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CARBON FOOTPRINT EVALUATION OF AN ITALIAN MICRO-BREWERY*

Paola Masotti[1], Barbara Campisi[2], Paolo Bogoni[2]**

[1]University of Trento, Department of Economics and Management, via Inama 5, 38122 Trento, Italy
[2]University of Trieste, DEAMS- Department of Economics, Business, Mathematics and Statistics "Bruno de Finetti", via Valerio 6, 34127 Trieste, Italy

Abstract

In the last 20 years, the sector of the Italian beer has shown particular attention to environmental issues, reducing by about two-thirds the amount of water used in the production phase, more than a quarter of the energy consumption per hectoliter of product and approximately one fifth the amount of used glass. But the most important results were obtained for the amount of aluminum used in cans and for CO_2 emissions (about -40%). These successes are probably attributable to the awareness and the marketing strategies of brewing companies of larger size (mainly for the ever-increasing use of kegs, which accounts for more environmentally friendly distribution system) while significant margins of improvement remain for microbreweries that represent the real entrepreneurial phenomenon in the beer sector, in both numbers of plants in the area and growth rates. Therefore, in this study we analyze the case of a micro-brewery of Friuli Venezia Giulia (FVG) Region to understand what may be, for a small private organization, the strengths and weaknesses in the management of the greenhouse gasses emissions. A Life Cycle case study was performed to detect and quantify the organization's carbon footprint deriving from the overall activities of the brewery. Direct and indirect GHGs emissions from 3 high fermentation and 3 low fermentation beers production processes and packaging systems (0.33cL and 0.75cL glass bottles) were considered as well as the emissions related to plant management such as lighting, electric energy, workers mobility and waste treatment. Primary data were collected from a small brewer located in FVG region, secondary data were sourced from literature and databases included in the LCA SimaPro software used to calculate the CF applying the IPCC 2007 GWP 100a method. The organization is the reference unit for the analysis and the basis for defining the system boundaries, within these a carbon footprint of 58.2 t CO_{2eq} was obtained mainly due to direct emissions, i.e. Scope 1, that contribute for 57% to the total GHG emissions of the organization.

Keywords: beer, carbon footprint, LCA, microbrewery

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** Corresponding author: e-mail: paola.masotti@unitn.it

1. Introduction

During the last few decades the threat of climate change to sustainable development has grown to become a major concern not only among NGO and politicians but also among consumers and society in general. In many nations leaders are discussing ambitious reduction targets for greenhouse gases (GHG) emissions. In October 2014, for instance, the European Union (EU) set a reduction target of at least 40% by 2030 compared to 1990 across all sectors of the economy. A target to be delivered with the reductions in the Emission Trading System (ETS) sectors (industry and energy) and non-ETS sectors (transport, buildings, agriculture, waste, land-use as well as forestry) amounting to 43% and 30% respectively by 2030 compared to 2005 (European Council, 2014). Initially this target was supposed to be based on global projections in line with the medium term ambition of the 2015 Paris Agreement. The first multilateral agreement on climate change, adopted by the United Nations Framework Convention on Climate Change (UNFCCC) at the COP21, covering almost all of the world's emissions, which will replace the approach taken under the 1997 Kyoto Protocol. Recently a new EU Commission's proposal for a Regulation on binding annual GHG emissions reductions by Member States from 2021 to 2030 has been defined. The aim of such proposal is to set national reduction targets (the 'minimum contributions') ranging from 0% to -40% below 2005 levels and to implement EU commitments under the Paris Agreement. In particular, the long-term goal is to keep the global temperature increase "well below 2°C above pre-industrial levels and to pursue efforts to keep it to below 1.5°C" (European Commission, 2016). According to the Intergovernmental Panel on Climate Change (IPCC), keeping global warming likely below 2°C above pre-industrial temperatures is an important goal to limit some climate change risks, such as risks to unique and threatened systems and risks associated with extreme weather events (IPCC, 2014).

