ARTICLE IN PRESS

Land Use Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

A methodological approach for assessing business investments in renewable resources from a circular economy perspective

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ARTICLE INFO

Keywords:
Biogas technology
Circular economy
Ecosystems
Renewable resources

ABSTRACT

In this paper, we have analyzed a feasibility project for the realization of a biogas plant at a company in the viticulture sector located in south-central Sicily. Using engineering formulas, we identified the electrical power that the plant could produce using waste products created by the vineyard itself, examined the new and interesting opportunities that have arisen with the encouragement and development of biogas production in Italy, and then assessed the economic feasibility of the investment itself, considering an investment scheme of total capital self-financing.

The possibility of using wastes from wine production comes from an in-depth study of the circular economy, that is, an economic system designed to regenerate on its own; indeed, in the circular economy, every waste product becomes a resource, and some resources can be taken from one production scheme and used in another without being discarded.

The concept of circular economy is based on the ability to recover onsite resources that are still circulating (overproduction, waste) instead of importing them from the outside. Recovering these substances creates sustainable agriculture, preserves soil fertility thanks to reconstructed biodiversity, and also helps locate proper uses for refuse and organic waste products.

1. Introduction

At a time of increasing interest in protecting the environment, the economic crisis, together with a scarcity of resources, has made it increasingly necessary to invent new production models which go beyond the traditional linear model of “production > consumption > disposal” and instead move toward circular models of “production > consumption > recycling > reuse”, or toward the so-called circular economy (Donia et al. 2017; Paolotti et al., 2016; Lacy et al., 2016). The term circular economy indicates an economic system designed to regenerate on its own; in particular, a circular economy is an industrial economy that is conceptually regenerative and reproduces nature by improving and actively optimizing its operating systems (Federico, 2015).

Thus, the principle of the circular economy is founded on the idea of reconstruction, and it can be seen as an alternative to the linear economy which is characterized by overproduction and waste. In circular economic systems, products maintain their added value for as long as possible, and there is no waste; indeed, each waste product becomes a resource, and some resources can be taken from one production scheme and used in another without being discarded (Iraldo and Bruschi, 2014).

Applying the principal of the circular economy to agriculture is a very important contemporary issue on the international political and economic agenda. Considering that, by 2050, the world’s population will reach nearly 10 billion people, raw materials will be increasingly scarce, and the planet will be increasingly overcrowded (Ehrlich and Harte, 2015). FAO projections indicate that, by 2050, agricultural production must increase by 70% across the globe, and by nearly 100% in developing countries, solely in order to satisfy the demand for food (FAO, 2009).

Due to modern intensive agriculture, the lack of nutrients in the soil is replaced by chemical fertilizers, thus promoting the loss of organic matter in the soil. This, in turn, results in erosion, making the soil increasingly fragile and facilitating increasingly widespread flooding and landslides. Each year, 24 billion tons of soil are lost to erosion (UNEP, 2007).

An agricultural system conceptualized in this way is not sustainable and is destined to collapse, especially under growing demographic pressure. A response to these problems could come from circular

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https://doi.org/10.1016/j.landusepol.2018.03.017
Received 19 January 2018; Received in revised form 5 March 2018; Accepted 6 March 2018
0264-8377/

Please cite this article as: Donia, E., Land Use Policy (2018), https://doi.org/10.1016/j.landusepol.2018.03.017

agriculture, through the possibility of recovering the resources taken out of the land but still in circulation (waste products) instead of importing them from abroad. The remaining resources available are wastes resulting from agri-food industries, civil waste and manure, exclusively organic substances resulting from the processing and consumption of agricultural products. Recovering these substances creates sustainable agriculture, preserves soil fertility through a reconstructed biodiversity, and also helps find appropriate uses for refuse and organic wastes.

Currently, the principal source (80% of the total) of greenhouse gas (GHG) emissions is energy production (EEA, 2008). The production and use of renewable energy resources can contribute to the mitigation of climate change, reduce dependence on fossil fuels, and diversify the productive activities of our societies (Cherubini and Strømman, 2011). Since around 1970, biomass crops have generated increasing interest in Europe (Valenti et al., 2017; Selvaggi et al., 2017; Manetto et al., 2016; Messineo et al., 2012). In terms of future energy supplies, biomass is seen as a solution that can satisfy a significant portion of their energy needs, thus reducing the production of carbon dioxide (CO_2) (Ragauskas et al., 2006;Hanegraaf and Biewinga, 1998).

The amount of organic waste produced in EU countries comes to approximately 2.5 billion tons annually, of which about 40% is made up of livestock effluents and agricultural residues, with the remainder being urban and industrial organic waste, sewage sludge, and forest lignocellulosic waste. The country in which anaerobic digestion has advanced the most in recent years is Germany, in particular in the livestock sector (Piccinini et al., 2004).

