



Energy efficiency, carbon emissions, and measures towards their improvement in the food and beverage sector for six European countries



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ABSTRACT

Basic and detailed audits of small and medium sized food and beverage enterprises were conducted in six European Union countries to determine product specific energy consumption and measures to reduce energy use and carbon emissions. Collected results showed that the companies' products had similar specific energy consumption as prior studies, but due to no standard metrics, the range was rather large. Auditors primarily recommended energy savings measures (process optimization and heat recovery), due to their low payback periods. Lower carbon energy sources were also recommended (solar thermal and combined heat/power), but often at higher costs, supported through government incentive programs. Through these measures, energy savings of up to 45% and carbon to 30% (~30,000 t CO₂ equivalent in the audited companies) were possible, dependent on the type, size of company, and fuel choice. Typically, very small companies and those using coal showed the greatest margin for improvement, though it varied greatly depending on the type of product produced and the installed heating and cooling equipment. Auditors noted significant barriers toward the implementation of measures, e.g. companies found the costs too high, did not know of efficient technologies and their performance, or did not have managerial support to implement efficiency measures.

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1. Introduction

The F&B (food and beverage) sector is the biggest economic sector within the EU (European Union) with a direct turnover of 1.24 trillion €/a. This translates to 15% of the overall production turnover of the EU and direct employment of more than 4.2 million people [1]. F&B is also one of the largest energy consumers, equivalent to 26% of the EU's final consumption in 2013 and 28% of this consumption comes directly from industrial processing [2]. This means that 7.3% of all energy consumed in the EU is dedicated towards F&B manufacturing. The five largest countries with regards to F&B production are Germany, France, Italy, Spain and the UK (United Kingdom), which account for 66% of the annual turnover. In order to study a large fraction of the EU F&B market for energy

efficiency and carbon dioxide equivalent (CO₂e) emission analysis, the GFS (GREENFOODS project) assessed companies from 6 member states (Austria, France, Germany, Poland, Spain, UK), which together accounted for almost 60% of the financial EU turnover in 2014 [1]. Through this study, a representative sample from the source of 4.3% of Europe's final energy consumption was assessed for energy efficiency and carbon reduction potential [1,2].

The role of SME (small and medium sized enterprises) is rather important in this context. The overwhelming majority (>99%) of the 285,000 companies in the F&B sector within the EU are deemed "SME," meaning that the companies employ less than 250 people and/or have an annual turnover of less than 50 million € [3]. The collection of EU SMEs contributes a share of 52% of the F&B turnover and 64% of the F&B employment (approx. 2.6 million), generating 99 billion € in value added in 2012 [1]. SMEs are in a difficult position, since their industry is fragmented in nature and information and technology adaption is rather slow, as competitors rarely inform each other of advancements to better their products

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Abbreviations

ACM	Absorption Chilling Machine	FRA	France
AUT	Austria	GER	Germany
BAFA	Federal Office for Economic Affairs and Export Control	GFS	The GREENFOODS project
Bev.	Beverage	GHG	Greenhouse Gas
C_{Factor}	Conversion factor from energy to tons of carbon dioxide equivalent	HP	Heat Pump
CHP	Combined Heat and Power	HR	Heat Recovery
CO ₂ e	Carbon Dioxide equivalent emissions	HSO	Heat Supply Optimization
COP	Coefficient of Performance	I	Investment Cost
CSO	Cold Supply Optimization	IEE	Intelligent Energy Europe
E_{input}	Input fuel consumption from audited companies	LED	Light Emitting Diode
E	Consumed energy from the audited companies	LHV	Lower Heating Value
EE	Energy Efficiency	NED	Netherlands
ESCO	Energy Services Company	OM	Operations and Maintenance
ESP	Spain	ORNL	Oak Ridge National Laboratory
η	Equipment efficiency	PBT	Payback Time
EU	European Union	PO	Process Optimization
EU25	25 European Union Countries	POL	Poland
F&B	Food and Beverage	PV	Photovoltaic
F&V	Fruit and Vegetable	SEC	Specific Energy Consumption
FP	Fuel Price	SHS	Solar heating system
		SME	Small and medium sized enterprises
		UK	United Kingdom

and production efficiency. In addition, due to the size of the companies and the low financial flexibility that comes with it, SMEs often cannot afford to invest in expertise in the area of production and resource efficiency as well as renewable energy integration. Often the awareness that inefficiencies even exist and how they can be reduced is missing. The available industry guidelines or best practices are generally only available for continuous production and large manufacturing sites [4], further limiting exposure and the potential for SMEs to reduce their energy consumption and carbon footprint. Due to this lack of information within SMEs, there are significant opportunities to increase their productivity in a resource efficient and sustainable way. As such, GFS targeted this group to perform energy consumption and production output audits, while determining which hindrances are experienced during potential energy efficiency retrofits, often called “Barriers”.

Within the F&B Sector, the branches with the highest turnover are Meat (20%), Beverage, which consists of beer, juice, soft drinks, and wine production (15%), Dairy (14%), Bakery (11%), and Processed F&V (Fruits and Vegetables) (6%) [5], and thus were a top target for study within GFS. Meat production has the largest environmental impact within the F&B industry, with the majority of energy expenditure occurring during production and processing [6]. The Beverage branch, and more specifically beer production, is dominated by SMEs (70%), employing nearly 2 million people (direct and indirect) while generating over 50 billion € in added value [7]. The EU Dairy branch, while not as big, still boasts more than 300,000 direct processing jobs, yielding 9.3 billion € in the EU trade balance [8]. European Bakeries hold strong, with nearly 100 billion € in revenues in 2012 while employing 1.36 million people [9]. The food and beverage sector is no doubt a powerful economic driver within the EU, however to achieve the Europe 2020 goals [10], the decrease of fossil fuel use and carbon dioxide emissions within this sector is of outstanding importance within the coming half decade.

Process integration, process intensification, and energy efficiency are now recognized as key drivers to reduce fuel consumption and to meet the regulatory demand of CO₂e emission

reduction goals of Europe 2020. A significant number of scientific and industrial studies have been conducted in this context [11–15]. It is agreed, that many companies require help from outside, which is directly reflected in the number of national and international research funds dedicated to the topic.

1.1. Energy consumption of food and beverage production

Food and beverage manufactures are or should be continually aware of their energy (fuel and electricity) consumption during the production of their product, as growing regulations and legal requirements require reduced energy consumption and carbon emissions. Energy use impacts product cost as well, though is generally less than 5% of the overall production cost [16] and is therefore of lesser concern. As such, significant efforts have been made to determine the SEC (specific energy consumption) for food and beverage products, referred to as a Benchmark, often reported in kilowatt-hours (thermal or electric) per product quantity required for its production. This is commonly done by conducting an energy audit at the production facility, determining the quantity of energy used within a certain time period or batch to make a product, then dividing this energy by the mass or volume of product created [17]. Table 1 shows a selected summary of studies which detail the SEC of food and beverage products within Europe and globally.

Table 1 indicates a wide range of SECs for similar products, both in the quantity and reporting measure. Some studies reported the individual thermal and electrical terms used to produce one ton of product, while others combined these values into one term. Those who did often followed Ramírez et al. [17] and calculated the primary energy demand by adding thermal energy to electrical energy, assuming a 40% electrical energy generation efficiency. While this process makes comparisons simpler, it reduces the reader's ability to determine if it is more thermally or electrically energy intensive. Nevertheless, the range of SEC values varied widely between different studies and different products. For example, in the Bakery branch in Europe, Le Bail [21] estimated primary SEC of

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