The Paris Agreement represents the response to a global call action for policymakers to define a new framework on climate change to report and verify the GHG emissions and consequently the achievements of the national climate plans. At the same time, this 'global climate deal' represents a clear market signal that the transition to a low-carbon economy is inevitable and that every economic sector must be part of the solution to the climate change challenges. That is true also for the food and drink manufacturers. The report from the IPCC in fact states that all aspect of food security will potentially be affected by climate change, including food production and quality, as a consequence of global temperature increases and a reduction of renewable surface water and groundwater resources which will intensify competition among sectors. The failure of climate change mitigation and adaptation together with water crises are considered among the most impactful risks for the coming years (ranking first and third respectively) also by experts and decision-makers in the World Economic Forum's multi-stakeholder communities (WEF, 2016). Extreme weather events such as droughts and storms will have implications for collectivity but even for corporate and business organizations. Among these latter ones there are the Food and Beverage manufacturers and that explains why environmental sustainability and climate change management are increasingly important also for this sector (FoodDrinkEurope, 2015). The growing interest in the relationships among strategies, environmental performance and communication is undeniably reflected by the number of companies that have decided on the one hand to invest in green management, adopting systemic and integrated approaches, and on the other to disclose the evolution of environmental performance levels achieved against objectives and targets.

During the last 25 years, the Italian beer sector, too, has shown particular attention to environmental issues, reducing by about two-thirds the amount of water used in the production phase, more than a quarter of the energy consumption per hectoliter of product and approximately one fifth the amount of used glass. But the most important results were obtained for the amount of aluminum used in cans and for CO_2 emissions (about -40%) (Assobirra, 2015). These successes are probably attributable to the awareness and the marketing strategies of brewing companies of larger size (mainly for the ever-increasing use of kegs, which accounts for more environmentally friendly distribution system) while significant margins of improvement remain for microbreweries that represent the real entrepreneurial phenomenon in the beer sector, in both numbers of plants in the area and growth rates.

Recently, a considerable number of studies addressed to the issue of environmental impacts that could result from beer production, see for example (Amienyo and Azapagic, 2016; Bonamente et al, 2016; Cimini and Moresi, 2016; Cordella et al, 2008; De Marco et al, 2016; Koroneos et al, 2005). In this study we analyze the case of a micro-brewery of Friuli Venezia Giulia (FVG) Region to assess the strengths and weaknesses in the management of the GHG emissions in a small enterprise. A Life Cycle case study was performed to detect and quantify the organization's carbon footprint deriving from the overall activities of the brewery.

2. Objectives

The objective of this study is to detect and quantify the organization carbon footprint deriving from the overall activities of an Italian micro-brewery that produces 3 high fermentation and 3 low fermentation beers, mainly consumed in Italy. The purpose of the study is also to identify the processes responsible for the great majority of GHG emissions to propose targeted actions for decreasing such emissions and that could become a best practice to be shared across brewery industries.

This work is divided in four main parts:

- selection of case study: a micro-brewery located in the Province of Trieste, Friuli Venezia Giulia, a North East Italian Region particularly rich in craft breweries.
- assessment of the most recent European guidelines on the environmental performance of products and organizations and especially on measuring and reporting greenhouse gas emissions This paper can be of interest for the beer sector since, to the best of our knowledge, it evaluates the carbon footprint of a micro brewery for the first time.
- choice of system boundaries, considering only all processes directly involved in the activities of the organization and therefore properly quantifiable (from raw materials transport to local delivery of products to customers)
- determination of organization's carbon footprint and identification of the processes most responsible for greenhouse gas emissions.

3. Materials and methods

Carbon footprint. An organization carbon footprint (CF) is the indicator used to quantify the total amount of direct and indirect carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions from all the organization activities, expressed as carbon dioxide equivalent (CO_{2eq}) (Baldo et al., 2009; Bonamente et al., 2016; Gao et al., 2014; Pandey et al., 2011).

