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Attitude survey of wine sector toward renewables for reducing GHG

Nieves García-Casarejos^{a,*}, Pilar Gargallo^a, Javier Carroquino^b

^aFaculty of Economic and Business, Universidad de Zaragoza, Zaragoza 50005, Spain

^bIntergia Energia Sostenible S.L., Zaragoza 50014, Spain

Abstract

The objective of this paper is to discover through a survey, the Spanish wine sector's attitude towards incorporating renewables. To that end, the multivariate statistical technique of factor analysis is applied to the information provided by a sample of 87 wineries stratified by Spanish regions. This resulted in a set of four indicators describing the determinant factors (Cost, Conviction, Motivation and Investment) influencing a winery's decision to implement renewable energies. Furthermore, a cluster analysis resulted in three groups of completely different wineries. The first contains a 25.3% of the wineries, which are not concerned about environmental issues. The second comprises a 26.7% of the wineries, which are dissuaded from adopting renewables as they perceive a high investment is necessary. The third group involves a 48% of wineries, which are committed to renewables because they are absolutely convinced of their benefits.

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1. Introduction

The negative effects of climate change are predicted to impact the agricultural sector in coming decades [1], and this will affect its associated industries. This will have serious consequences because the agricultural sector is hugely important in driving a society's development and socio-economic advancement. Although the agricultural sector is usually portrayed with idyllic, sweeping green vistas [2], most agricultural tools and equipment operate using fossil

* Corresponding author. Tel.: +34 976 761782.

E-mail address: ngarcia@unizar.es

fuels, which are the main sources of the greenhouse gases (GHG) accelerating global warming [3-4]. The use of fossil fuels, either for mobile equipment or at fixed locations, produces pollutant emissions such as carbon dioxide (CO₂), carbon monoxide (CO), sulfur oxides (SO_x), nitrogen oxides (NO_x), volatile hydrocarbons and solid particles. Furthermore, by accident or by mismanagement, discharges of its own fuel, lubricants and other substances and polluting residues (air and fuel filters, etc.) occur. Engines are also a source of noise pollution. As one of the main sources of GHG emissions, the contribution of agricultural systems to global anthropogenic GHG emissions is between 19% and 29% [5-6].

Within agribusiness, the wine sector in Spain is by no means insubstantial. According to the latest data published by the World Wine Organization, world wine production in 2016 was 267 million hectolitres, led by France, Italy and Spain. The wine industry is also at risk of substantial climate-related threats [7]. The primary negative effects of climate change on the wine industry are potential losses of product quantity and quality [8]. More concretely, global warming and its effects on the wine sector could be summarized as follows: high temperatures during vine growing exerting a negative effect on grape composition and wine quality [9-11]; ripening accelerating [12], leading, in turn, to excessive sugar accumulation in the grape and an increase of 50% in the alcohol level in the wines [13]; a faster depletion of organic acids in the grape juice; a faster increase in pH values; the general flavour profile may atypically change to over ripe.

Some authors address the study of some of the main areas of environmental concern currently facing wine organizations [2, 14-15]. These authors agree that the most relevant environmental aspects, without being exhaustive, are the following: water use and management, solid organic and inorganic waste, energy use and greenhouse gas emissions, air quality, agrochemicals, land use issues and biodiversity.

This paper focuses on the environmental aspect of energy use and greenhouse gas emissions in the wine sector. Although this fact is not readily appreciated, wine production consumes large amounts of energy and generates a sizeable quantity of greenhouse gases. Winemaking involves many different phases, such as grape harvesting, vinification, bottling and distribution. As an example, the major contribution of the winery phase to the corporate carbon footprint (73%) is mainly due to glass production for bottling (45.6% contribution) and electricity consumption (9.2%). In the vineyard phase, contribution comes mainly from diesel production and combustion due to field works (11.3%) and the use of phytosanitary products (6.0%) [16]. Most of the energy currently used in the wine sector is based on non-renewable energy sources. Therefore, one of the possible solutions to CO₂ emissions involves a fundamental change in the energy system, which will only be possible with a greater participation of renewables in the energy model.

