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THE CARBON FOOTPRINT OF A MEAT PROCESSING COMPANY

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ABSTRACT

Plans for mitigating greenhouse gas (GHG) emissions in the agri-food sector should not only include the production of agricultural raw materials but also the food processing industry. The aim of the research was to determine the carbon footprint of a meat processing enterprise and to analyze the intensity indicators of GHG emissions. The study was conducted in a medium-sized company, located in the Wielkopolska Province, for which pork is a basic feedstock for the production (over 81.0%). The results show that the largest GHG emissions were related to the consumption of electricity, natural gas and fuels in the transport of products. There were estimated values of several indicators of emission intensity. The main indicator of GHG emissions related to the unit of product was 519 g CO_2 eq. per 1 kg. It is concluded that the analysis of the carbon footprint can be an important instrument for the management of GHG emissions at the company level and can also serve the purpose of assessing the effects of implementing plans for a low-carbon economy in the meat processing sector.

Key words: carbon footprint, GHG emissions, climate change, food industry, transport, emission intensity indicators

INTRODUCTION

Adopted by EU countries in 2013, an action plan for the reduction of gaseous emissions in sectors, not covered by the emission trading scheme, requires a reduction of greenhouse gas (GHG) emissions by 30% by 2030 [European Council Conclusions 2014]. This means that the control of GHG emissions in the agricultural and food sectors should also be considered as an important instrument for supporting environmental management, aimed at mitigating the effects of climate change. In the context of the global increase in demand for food, efforts for emission reductions must focus on all places of the food production chain [Matthews et al. 2008].

Consumer demands and both international regulations and national ones require that sustainable methods of production and high quality environmental products be used [Communication… 2013]. Fulfilling the expectations of consumers and climate policies, companies operating in the agri-food sector must have new diagnostic tools and know how to use them in the evaluation of the environmental effects associated with production processes and manufactured products. To assess the GHG emissions associated with manufacturing processes, the method of the carbon footprint is increasingly used [Burritt et al. 2011]. Dissemination of its application in Poland will allow the monitoring of progress in the development of a low-carbon economy and to achieve long-term climate targets for the country.

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The relatively large load of GHG emissions are ascribed to animal products. Estimates of the FAO show that about 18% of global GHG emissions come from livestock production. The projection of doubling global livestock production by 2050 should be considered as a threat to sustainable development [Steinfeld et al. 2006]. The desire to reduce GHG emissions can not only focus on the agricultural sector of animal production. It should also include the link to the meat processing industry. In this respect, by integrating different chains of meat production, it is possible to comprehensively grasp emissions from other important stages of the life cycle of meat products.

Today, companies in processing industries in Poland are not required to simply record carbon flows. Currently, the best known international standard for connecting goals of the global climate policy with the recording of GHG emissions at the enterprise level is the greenhouse gas standard protocol developed by the World Resources Institute and World Business Council for Sustainable Development [The Greenhouse... 2004]. Reporting GHG emissions in the company is the most recognized form of environmental accountancy, which is also an important measure of a company's sustainable activity [Burritt et al. 2011].

The aim of the study was to identify, using the method of the carbon footprint, GHG emissions for the slaughter and meat processing company, acquiring basic raw materials entirely from the local market. Supplementary purpose of the research was to provide indicators of the GHG emission intensities for the studied company.

MATERIAL AND METHODS

Data for the analysis was acquired from the slaughter and meat processing plant located in the southern part of Wielkopolska. Source data came from existing documentation for the years 2013–2014. In terms of the number of employees, the company is ranked as medium-sized (over 240 people). The basic raw materials for processing is obtained from the local market by co-operating with a number of pig producer groups. Smaller quantities of slaughter material (18.3% of total use), in the form of poultry carcasses and quarters of beef, come from the wholesale market. The company has its own network of retail sales outlets and transport.

The analysis of the carbon footprint of the company was based on the methodology described in the GHG standard protocol for the organization [The Greenhouse... 2004]. The carbon footprint is a measure of climate warming potential of the company resulting from its high GHG emission of industrial processes. It is measured in kg CO_2 equivalents (eq.) It is calculated as the sum of the products of global warming potentials for individual GHG (kg CO_2 eq.$\cdot$kg^{-1} GHG) and emissions (kg). Global warming potentials for different gases have been identified in the IPCC report [Solomon et al. 2007]. They express the warming effect for a given GHG relative to CO_2 over a 100-year time horizon. Thanks to the equivalency factor approach is possible to compare and aggregate different types of emissions between enterprises and products. In the primary agricultural production and processing of agricultural raw materials, the most important gaseous compounds in GHG emissions are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