In this study, the carbon footprint of a micro-brewery, located in the Province of Trieste (Italy), has been modeled taking into account two main standards: the greenhouse gas GHG Protocol, the internationally recognized standard for the corporate accounting and reporting of GHG emissions (WBCSD and WRI, 2004; WBCSD and WRI, 2009) and the ISO 14064-1 standard that defines how to manage GHG inventories at organization and company level (ISO, 2006). Both standards follow an approach based on life cycle methodology for the measurement of the GHGs emissions. Furthermore, two guidelines, aligned with the former standards, have been used: the UK ministerial guidance that defines general principles to help organizations to measure and report greenhouse gas emissions (DEFRA, 2009) and Beverage Industry Sector

Guidance for Greenhouse Gas Emissions Reporting (BIER, 2013). Carbon footprint calculation was based on the method: IPCC 2013, contained in the SimaPro software (PRè, 2016).

System boundaries. In this study, GHG emissions of a small brewery wholly owned by a single owner have been measured. Therefore, being a simple organizational structure and according to the above mention standards (GHG Protocol and ISO 14064 Standard), the organizational boundaries encompass all the activities that take place within the production site while the operational boundaries categorize the emissions resulting either directly or indirectly from the organization's operations, facilities, and sources. Operational boundaries (Fig. 1) have been established by classifying the emission-released activities under organization's control in three groups called scope by the GHG Protocol.

Scope 1: Direct emissions resulting from company owned and controlled assets. In this investigation, the following activities related to direct GHG emissions were identified: a) combustion of NG to generate hot water for plant heating and to generate steam boiler for beer processing; b) use of carbon dioxide during bottling and liquid decanting operations; c) must fermentation and partial conversion of sugar into carbon dioxide; d) use of a company-owned van for local distribution (Trieste Province) of beer bottles and kegs.

Scope 2: Indirect emissions from purchased electricity. One activity generating indirect emissions was considered: use of electricity for lighting the brewery's rooms and warehouse cooling (approximately 20%) and use of electricity for the of production equipment (approximately 80%).

Scope 3: All other indirect emissions resulting from the activities related to the organization. The following activities were taken into account: a) transport of malt, hop, yeast, coadjutants, primary and secondary packaging materials, corks, detergents from the distributor sites to the micro-brewery gate, b) workers' car commuting.

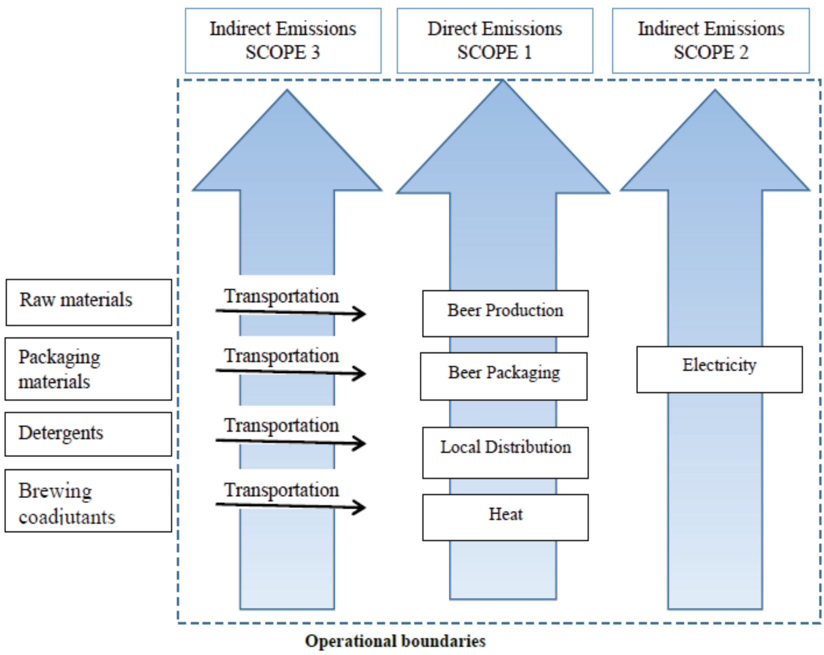

Fig. 1. Operational boundaries and activities within the scopes considered in the case study

Data collection. In order to collect proper data the organizational processes were established and the related activities responsible for greenhouse gas emissions identified. The primary data were gathered through personal interviews with the beer manufacturer and were referred to activities carried out in 2015 at the brewery. All data are referred to the total annual production equal to 57.95 m^3. Secondary data were obtained from EcoInvent 3 database included in the SimaPro 8.1 software.