Bearing the above in mind, the objective of our work is to discover the penetration of renewable energies in the Spanish wine sector. To that end, a sample of Spanish wineries stratified by region completed a questionnaire for knowing the drivers and barriers in the implementation of renewable energies. With the information provided by the respondent wineries and applying the multivariate statistical techniques of factor and cluster analysis, we determine groups of wineries different with respect to their attitude toward renewables.

The layout of the paper is as follows: Section 2 briefly describes the importance of the Spanish wine sector and its energy use. Section 3 analyses the penetration of renewable energies in the Spanish wine sector, establishing groups of wineries based on their attitude towards renewables. Finally, Section 5 presents the most relevant conclusions.

2. The Spanish wine sector and some hotspots in renewables

The Spanish wine sector is highly important due to its economic, social, cultural and environmental value. In fact, according to the data provided by the Spanish Statistical Office, the wine sector represents around 1% of the country's Gross Domestic Product (GDP). To this percentage we should be added the importance of Spanish wine as an image of the country abroad; therefore, this sector is of extraordinary relevance for the Spanish economy. In addition, the International Organization of Vine and Wine (OIV) showed that in 2016 the Spanish area under vines, with 975 thousand hectares, was the largest in the world —14% of the world vineyard area and 30% of the European vineyard—. Besides, Spain with 39.4 million of hectolitres was the third wine-producing country in the world. In terms of consumption, Spain was ranked in seventh place worldwide in volume, with 9.9 million consumed hectolitres. Other relevant data was that Spain remained the largest exporter with 22.9 million hectolitres in terms of volume and 28.9 billion euros, in terms of value, representing a global market share of 22%.

Wine production consumes large amounts of energy and generates a sizeable quantity of greenhouse gases, a fact that is not readily appreciated. Many systems, spaces and processes are required in the winemaking facility and each of them has a role and an energy requirement involved in producing different types of wines [17].

Most of the energy currently used in the Spanish wine sector comes from non-renewable energy sources. The development of production systems and practices solving the problem of CO₂ emissions and also enhancing the socio-economic environment will only be possible with a greater participation of renewables in the energy mix, which will allow wine activities to become sustainable. Consequently, all necessary facilities should be provided to companies wishing to implement energy sustainable initiatives, reduce greenhouse gas emissions and benefit their environment. This is why the European Union has promoted the use of renewable energy sources by issuing several directives.

Wineries' interest in the environment is also closely related to consumer demand [18]. It is increasingly common for their clients to be "environmentally aware", in other words, they care about the environment and want their purchases to fit in with their way of thinking and lifestyle. This type of consumer would assume wineries are committed to transitioning from fossil fuels to clean energy.

However, historically there have been several barriers preventing a rapid generalization of the use of renewable energy [19]. They include the initial investment making them seem unprofitable even though this is not the case in the long term.

In addition to the companies involved in the supply and demand of alternative energies, we must consider the regulatory role adopted by public administrations, whose policies either favour or hamper the rapid implementation of renewable energy sources. Measures favouring investment in renewable energy facilities include aid and subsidy programs, and tax deductions [20].

In general, energy security requires a confident supply at a competitive price stable over time. However, in rural areas, where wine activities take place, the quality of the power grid supply is not always guaranteed. Moreover, long-term energy security is linked to the concept of sustainability, since it includes a more comprehensive vision, considering social, economic and environmental aspects.

Given the above, the objective of this paper is to discover whether the Spanish wine sector is willing to incorporate renewables. Our aim is to learn which determinant factors influence Spanish wineries to adopt or reject the use of renewable energies.

3. Penetration of renewable energies in the Spanish wine sector

According to SABI (*Sistema de Análisis de Balances Ibéricos*), an online database which contains financial information on 940,000 Spanish and 100,000 Portuguese companies, the Spanish wine map in 2016 was formed by 3,894 wineries. These wineries are spread for all the regions (Autonomous Communities); therefore, in order to have a photo of the whole Spanish wine sector, we decided to use a simple random sample of 87 wineries, stratified by regions, that correspond to a confidence level of 94% and an error of 10%. Table 1 presents the final sample.