Nearly 72% of existing biogas plants are located on farms that use agricultural wastes, fertilizers, and energy crops. Biogas, as a renewable energy source, has the advantage of being in line with two aspects of the European Union's energy policy. Indeed, it runs parallel to the main objective of the Renewable Energy Directive (2009/28/EC) which, by 2020, aims to reach 20% of total energy production from renewable sources. At the same time, biogas technology meets the objectives of organic waste management through which the European Union requires Member States to reduce the amount of biodegradable waste deposited in landfills (1999/31/EC). The use of biomass, including biodegradable waste, as a basis for obtaining energy has so interested European countries that the biogas industry is receiving a strong boost, especially from the financial point of view, with incentives to build new plants as well as very favorable electrical rates. This is why Europe has been experiencing a very significant biogas growth trend, especially during the last decade. The boom in this technology, and the consequent growth of electricity produced by it, is largely due to development in the agricultural sector where methanization is increasingly based on energy crops. Again, the nation at the forefront with regard to the development of this technology, and which is pushing the rest of the industry, is certainly Germany, where most of the plant manufacturers are concentrated. However, in recent years, countries such as Italy have experienced an evolution in the biogas industry with a growing number of manufacturing companies and a constantly evolving market; in fact, in 2015, there were an estimated 1924 biogas plants in Italy, for a total capacity of 1406 MW (GSE, 2015).

In this paper, considering the new and interesting opportunities for the promotion and development of biogas production in Italy, we present a case study, analyzing a feasibility project for the realization of a biogas plant at a company in the viticulture sector located in south-central Sicily; through the use of engineering formulas, we identify the electrical power that the plant could produce using viticultural waste products created by the vineyard itself. Subsequently, the economic feasibility of the investment is assessed by considering an investment scheme of complete capital self-financing. This study, based on a real plant built in Sicily in 2012, forms a theoretical model aimed at supporting business choices in rural areas where growth and development are essential conditions for people remaining in the area. Our work, considering the total self-financing of capital, highlights how it can be possible to overcome the fragmentation of Italian agriculture (formed by an overwhelming majority of small companies), creating the conditions of "critical mass" which can, from the point of economic view, justify investments. Finally, the study shows that, despite an absence of public contributions, conditions can be created for competitiveness in local businesses.

2. Material and methods

Biogas production technology, which enables us to exploit renewable energy, stabilize biomasses, and control GHG emissions, has allowed the development of different agricultural and agri-industrial biomasses; the latter include fresh grape pomace which, though an enormous potential resource, is problematic to dispose of due to bureaucratic procedures.

As a case study, we have chosen a wine producer in Sicily operating on 1500 ha and producing 80,000 hl/year of wine. From data communicated by the company, in 2015 it consumed 962,683 kW h of electricity, at a cost of € 200,268.05. It also consumed 2102 m^3 of natural gas, at a cost of € 15,000.

In this work, we wanted to design the scale of the plant so that it would use only the byproducts of the winery, enhancing the business first from the point of view of energy, and then economically, transforming the already-present waste products into opportunities for profit and efficiency. The plant, once built, would be powered by byproducts of biological origin. Biogas is obtained from biomass through an anaerobic digestion process that takes place in the absence of oxygen within a fermenter. Biogas is a fuel for an internal combustion engine, which ultimately drives an electric generator. We should not forget that such an operation would bring benefits to the company, which could be considered to be a "green" company looking to the world of the "green economy" and would be able to pursue further energy certifications.

For calculating the size of a biogas plant, the starting point is the feed matrix, in particular the type of products/byproducts available and their quantity (tons/year). Once these data have been defined, the size of the plant can be calculated; indeed, based on the biogas yields of the various feed substrates, the amount of biogas producible in the digester over the period of one year can be determined. In Table 1, the yearly quantities of waste products produced by the vineyard are reported. To guarantee optimal fermentation and a high level of biogas production, the biomasses must be broken down into pieces of approximately 10 mm in size.

The biogas yields of the different waste products are 180 $m^3\,t^{-1}$ for pomace, 150 $m^3\,t^{-1}$ for stalks, and 150 $m^3\,t^{-1}$ for lees (Ragazzoni and Banzato, 2014; Pirazzoli and Ragazzoni, 2013), with a percentage yield of CH4 of 55%, 53%, and 54%, respectively. Thus the total biogas produced in a year from a biomass (t t.q.) was calculated, multiplying it by its biogas yield ($m^3\,t^{-1}$) to arrive at the total amount of CH_4 produced by means of the percentage yield of CH_4 for the biomass.

Calculating the amount of biogas generated in a year, it is possible to obtain the electrical and thermal energy produced annually by the plant. Initially, the average percentage of CH_4 produced by the plant was calculated (1):

$$\text{average } \%\ CH_4 = CH_4 \text{ produced/biogas produced} \times 100 \qquad (1)$$

Table 1
Yearly quantities of waste products produced by the vineyard.

Biomass	Quantity (t/year)	Dry matter (%)
Pomace	1,400	42.0%
Stalks	600	50.0%
Lees	400	38.0%
TOTAL	3,400	

Source: our analysis of the gathered data.