Inventory Analysis. Primary data collected at the brewery and used to calculate the CF of the organization are summarized in Table 1. The data have been assigned to the different scopes previously described. In scope 1 the total natural gas consumption (8999 m^3) has been divided as follows: (i) 20% (3365 m^3) to supply a thermal boiler of 30 kW rated power, 86% yield and (ii) 80% (5634 m^3) to supply a steam generator of 175 kW rated power with a 90% yield. The carbon dioxide direct emissions from beer fermentation were calculated considering the degrees Plato (°P) (percentage of sugars in the wort before fermentation), the degree of attenuation (the percent of malt sugar converted to ethanol and CO_2) at 70%, the amount of wort produced for the different types of beer and the 10% of CO_2 that approximately remains in produced beer. Regarding local distribution, the organization delivers the 30% of total production (that is about 26.6 t, adding the beer and the primary packaging weight) in the Trieste Province by means of a van with an average load factor of 0.98 t (as modeled in SimaPro). From the data provided by the company on the mileage and the number of trips made, the average distance travelled has been calculated.

Table 1. Primary data for total annual beer production

Data for total annual beer production (57950 L)								
SCOPE 1			***SCOPE 2***			***SCOPE 3***		
Inputs	***Unit***	***Amount***	***Inputs***	***Unit***	***Amount***	***Inputs***	***Unit***	***Amount***
Natural Gas	**m^3**	**8999**	**Electric Energy**	**kWh**	**27383**	**Transportation**		
heat generation	m^3	3365				Transportation (16-32 t)	tkm	1523.6
steam generation	m^3	5634				Transportation (7.5-16 t)	tkm	168.6
CO_2						Transportation (3.5-7.5 t)	tkm	836.6
Beer fermentation	t	2.82						
Purchased	t	1.26						
Local Distribution (3.5-7.5 t)	tkm	9435						

In scope 2 the total annual organization consumption of electricity is reported.

In this case study, upstream activities identified as scope 3 by the GHG Protocol (i.e. raw materials, processed materials and packaging materials, coadjutants and processing aids) were not taken into account except the transportation of the overall materials from suppliers to the brewery. Data provided by the manufacturer on transport distance and annual material purchased were used to calculate the values of tkm as the weight of the transported materials multiplied by the average transport distance related to the three different vehicles type

Regarding brewery by-products 4.06 t per year, spent grains and surplus yeast were used as cattle feed in a farm very close to the brewery (about 1 km), considering the very low traveled distance emissions caused by this transportation as negligible.

4. Results and discussion

In order to estimate the CF of a micro-brewery the SimaPro 8 software was used to model the system and the IPCC2013 100a method was applied to calculate the CO_{2eq} emissions.

The percentage contribution of each of the three Scopes is reported in Fig. 2**.** As can be seen the direct emissions, i.e. Scope 1, contribute for 57% to the total GHG emissions of the organization, the EE indirect emissions, i.e. Scope 2, for 29.2% and the indirect emissions others, i.e. Scope 3, only for 13.4%. Regarding scope 3 it should be noted that only the materials' transportation has been considered and not their production that contributes to a significant extent to the GHG emissions (Amienyo and Azapagic, 2016; Pattara et al., 2012).