This sample of wineries was asked to complete a questionnaire, which started with Block I with questions to identify and locate the wineries; the purpose of Block II was to learn the company's activity; Block III focused on environmental responsibility and policy; Block IV aimed to analyse wineries' attitudes to climate change; Block V included questions on renewable energy; and Block VI aimed to learn whether the use of renewable energies was technically and economically viable.

Given that our objective is to discover the penetration of renewable energies in the Spanish wine sector, this paper is focused in the questions of Block V, related to whether the winery is convinced about using renewable energy, its opinion on the cost of implementing renewable energy (investment, maintenance and operational costs), and its motivations to adopt the use of renewable energy (reliability, environmental sustainability, existence of subsidies and corporate image). More specifically, the variables are as follows:

- Convinced use: This variable is measured on a 0-10 scale and collects the answers to the question: "Winery's degree of agreement with the need to use renewable energies", where 0 represents that the winery strongly disagrees and 10 strongly agrees.

- Investment: This variable, measured on a 0-10 scale, includes the answer to the question on the winery's perception of the importance of the investment associated with the implementation of renewables, where 0 indicates that the winery thinks it is a very small expense and 10 that the expense is very high.
- Operational costs: This variable, measured on a scale from 0 to 10, includes the answer to the question on the winery's perception of the dimension of operational costs associated with adopting renewable energies, where 0 indicates that the winery thinks it is a very small expense and 10 that the expense is very high.
- Maintenance costs: This variable, measured on a scale from 0 to 10, includes the answer to the question on the winery's perception of the dimension of maintenance costs associated with adopting renewable energies, where 0 indicates that the winery thinks it is a very small expense and 10 that the expense is very high.
- Grants: This variable, measured on a scale from 0 to 10, includes the answer to the question on the importance that the winery gives to the existence of subsidies to adopt renewable energies, where 0 indicates that the winery considers it is not important and 10 that it is absolutely decisive.
- Image: This variable, measured on a scale from 0 to 10, includes the answer to the question on the importance for a winery of the impact of their corporate image on adopting renewable energies, where 0 indicates that the winery considers it is not important and 10 that it is absolutely decisive.
- Reliability: This variable, measured on a scale from 0 to 10, includes the answer to the question on the importance that the winery gives to the reliability of renewable energies at the time of deciding its adoption, where 0 indicates that the winery considers it is not important and 10 that it is absolutely decisive.
- Sustainability: This variable, measured on a scale from 0 to 10, includes the answer to the question on the importance the winery gives to sustainability in its decision to implement renewable energies, where 0 indicates that the winery considers it is not important and 10 that it is absolutely decisive.

Table 1. Population and sample sizes by Spanish regions

Spanish regions	Population wineries	Sample wineries
Andalucía	287	7
Aragón	144	3
Asturias	19	0
Baleares	57	1
Canarias	84	2
Cantabria	5	0
Castilla-León	597	13
Castilla-La Mancha	445	10
Cataluña	603	13
Extremadura	118	3
Galicia	342	8
La Rioja	326	7
Madrid	195	4
Murcia	87	2
Navarra	116	3
País Vasco	261	6
Valencia	208	5
Total	3,894	87

3.1. Determinant factors

The information provided by the respondent wineries was manually coded and processed using the Statistical Package for Social Sciences (SPSS). Applying the multivariate statistical technique of factor analysis, we constructed a set of indicators that allowed us to describe the determinant factors influencing the implementation of renewable energies. Factor analysis is one of the most commonly used inter-dependency techniques which is utilized when the relevant set of variables shows a systematic inter-dependence and the objective is to find out the underlying latent factors, permitting a reduction of the set of variables. In our case, this technique allowed us to reduce from the previous 8 variables to 4 factors. The used estimation method was principal components together with an orthogonal varimax

rotation. The main four factors explain the 77.4% of the total variability of the eight variables, and are interpreted as follows:

- **Costs factor:** This factor is positively related to operational and maintenance costs. Consequently, a winery that has a high score in the costs factor considers that costs associated with implementing renewable energies are high.
- **Conviction factor:** This factor is positively related to the conviction of using renewable energies, reliability and environmental sustainability. Consequently, a winery with a high score in the conviction factor is very convinced of using renewables and gives great importance to reliability and environmental sustainability.
- **Motivation factor:** This factor is positively related to some motivations that can lead a winery to adopt renewable energies, such as the importance of image and the existence of subsidies. Consequently, a winery that has a high score in the motivation factor believes that the corporate image and existence of subsidies are absolutely decisive for implementing renewables.
- **Investment factor:** This factor is positively related to investment, so a winery that has a high score in the investment factor considers the investment associated with the implementation of renewable energies to be too high, and, therefore, it probably prefers to adopt other measures to mitigate climate change.