The key issue in the method used is to determine first the organizational boundaries and then – operational limits of the company. For large businesses with a complex organizational structure and ownership bringing together a wide variety of enterprises, emissions from different enterprises are consolidated at the corporate level in proportion to its capital share or the degree of financial control in dependent companies. In a further step, there are determined operational limits of the analyzed companies, which include those activities in which it is possible to identify emissions with a specific production activity. The registration of emissions is carried out in three different scopes, depending on the degree of feasibility of its control. Scope 1 includes direct GHG emissions of the company. Scope 2 embraces the emissions of the production stage related to the generation of electricity which is used by the company. Scope 3 is an optional step. It brings together all the other indirect emissions. The cause of their creation is a business activity of the production company that purchases certain materials for production and then sells their finished products to distribution networks. At this stage, intermediate load emissions could also apply to the phase of product use and the final waste management.

Direct emissions of GHG included in scope 1 are generated as a result of:

- the combustion of fossil fuels in stationary furnaces, boilers or turbines;
- chemical and physical processing;
- transport of raw materials, products and waste, provided they have their own means of transport or control their use in the company;
- emissions of volatile compounds from installed different devices on the company premises, mostly from refrigeration equipment and air-conditioning.

Emissions registered under scope 2 of company inventory are related to electricity, which is used by the machinery and electrical equipment owned by the company or by being under its control. This is the category of indirect emissions. By investing in new technologies with greater energy efficiency, companies have the potential to reduce electricity consumption and related GHG emissions.

Emissions whose place of origin is not already assigned to scope 1 or 2 fall under scope 3. A full catalog of sources of such emissions include:

- extraction of raw materials and production of materials used later by the processing company;
- transportation services provided by an external body, e.g. transport of fuel purchased, transport of input materials, employee travel to and from the workplace, transport of final products and wastes by external entities;
- extraction, production and transport of fuels to power generators in the company;
- consumption of products and waste management;
- outsourced services, and also leased equipment in case of operating leases or of possessing the financial control of the company or equity shares. Due to narrowly defined reporting boundaries for the company, emissions in this scope were not quantified.

In the analyzed company, catalogued direct emissions were from:

- the consumption of diesel, gasoline and motor oil in road transport;
- consumption of natural gas by gas boiler, c) consumption of diesel by the power generator;
- consumption of LPG by forklifts for gas;
- the loss of refrigerants with properties of greenhouse effects during the operation of the cooling system (due to a leak or system failure). Indirect emissions accounted for GHG emissions associated with the consumption of electricity for driving various machinery and electrical equipment in the company.

Emissions of N_2O from fuel and CO_2 from motor oils in road transport were calculated based on an algorithm appropriate for a Tier 2 of GHG inventory [EMEP/EEA... 2013]. Its structural elements were: categorization according to the characteristics of the vehicle type, fuel type and engine technology, the number of kilometers driven in the year by the vehicles of a given category and N_2O emission factors ($g \cdot km^{-1}$). Emission of CH_4 was calculated on a more detailed basis, corresponding to a Tier 3 methodology IPCC [IPCC 2006]. Emissions of GHG from the combustion of natural gas was calculated based on the amount of energy contained in the fuel purchased (kWh) and emission factors for CH_4, N_2O and CO_2 from stationary combustion sources in the sector of processing industry based on a Tier 1 approach [IPCC 2006]. These emission factors were, respectively: 1 kg CH_4 $T \cdot J^{-1}$, 0.1 kg N_2O $T \cdot J^{-1}$ and 56,100 kg of CO_2 $T \cdot J^{-1}$ net calorific value. Greenhouse gas emissions attributed to the combustion of LPG by forklifts was calculated based on the amount of consumed gas and emission factors specified for Tier 1 in the processing industry using non-road mobile machinery. According to IPCC data, emission factors for CH_4, N_2O and CO_2, per 1 t of consumed LPG were respectively: 354 g, 161 g and 2,990 kg [IPCC 2006]. Occasional use of the power generator also contributed to GHG emissions. In this case, emissions were calculated by using data based on: the amount of diesel fuel, fuel density, calorific value and emission factors. They refer to stationary sources of diesel fuel combustion, including power generators in the processing industry for Tier 1, and whose emission factors for CH_4, N_2O and CO_2 are equal, respectively, to 3 kg $T \cdot J^{-1}$, 0.6 kg $T \cdot J^{-1}$ and 74,100 $T \cdot J$ kg^{-1} [IPCC 2006]. The refrigerants R507 and R407C, present in the company refrigeration system, were also included in the recording of GHG emissions. Of particular importance is their influence on the creation of the greenhouse effect which is underlined by high global warming potentials (GWP) of 3,900 and 1,774 kg CO_2 eq. respectively [Gutkowski and Butrymowicz 2015].