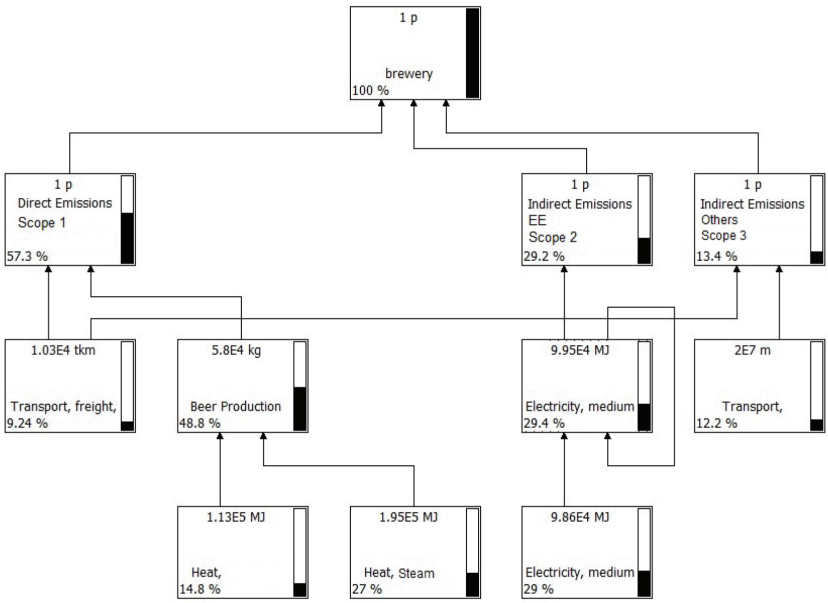

Fig. 2. Percentage contribution of different phases to the organization Carbon Footprint

Direct emissions are determined by two activities: local transport of beer and beer production that contribute for 9.24% and 48.8% respectively to the total GHG emissions of the organization. These values point out that in this specific case study, activities for beer production contribute to most of the greenhouse gas emissions and are mainly caused by the methane combustion for steam production (27%) and heat production (14.8%), while process CO_2 and biogenic carbon dioxide released during the fermentation account for 7% (Fig. 2).

Indirect emissions from electricity use amounts to about 30% of total GHG emissions and corresponds to 47 kWh hL^{-1}, a quite high value if compared with other case studies: 8 to 12 kWh hL^{-1} according to Olajire (2012), 8.61 kWh hL^{-1} according to (Cimini and Moresi, 2016).

To explain this result it must be considered that brewing is an energy intensive process and many factors can determine site specific variations due to differences in-product recipe and packaging type, the incoming temperature to the brewery of the brewing water and climatic variations (Olajire 2012), but above all the size of the organization: large, medium, small or even micro enterprise as in this study.

A more detailed analysis of the data allows to calculate the contribution, expressed in t CO_{2eq}, of different processes to the total emissions, the results are reported in Fig. 3. The consumption of natural gas for steam production used for wort boiling, water heating, and in the bottling hall is responsible for the major contribution to GHG emissions that is 12.17 t CO_{2eq}, followed by emissions from power generation plants (referred to Italian electric production) 7.38 t CO_{2eq} and further consumption of natural gas burned at the plant to obtain heat 6.71 t CO_{2eq}.