3.2. Types of wineries

With the four previous indicators, a multivariate cluster analysis technique in two steps was applied to classify the wineries. The first stage of this method consists of a pre-classification that sequentially builds a tree, whose nodes represent the groups. The previous solution is refined in the second stage through an agglomerative hierarchical procedure. The final algorithm automatically selects the number of clusters using a model selection criterion for different grouping solutions. In our case, we used the Bayesian information criterion (BIC) to select a solution with three groups of wineries. Again, the procedure was carried out by means of the software SPSS. The groups are as follows:

- **Group 1 (not committed to environmental issues) (25.3%):** This group includes wineries with very low scores on conviction and investment factors and moderately high scores on costs and motivation factors. Therefore, the wineries in this group are not convinced of using renewables. They are not concerned about environmental sustainability and do not trust the reliability of renewable energies, probably because they consider their maintenance and operational costs are quite high. These wineries could be encouraged to implement renewables if it could be demonstrated that they are reliable and that implementing them would have a favorable impact on their corporate image.
- **Group 2 (rejection of renewables due to investment) (26.7%):** This group comprises wineries with moderately and quite high scores in conviction and investment factors, respectively, as well as very low scores in cost factors. They give a moderate assessment to the motivation factor. Therefore, the wineries in this group are moderately convinced of using renewables, and reasonably concerned about their reliability and about environmental sustainability. Although they are fairly convinced of using clean energy, it is their high investment rather than their maintenance and operational costs that seem the main reason why they are reluctant to implement renewable energies. Therefore, to encourage the use of renewables in this group of wineries, their economic feasibility would have to be demonstrated.
- **Group 3 (committed to renewables) (48%):** This group consists of wineries with very high scores on conviction and costs factors. They give a moderate assessment to the investment factor and quite a low assessment to the motivation factor. Thus, these wineries are extremely convinced of the use of renewables, because they are very concerned about environmental sustainability and fully trust their reliability. Their belief that renewable energies are powerful measures to mitigate climate change is so strong that neither their high maintenance and operational costs nor the lack of subsidies could prevent them from being adopted. This group of wineries does not prioritize improving their corporate image over their commitment to the environment and does not consider that the necessary investment is high, compared to the benefit that can be obtained from them.

4. Conclusions

This paper focuses on the environmental aspect of energy use and greenhouse gas emissions in the wine sector. Concretely, we have characterized the Spanish wine sector in terms of its interest in implementing renewable energies, identifying three groups of wineries. The first comprises wineries unconcerned about environmental issues; the second is formed by wineries which are reticent to adopt renewables due to the required high investment; and, finally, the third group includes wineries committed to renewable energies because they are absolutely convinced of their benefits.

The wine sector needs a high consumption of energy in all the different phases (grape harvesting, vinification, bottling and distribution) and is highly threatened by climate change. In fact, the energy use within the sector is a relevant issue, not only because it represents an important part of its costs but also because it provokes environmental damages. For instance, from the carbon footprint of a wine bottle, a 11.3% is due to the diesel production and combustion in the vineyards and a 9.2% to the electricity consumption in the wineries. For this reason, it would be advisable for the sector to make the transition from fossil fuels to clean energies. Nevertheless, implementation depends on the stakeholders.

This research has shown that a large percentage of Spanish wineries are willing to incorporate renewable energy and a similar scenario is likely to occur in other countries. The results also show two main ways to overcome the barriers to that decision in other wineries: facilitating the financing of investments and disseminating information on both the sustainability and feasibility of renewable energy in the wine sector.

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