RESULTS AND DISCUSSION

The total GHG emissions of the analyzed company is presented in Table 1. In accordance with the requirements of GHG protocol of corporate accounting and reporting standard, emissions were split into two distinct scopes. Approximately 60% of GHG emissions were concentrated in scope 2. Indirect emission that falls into this scope involves total consumption of electricity in the company used mainly for the propulsion of machinery and meat processing equipment, smokehouses and refrigeration units.

Table 1. Annual GHG emission for the analyzed slaughtering and meat-processing firm

Specification	GHG emission	
	Mg CO_2 eq.	%
Scope 1	973	39.9
Scope 2	1 469	60.1
In total	2 442	100.0

Source: Own calculation.

A possibility of reducing emissions by the company in this area will be associated with the improved energy efficiency of installed equipment which usually occurs as a result of modernization works induced by technological development in the meat industry. In the future, the projected changes in the intensity of CO_2 emissions in the Polish power industry, from 0.95 to 0.70 kg $CO_2 \cdot kWh^{-1}$ in 2030, will be the additional cause of reducing emission processes in the food processing industry [IEA 2011]. The analyzed company has a network of retail sales of their own products. Freight operations, from the place of production to a shop network, are carried out by the transport department. Transport activity generates about 11% of total GHG emission of the company (Fig.).

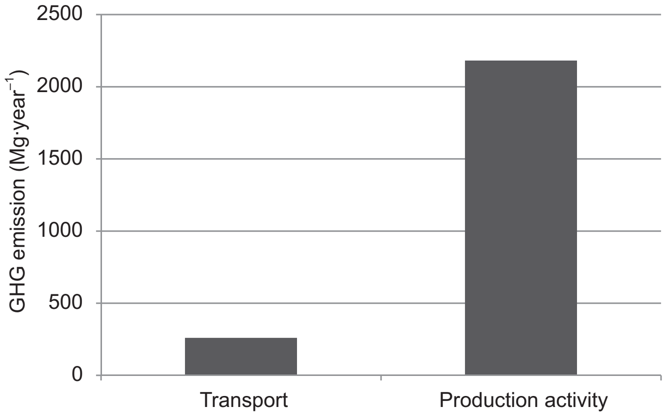

Fig. Annual GHG emission according to company's main activities

Source: Own calculation.

It is estimated that the transport of food products throughout the world is responsible for generating more than 11% of GHG emissions attributed to the production of food [Weber and Matthews 2008]. The total level of GHG emissions in the company is mainly determined by emissions which are associated with direct production activities. Detailed analysis of emission sources within the company indicates that the largest GHG emissions could be assigned to electricity consumption, then consumption of natural gas in the production process and fuel use in transport activity (Table 2).

Table 2. Emission structure according to different sources of emission in the company

Type of activity	Emission source	Share (%)
Transport	product distribution	8.2
	duty trips	0.6
	other uses	1.9
Production activity	electricity use	60.1
	electricity generation	0.1
	cooling system	0.4
	use of natural gas for heat and technological steam production	28.6
	use of LPG	0.1

Source: Own calculation.

Taking into account different sources of emission, GHG emissions related to electricity used was more than two-fold higher than the GHG emissions from the combustion of natural gas. Third in ranking order was emissions from product distribution with a much lower share in total emissions of the company, compared to two major components of total emissions. All other sources of emissions were marginal (3.1%) in the general emission load of the company. By incorporating knowledge of the structure of emission sources into emissions management, important information can be obtained for setting up priority directions of investments to improve the efficiency of electrical appliances and management of processing operations, which at the same time altogether reduce their impact on the GHG emissivity.

In the ongoing company activity, measuring progress in limiting emissions, which would correspond with national and sectoral plans for a low-carbon economy, is not possible without analyzing indicators of emission intensity. They describe most frequently the impact of GHG as expressed per unit of production or unit of economic effect. Intensity indicators calculated per physical units of production are useful for conducting comparative analysis of different companies operating in similar sectors of the economy which provide similar products. Decreasing values of GHG emission intensity over time indicates an improvement of production processes with regard to more efficient use of energy sources. In the case of the company analyzed, the emission intensity was defined by a set of several basic indicators (Table 3).