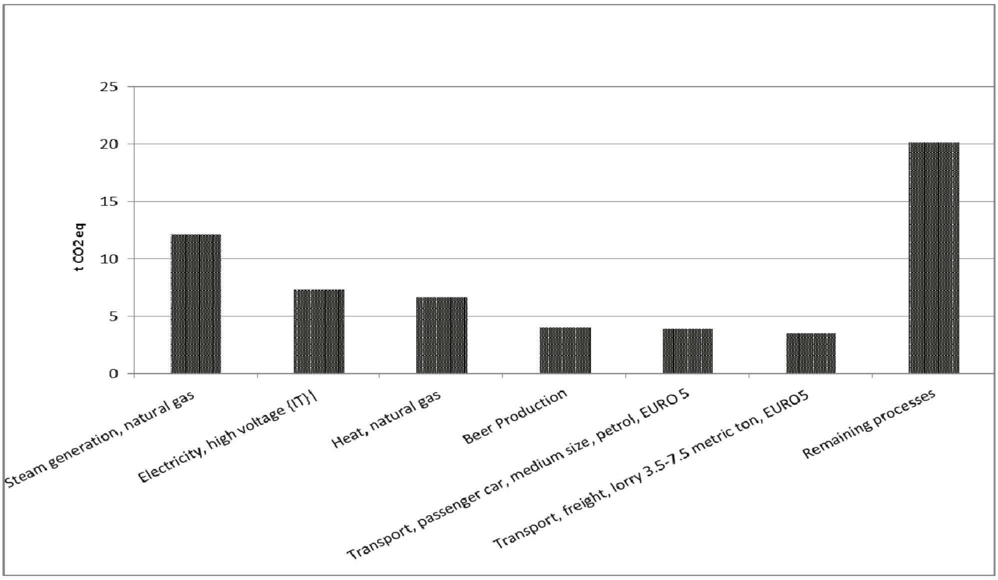

Fig. 3. Contribution of different processes to the organization Carbon Footprint

To the best of our knowledge, this study estimates the carbon footprint of a micro-brewery for the first time, therefore it is not possible to compare these preliminary results with others concerning the organization carbon footprint of similar craft breweries. However, by considering the value of 58.2 t CO_{2eq} and dividing it by the annual production 579.5 hL the value of 100 kg CO_{2eq} hL^{-1} is obtained, a higher rate than other ones concerning the product carbon footprint of industrial breweries, see for example (Cimini and Moresi, 2016).

It is worth noting that this high value of CF was obtained, even if only scope 1 and scope 2 (scope 3 partially) were taken into consideration in our study. Indeed we purposely analyzed only the stages where a small organization, as a micro-brewery, can more easily intervene to improve its environmental performances. Consequently, significant stages have been neglected, such as the national and overseas distribution, as well as the agricultural production of raw materials, that generally appeared as the most impacting stages. See for example (Pattara et al , 2012).It can be hypothesized that this high rate is attributable to shortcomings of optimization processes and economies of scale, present on the contrary in industrial breweries.

Within Scope 1 and Scope 2 energy consumption is the most critical hotspot since it accounts for nearly 70% of greenhouse gas emissions due to the use of electric energy and natural gas; it follows that to improve the organization environmental performance and to increase its value as well as reduce the resources consumption some improvement measures can be adopted. Actions could be taken on one hand for a better and more efficient management of operational activities by decreasing, for example, the amount of energy used per unit of beer produced or by recovering waste heat from the steam generation boiler; on the other hand by using electricity from renewable sources through the installation of a photovoltaic system and thermal energy collectors.

5. Concluding remarks

In this preliminary study the LCA methodology was applied to evaluate the carbon footprint of a small company and to identify the most impacting stages. From this investigation emerged the difficulty in obtaining accurate data from small companies. At the same time, the majority of European consumers, due to their growing interest in the climate change issue, is interested in a mandatory label indicating the carbon footprint of a product (European Commission 2009). In addition, considering the importance that the EU attributes to the Organization Environmental Footprint (OEF), it is desirable that the OEF Guide established by the JRC (JRC European Commission, 2012) will adequately take into account small companies' needs.

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References

Amienyo D., Azapagic A., (2016), Life cycle environmental impacts and costs of beer production and consumption in the UK, *The international Journal of Life Cycle Assessment*, **21**, 492-509.

Assobirra, (2015), *Annual Report 2014*, On line at: http://www.assobirra.it/press/wp- content/ annualreport 2014ita.pdf.

Baldo G.L., Marino M., Montani M., Ryding S.-O., (2009), The carbon footprint measurement toolkit for the EU Ecolabel, *The international Journal of Life Cycle Assessment*, **14**, 7, 591-596.

BIER, (2013), Beverage industry environmental roundtable, beverage industry sector guidance for greenhouse gas emissions reporting, On line at: http://media.wix.com/ugd/49d7a0_ 6339d006853c4d3bbdf6087b43d91580.pdf.

Bonamente E., Scrucca F., Rinaldi S., Merico M. C., Asdrubali F., Lamastra L., (2016), Environmental impact of an Italian wine bottle: Carbon and water footprint assessment, *Science of the Total Environment*, **560-561**, 274-283.

Cimini A, Moresi M., (2016) Carbon footprint of a pale lager packed in different formats: assessment and sensitivity analysis based on transparent data, *Journal of Cleaner Production*, **112**, 4196-4213.

Cordella M., Tugnoli A., Spadoni G., Santarelli F., Zangrando T., (2008), LCA of an Italian lager beer, *The international Journal of Life Cycle Assessment*, **13**, 133-139.

