Carbon footprint calculator for textile and clothing sector: development, application and validation

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INTRODUCTION

Climate change is the most pressing issue of our times, constituting one of the greatest environmental, social and economic threats. The industrial sector, especially the Textile and Clothing Sector (TCS), has an important role once is characterized to be the fourth in terms of negative impact on the environment and climate change (Roth et al., 2023). The waste produced associated with the low recycling rate, high consumption of water, energy and chemical products as well as the emission of microplastics into the oceans are critical aspects of the production process (Aitex, 2021). Therefore, the decarbonization of the sector is fundamental to achieve the objectives identified in the Roadmap for Carbon Neutrality 2050 and in the National Energy and Climate Plan 2030 (Presidency of the Council of Ministers, Resolution Nº 53/2020). An activity, process, product or service is considered carbon neutral when all Green House Gases (GHG) emissions from the activity are properly quantified, and an environmental compensation action is carried out in the same proportion (IPCC, 2021). The knowledge of the environmental impact will allow to make the processes more efficient, consuming fewer resources, but guaranteeing the quality and characteristics of the products. Thus, the motivation for this study relies in two major factors: firstly, realizing how to make textiles more environmentally sustainable, therefore, improving the environmental participation of this sector, and secondly, replying to global and community demands, which are reflected in the protocols and decree-laws. The main objective was to develop a carbon footprint calculator (FC) applied to the TCS, which allows the evaluation and classification of its activities and/or products, regarding their environmental impact. Moreover, it was intended to apply the FC to two real cases, one from the textile sector, the other from the clothing sector, and validate the calculator through the self-assessment method (by comparison).

METHODOLOGY

In the first phase a survey of the various environmental components and indicators was carried out, to define which ones to use in the calculator. Once the indicators were identified, the associated emission factors were selected, and Portuguese data were used whenever possible. The FC calculator followed the GHG Protocol methodology and was developed using Microsoft Excel, applied on the product life cycle assessment (LCA). The emissions of the 3 scopes were considered (1, 2 and 3). Those associated with the energy components (includes the cogeneration process), transport (raw materials, finished products and people), and water capture, were considered in scope 1. Scope 2, associated with the electricity component, and scope 3, associated with the value chain emissions namely impacts related with public water consumption, wastewater, transport of people, raw materials and finished products by third parties, business trips (includes overnight stays), waste and end-of-life treatments. The calculator also allows to quantify avoided and offset emissions. Avoided emissions associated with the production of electricity through renewable sources (e.g. photovoltaic panels) and recovery/reuse of waste, compensated with the planting of trees. The calculator was applied to two companies, one from the textile sector (A) and the other from the clothing sector (B). The calculator was validated using the self-assessment method, that is, by comparing it with two calculators available online, the Greenhouse Gas Emissions Calculator (GGEC), developed by the United Nations Climate Change (https://unfccc.int/documents/271269?gclid=EAIaIQobChMIsOzv_7algwMVElJBAh1OyQsVEAAYASAAEgIdr_D_BwE) and the Huella de Carbono de una Organización (HCO), developed by Spanish Ministry for Ecological Transition (https://euro-funding.com/es/servicios/huella-de-carbono/). It was possible to compare the components energy, transport (products and people) and electricity with both calculators, but for the components water, wastewater, raw materials, business trips (includes plane trips and overnight stays) only with the GGEC calculator.

RESULTS

The calculator was applied to two companies, one from the textile sector (A) and the other from the clothing sector (B). For Company A, the total carbon footprint was 10 kt CO_2e and 188 t CO_2e for Company B. For company A, scope 1 emissions contributed 78%, scope 2 emissions contributed 15%, scope 3 with 7% and avoided emissions with 1% for the company's final footprint. For Company B, scope 1 emissions contributed 16%, scope 2 emissions

contributed 35% and scope 3 emissions contributed 49% to the final footprint. The largest contribution, in the case of Company A, was the consumption of natural gas (76%) while for B it was waste (38%).

In the self-validation process of the calculator, it was showed a similarity with the HCO calculator for both Companies, in terms of transportation (Table 1).

Table 1. Results for self-validation process

Component		Quantity	PC Calculator	GGEC	HCO
			Emissions (KgCO2e)		
Company A					
Energy	Natural gas (m^3)	2 805 901	6 161 927	5 671 708	----
	Biomass (kg)	2 762 874	82 886	170 794	377 591
Road Transport	Diesel (L)	73 073	175 160	-------	165 573
Electricity (kWh)		7722395	1 541 390	1 758 718	1 953 766
Company B					
Road Transport	Diesel (L)	12200	29 244	-----	27 643
Electricity (kWh)		405 148	66 444	92 270	68 470

Analyzing the data obtained with the FC calculator for both Companies, it is shown that the results are lower than the obtained by others, with the exception for the energy component (consumption of natural gas), and wastewater. The difference is related to the Emissions Factors (EFs) considered in the calculators, which, in most of the components (natural gas, electricity, waste, end-of-life treatment, wastewater), were calculated from Portuguese data, therefore, representing more realistic results. Accordingly, the calculator is a useful tool for this sector corporations to estimate and monitor their emissions and thus define measures that allow to reduce or offset their carbon footprint. With the self-assessment, it is concluded that the EFs used influence significantly the carbon footprint results.

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