Bacenetti J., Fiala M.,** *"Carbon footprint of electricity from anaerobic digestion plants in Italy"* Environmental Engineering and Management Journal, 14, 1495-1502, (2015).
5) **Jacobsen, N.B.,** *"Industrial symbiosis in Kalundborg, Denmark: a quantitative assessment of economic and environmental aspects"* Journal of Industry Ecology 10, 239–255, (2006).
6) Legambiente, "*Comuni rinnovabili*", (2016)
7) **Manzonea M., Paravidinob E., Bonifacinob G., Balsaria P.,** *"Biomass availability and quality produced by vineyard management during a period of 15 years"* Renewable EnergyVolume 99, 465–471, (2016).
8) Patrizio P., Chinese D., *"The impact of regional factors and new bio-methane incentive schemes on the structure, profitability and CO2 balance of biogas plants in Italy"* Renewable Energy, 99, 573–58, (2016).
9) **Pearce, J.M.,** *"Industrial symbiosis of very large-scale photovoltaic manufacturing"* Renewable Energy 33, 1101–1108, (2008).
10) **Sokka, L., Lehtoranta, S., Nissinen, A., Melanen, M.,** "*Analyzing the environmental benefits of industrial symbiosis*" Journal of Industry Ecology 15, 137–155, (2011).