De Marco I., Miranda S., Riemma S., Iannone R., (2016), Life Cycle Assessment of ale and lager beers production, *Chemical Engineering Transactions*, **49**, 337-342.

DEFRA, (2009), *Guidance on how to measure and report your greenhouse gas emissions*, On line at: http://www.defra.gov.uk/environment/business/reporting/index.htm.

European Commission (2016), Proposal for a Regulation of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 for a resilient Energy Union and to meet commitments under the Paris Agreement and amending Regulation No 525/2013 of the European Parliament and the Council on a mechanism for monitoring and reporting greenhouse gas emissions and other information relevant to climate change, On line at: https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-482-EN-F1-1.PDF.

European Commission, (2009), Europeans' attitudes towards the issue of sustainable consumption and production, Flash Eurobarometer, no. 256, On line at: http://ec.europa.eu/public_opinion/archives/ flash_arch_269_255_en.htm.

European Council, (2014), Conclusions on 2030 Climate and Energy Policy Framework. On line at: http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145356.pdf.

FoodDrinkEurope, (2015), A Time to Act. Climate Action and the Food and Drink Industry. FoodDrinkEurope, Belgium, Brussels, On line at: http://www.fooddrinkeurope.eu/uploads/publications_documents/FoodDrink_Europe_Climate_Action_Brochure.pdf.

Gao T., Liu Q., Wang J., (2014), A comparative study of carbon footprint and assessment standards, *International Journal of Low-Carbon Technologies*, **9**, 237-243.

IPCC, (2014), *Summary for Policymakers*, In: *Climate Change 2014: Impacts, Adaptations, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Woriking Group II to the Fifth Assessments Report of the Intergovernamental Panel on Climate Change*, Field C.B., Barros V.R., Dokken D.J., Mach K.J., Mastrandrea M.D., Bilir T.E., Chatterjee M., Ebi K.L., Estrada Y.O., Genova R.C., Girma B., Kissel E.S., Levy A.N., MacCracken S., Mastrandrea P.R., White L.L. (Eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1-32.

ISO, (2006), ISO 14064-1:2006 Greenhouse gases. Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*,* International Organization for Standardization, Geneva.

JRC European Commission, (2012), Organisation Environmental Footprint (OEF) Guide, On line at: http://ec.europa.eu/environment/eussd/pdf/footprint/OEF%20Guide_final_July%202012_clean%20version.pdf.

Koroneos C., Roumbas G., Gabari Z., Papagiannidou E., Moussiopoulos N., (2005), Life cycle assessment of beer production in Greece, *Journal of Cleaner Production*, **13**, 433-439.

Olajire A.A., (2012), The brewing industry and environmental challenges, *Journal of Cleaner Production,* **30**, doi: 10.1016/j.jclepro.2012.03.003.

Pandey D., Agrawal M., Pandey J. S., (2011), Carbon footprint: current methods of estimation, *Environmental Monitoring and Assessment*, **178**, 135-160.

Pattara C., Raggi A., Cicchelli A., (2012), Life Cycle Assessment and Carbon Footprint in the Wine Supply Chain, *Environmental Management,* **49**, 1247-1258.

PRè, (2016), *SimaPro 8.1.1 Life Cycle Assessment Software Package,* Amersfoort (NL), PRè Consultant

WBCSD and WRI, (2004), *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* World Business Council for Sustainable Development, WRI (World Resources Institute), Switzerland, Geneva, On line at: http://www.ghgprotocol.org/standards/corporate-standard.

WBCSD and WRI, (2009), *The Greenhouse Gas Protocol Initiative: Scope 3 Accounting and Reporting Standard* (Revised Edition), Switzerland, Geneva, World Business Council for Sustainable Development and WRI World Resources Institute, On line at: http://www.ghgprotocol.org/standards/corporate-standard.

WEF, (2016), World Economic Forum's Global Risks Report 2016. 11th Edition. WEF, Switzerland, Geneva, On line at: http://www3.weforum.org/docs/Media/TheGlobalRisksReport2016.pdf.