Emissions of GHG indicator related to 1 kg product was equal to 519 g CO_2 eq., while when calculated per 1 kg of slaughtered meat it was lower and amounted to 460 g CO_2 eq. The process of slaughtering and meat processing was accompanied by the emission of more than 485 g of CO_2 per 1 kWh of energy consumed. In China, the estimated emission intensity across the whole sector of processing of agricultural raw materials amounted to 468 g of CO_2 per 1 kWh energy intake [Lu and Price 2012]. However, it cannot be directly comparable with the intensity indicator of the analyzed company, because the emission intensity quoted for China

Table 3. Intensity indicator of GHG emission for the analyzed company

Indicator	Unit	Value
Indicator of GHG emission linked to production and transport of 1 kg of products in total	g CO_2 eq.·kg^{-1}	519.1
Indicator of general GHG emission per 1 kg of slaughtering materials	g CO_2 eq.·kg^{-1}	460.3
Indicator of GHG emission associated with the production per 1 kWh of energy use in the production process	g CO_2 eq.·kWh^{-1}	485.4
Indicator of GHG emission per 1 tkm	g CO_2 eq.·tkm^{-1}	45.2
Indicator of general GHG emission per 1 person employed	g CO_2 eq.·$person^{-1}$	10 134

Source: Own calculation.

comprised entirely of both processing of raw plant and animal materials. The usefulness of this indicator in managing the GHG emissions is underlined by the fact that one of the objectives of China's strategy for reducing CO_2 emissions is to reduce the emission intensity of the national economy by 40% by 2020 compared to the level in 2005. Distribution of food products also exerts an essential influence on GHG emissions because of the need to transport great quantities of commodities to a widespread network of sales points often over long distances. The suitable index representing emission intensity in transport is GHG emissions per 1 tkm (tkm represents 1 t of cargo transported over the distance of 1 km). In the analyzed company this indicator amounted to 45.2 g CO_2 eq. The calculated value was well below the recommended level of emission intensity for road transport, being equal 62 g CO_2·tkm^{-1} [McKinnon and Piecyk 2011]. This result points to a certainly good utilization of loading capacity of commercial vehicles in the company and to a shortened supply chain through the transport of products directly from the company to a network of stores.

CONCLUSIONS

In order to determine the GHG emissions generated across the whole meat processing company, the method of the carbon footprint has been applied. It has been shown that, when having access to a company's documentation containing information on the consumption of energy carriers and to the detailed data from the company transport department, it is possible to estimate the carbon footprint in accordance with an international protocol of recording GHG emissions in enterprises.

It is easier for management to consider the economic costs of new solutions for modernization work directed at reducing emissivity of processes against expected production effects if different cross sectional data on company's GHG emissions is available. Such information facilitates the development planning if the company has in its business strategy also the efficiency improvements of new projects in mitigating GHG emissions. The results of the research and the carbon footprint of companies will also provide a basis for increasing their competitiveness in the market in the future.

The emission effects of a company are related to a specific type of production, technology and volume of production. Synthetic assessment of the state of GHG emissions in enterprises is not possible however without linking emissions with specific characteristics of production. Better recognition of energy use and GHG emissions accompanying the various places of technological process makes it easier to identify the potential for reducing emissions and increase energy efficiency in the most critical areas of manufacturing processes.

An important instrument for managing GHG emissions in the company are indicators of emission intensity. Their use gives a possibility to track changes in emission levels in connection with a scale of production and technology in the long-term perspective. They can be useful at the level of environmental policies, focusing on development of a low-carbon economy, and for evaluations of the effectiveness of climate policy in various industrial sectors. On this basis, the company will gain a better understanding of the distance, in terms of actual emission intensity, from the reference values of the indicators adopted as the benchmark for specific industries. Indicators of this type can also be used by the National Center for Emissions Balancing and Management (KOBiZE), which is obliged by law to the development and analysis of emission indicators per unit of manufactured goods, fuel consumed or raw material used.

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ŚLAD WĘGLOWY PRZEDSIĘBIORSTWA PRZETWÓRSTWA MIĘSNEGO

STRESZCZENIE

Plany mitygacji emisji gazów cieplarnianych (GHG) w sektorze rolno-spożywczym powinny obejmować poza produkcją surowców rolniczych również przemysł przetwórczy żywności. Celem badań było wyznaczenie śladu węglowego przedsiębiorstwa przetwórstwa mięsnego oraz przeprowadzenie analizy wskaźnikowej intensywności emisji GHG. Badania przeprowadzono w przedsiębiorstwie zaliczanym do grupy MŚP, położonym w województwie wielkopolskim, wykorzystującym w produkcji głównie surowiec wieprzowy (ponad 81,0%). Wyniki badań wskazują, że największe emisje GHG były związane ze zużyciem energii elektrycznej, gazu ziemnego oraz paliw w transporcie produktów. Oszacowano wartości kilku wskaźników intensywności emisji. Podstawowy wskaźnik emisji GHG odniesiony do jednostki produktu wynosił 519 g CO_2 ekw. na 1 kg. Analiza śladu węglowego może być ważnym instrumentem zarządzania emisjami GHG na poziomie przedsiębiorstwa oraz może także służyć ocenie realizacji planów niskoemisyjnej gospodarki w sektorze przetwórstwa mięsa.

Słowa kluczowe: ślad węglowy, emisje GHG, zmiany klimatu, przemysł spożywczy, transport, wskaźniki intensywności emisji