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Industrial Alliance for Reducing Energy Consumption and CO_2 Emissions

IND ECO

Ind-Eco Contract IEE/11/949/SI2.615946

WP2	Inventory and Benchmarking
Task 2.3	Benchmarking definition
Deliverable 2.3	Benchmark for energy performances in tanning and footwear industries – Footwear benchmarking
Date	31st July 2013 (V3) + April 2015 introduction of grading in the last pages (V4) + June 2015 introduction of logo and disclaimer in cover page (V5)
Deliverable responsible	CTCP

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1. Summary

This document aims to reply to deliverable 2.3 - Benchmark for energy performances in tanning and footwear industries.

For this purpose in a first stage the Ind-Eco Consortium developed, on task 2.2, two inventories directed to this sectors – footwear and leather manufacturers. In a second step, to facilitate and widespread the collection of a larger number of inventories, CTCP developed two on-line tools that are user friendly and are accessible to be filled up by tanning and footwear companies in an easy way (INDECO – FOOTWEAR, http://indeco.ctcp.pt/login.asp & INDECO-LEATHER http://indeco-leather.ctcp.pt/login.asp). These tools also include a private session to be used by Ind-Eco partners for manage and analyze the inventories data.

To complement and support the definition of Benchmark for energy performances in tanning and footwear industries the Ind-Eco consortium done an exhaustive literature review on energy efficiency and energy consumer in footwear and leather industries field.

In this way this document include the literature review, Ind-Eco Inventory Results analyzes and benchmarking definition.

2. Introduction to greenhouse gas emissions calculation

Nowadays, "global warming", "climate changes", "greenhouse gas emissions" are current issues of discussion among worldwide population. In the last years we assisted to a technological and industrial growth that may contribute to accelerate the climate changes. But, just recently we understood the negative impact and consequences of these climate changes and "sustainability growth" was included in our vocabulary.

Kyoto Protocol, approved in 1997 and implemented in 2005, is an international treaty that sets binding obligations to adhering industrialized countries to reduce emissions of greenhouses gases (GHG). This protocol recognized that developed countries are the main responsible for the GHG emissions and global warming due the industrialization.

European member states established a set of measures to reduce the emissions of GHG up to the year of 2020:

- Reduce the emissions of global greenhouse gases in a percentage of 20% (relatively to the year of 1990);
- Increase the use of renewables in a percentage of 20% in EU energy consumption.
- Reduce in 20% the energy consumption by increasing the energy efficiency.
- Establish individual objectives to reduce the emissions from buildings, transports, agriculture, and wastes in 10% (relatively to the year of 2005).

2.1 Greenhouse gases

Kyoto Protocol establishes the reduction of 6 greenhouse gases emission, namely:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorcarbons (HFC)
- Perfluorcarbons (PFC)
- Sulfur hexafloride (SF_6)

The Global Warming Potential measures the contribution of an amount of GHG to the global warming in a certain period of time. All gases are compared to carbon dioxide (CO_2).

Table 1. Global Warming Potential

GHG	GWR (CO_2e)
CO_2	1
CH_4	21
N_2O	310
HFC	140-11.700
PFC	6.500-9.200
SF_6	23.900

Source: NIR 2010

2.2. Operational limits

In a company is necessary to consider the operational limits. The definition of these limits involves the emission identification in each operation. The emissions can be classified as direct and indirect emissions.

- **Direct GHG emissions** are from sources that are owned or controlled directly by the company.
- **Indirect GHG emissions** are emissions that are a consequence of the activities of the company, but occur at sources owned or controlled by another company.
- **Other indirect emissions** are important emissions for the company business, but occur at sources that aren't owned or controlled by the company (e.g. extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the company, electricity-related activities, outsourced activities, waste disposal, etc.)

Table 2. Example of operational limits of a footwear company.

DIRECT EMISSIONS	INDIRECT EMISSIONS	OTHER INDIRECT EMISSIONS
Stationary combustion – Own production of heat, vapor or electricity • **Boilers** • **Ovens** • **Heaters** • **Other** Mobile Combustion • **Cars** • **Trucks** • **Forklifts** • **Other** Production process • **VOCs emissions** Emergency generators Refrigeration systems	Electric energy consumption	Activity transport • **Transport of raw materials to companies** • **Transport of final product** • **Business travel** Waste treatment Effluent treatment Water consume Raw materials

2.3 Methodology to calculate GHG Emissions

2.3.1 Direct Emissions

a) TRANSPORTS - MOBILE FUEL

STEP 1. Conversion of fuel volume (l) to weight (tons)

$$Activity\ data\ (tons) = Density\ \left(\frac{kg}{m^3}\right) * Activity\ data\ (l) * 10^{-3}$$

STEP 2. Energetic conversion to Gigajoules (GJ)

Table 3. Energy conversions

FUEL Type	Unit		GJ
Petroleum derivatives			
GPL (Butane, Propane and gas)	1	ton	46.00
Gasoline's (additive, lead free and aviation)	1	ton	44.00
Diesel (road e colored)	1	ton	42.60
Natural gas	10.000	Nm^3	38.60
Renewable			
Firewood	1	ton	10.47
Vegetable waste	1	ton	14.65
Municipal Solid Waste	1	ton	7.04
Bleaches/liqueurs sulphitic	1	ton	12.14
Biogas	10.000	Nm^3	23.03

Source: *DGEG, 2010*

STEP 3. Calculation of emissions by type of GHG (CH_4, CO_2, N_2O)

$$Emission_{GHG} = Activity\ data\ (TJ) * EF_{GHG}$$

$Emission_{GHG}$ Emissions by type of GHG (kg)

EF_{GHG} Emission factor by type of GHG (kg/TJ)

STEP 4. Calculation of total emissions in CO_2e

$$TE_{CO2e} = \sum Emissions\ GHG * \ GWP_{GHG}$$

TE_{CO2e}	Total Emissions (kg CO_2e)
$Emissions_{GHG}$	Emissions by type of GHG (kg)
GWP_{GHG}	Global Warming Potential of GHG

Formulas and data to calculate namely the following emissions are also available in the literature:

b) OWN GENERATION OF ELECTRICITY, HEAT, STEAM STATIONARY COMBUSTION;

c) PROCESSING EMISSIONS (NMVOC).

2.3.2 Indirect Emissions

$$Emissions_{GHG\ Electricity} = Activity\ data * EF$$

Activity data	Electricity consumption (GHh)
EF	Emission factor for electricity (ton/GWh)

2.3.3 Other Indirect Emissions

a) ACTIVITIES RELATED WITH TRANSPORT

Transports have an important contribution to the GHG emissions. We can include the following activities in this category:

- Transport of raw materials to the company;
- Transport of final product;
- Commuting travels (house-work-house);
- Businesses travel.

The calculation of emissions related with this type of transport is based on the distance (km) instead of the fuel consume due to the difficulty in getting these data.

b) RAW MATERIAL

GHG emissions that result from the raw materials may be accounted in two ways:

- Energy incorporated in the materials (amount of energy needed to produce the materials);
- Emission of NMVOC from the production process of the materials.

$$Emissions_{RM} = EF * Activity\ data$$

Formulas and data to calculate namely the following emissions are also available in the literature:

c) WASTE TREATMENT

d) WATER CONSUMPTION

3. Footwear and Energy Efficiency: Case Studies

3.1 Case Study 1: PAKLIM and Adidas Sourcing Ltd

The studies about energy efficiency in footwear sector are very limited in literature. Recently footwear companies started to pay attention and understand the importance of energy efficiency for the costs reduction and environment.

The German – Indonesian cooperation program in the framework of "Policy Advice for Environment and Climate Change (PAKLIM)" established a partnership with Adidas Sourcing Ltd to realize a study to improve the energy efficiency in apparel and footwear industry.
In table 4 is presented a summary of 3 case studies (PT Shyang Yao Fung, PT Glostar Indonesia 2, PT Panarub Industry) done in this program with footwear manufacturers. From the results of these studies is possible to conclude that electricity is the principal source of energy consumption and motors the most important energy consumers. In this study were also identified good practices actions to save energy (reduction of energy consumption) as:

- substitution of motors to motors servo;
- substitution of normal fluorescents to LED lamps;
- improvement of automation level;
- reduction/minimization of compressed air leaks.

PT Panarub Industry conducted a pilot study to determine the energy savings by substituting the standard fluorescent lamps by LEDs. Table 5 establishes a comparison between the use of these lamps and table 4 the annual cost saving due to retrofitting of LED lights.

Table 4. Case studies of energy efficiency and savings in footwear manufacturer companies.

Company	General information	Primary energy	Energy Consumption	Good Practices	Savings
PT Shyang Yao Fung Footwear Manufacturer	Employees – 3859 Operators – 3355	Electricity	Motor – 58% Compressed air – 15% Lighting – 11% Air conditioning – 11% Other – 5%	Change of induction to servo motors. Elimination of compressed air leaks. Energy saving awareness campaign to motivate the employees.	> 70% 10% ---
PT Glostar Indonesia 2 Footwear Manufacturer	---	Electricity	Motors – Majority of energy consumption	Involvement of employees in energy efficiency. Improvement of the level of automation	--- 16% EnPI: 3.37 (2011) & 2.83 (2012) Energy saving of 2.7 GWh (more than IDR 1 billion in 2012)
PT Panarub Industry Sport shoes manufacturer	Production in 2011: 11 million pairs Staff – 10939	Electricity	Machine – 48% Air compressor – 10% Extraction fume – 8% AC – 8% PC computer – 7% Lamps – 8% Chiller – 5%	Replacement of fluorescent lamps in the production area with LED lamps	Electricity cost reduction IDR 450 million

Table 5. Saving calculation by substituting standard fluorescent lamps by LEDs.

Parameter	Unit	Standard Fluorescent	LED
Electricity consumption	W/unit	50	20
Number of lamps	Unit	8000	8000
Operation time	Hours/year	2760	2760
Power Consumption	MWh/year	1104	442
Lifetime	Hours	10000	50000
Operational Cost (including cost of electricity and maintenance)	IDR [*1000]	788497	300288
Depreciation cost	IDR/year [*1000]	37536	99360
Total cost (operational cost + depreciation cost)	IDR/year [*1000]	826033	399648
Total savings	Annual energy savings (MWh)		662
	Annual cost savings (million IDR)		426,385
Total project cost (million IDR)			1600
Payback on investment (years)			3.7
Annual reduction in CO_2 emissions (tonnes)			520

3.2 Case Study 2: EEPEX project

In EEPEX project (2005-2008) Adidas group conducted a study in the environmental framework in 5 countries (Germany, USA, Canada, Japan, China). In table 6 are presented the data for average resource consumption of Adidas production between 2005 and 2008. The average energy use in these years was 2.75 ± 0.27 (kWh/pair). The water waste was reduced in 47% (from 0.057 to 0.03 m^3). The average VOC in these 4 years was 20.3 ± 0.7 (g/pair).

Table 6. Average Resource Consumption of Adidas Production based in 2005-2008.

Average resource consumption/ pair of sport shoes	2008	2007	2006	2005
Energy use (kWh/pair)	2.76	2.93	2.36	2.93
Waste water (m^3/pair)	0.03	0.034	0.045	0.057
Average VOC (g/pair)	21.1	20.3	19.3	20.5

3.3 Case Study 3: Timberland

Timberland defined as goal the decrease of CO_2 emission. In 2001 made its first inventory of GHG emissions and in 2003 realized an extensive inventory. In 2007 Timberland developed the Green Index to compare the environmental impact of their shoes. Total emission values are converted in a scale of 0 to 10 and this numbers represent GHG emissions between 0 - 100 kg CO_2e/pair. Table 7 summaries the resulting data of carbon footprint.

Table 7. Timberland carbon footprint data.

1º Inventory (2001)	Extensive inventory (2003)	Main emissions	Green Index (2007)	Emissions of CO2/pair of shoes (defined)
Energy consumption of: - Officers - Stores - Fairs - Business travels	Energetic consumption of logistic, distribution and sales	Business travels	Measures the GHG emissions from raw material extraction to final product Timberland uses the GaBi software to estimate total GHG emissions in CO_2e.	< 2.49 kg

3.4 Case Study 4: Nike

Nike performed its first carbon footprint in 2002 and established the goals to reduce greenhouse gas emissions. Nike eliminated SF_6 gas of its shoes and reduced the CO_2 emissions in 18%, between the years 1998 and 2005.

In 2007 and 2009, Nike evaluated its energy consumption and GHG emissions, concluding that material production is the most important contributor for energy consumption.

In 2008 and 2009, Nike reduced the emissions by pair of shoe in 14% despite the 9% production increase.

Table 8. Nike energy consumption data.

Energy consumption of running shoes	CO_2/pair of running shoe	Results in 2008/2009
Materials - 59% Production - 22% Transport - 10% If materials energy was excluded 62% of emissions are associated to production	18,14 kg CO_2 /pair	Emissions reduction in 14% with a production increase of 9%.

3.5 Case Study 5: PUMA

Puma understood the importance of the need to take measures for the energy efficiency and use renewable resources due to climate changes. In 2007, Puma initiated a process to minimize its contribution to environmental impact and decrease the electricity consumption. For the emissions Puma considers electricity consumption and products transportation. In 2008, Puma energy consumption achieved 1.76 kWh/pair of shoes and CO_2 total emissions of 0.95 kg/pair. This value corresponds to a decrease of 12% since 2005.

3.6 Case Study 6: ECOSHOES

Ecoshoes is Brazilian partnership between Chemical Faculty of Catholic University of Rio Grande do Sul (PUCRS) and the footwear sector to produce footwear that respond to strict criteria of environmental responsibility. This project intends to optimize the footwear production process in each stage.

In this project the emissions values determined for generic shoes was 2.02 kg CO_2e and for alternative shoes of 1.25 kg CO_2e.

3.7 Case Study 7: "Portuguese Shoes"

Portuguese Footwear sector performed a first estimative of emissions associated to shoe production in Portugal based on a preliminary approach and a general sector characterization. This study is just a bottom line that needs to be deepened to obtain the reality of energy consumption and GHG emissions of Portuguese footwear.

Footwear carbon inventory was performed based on ranges of indicators of fossil fuel consumption, electricity and VOC emissions per pair of shoes. These ranges were compared with GHG emissions estimated based on indicators available in literature and studies performed in the sector.

In this first Portuguese footwear inventory were defined the indicators that are in table 9.

Table 9. Portuguese Footwear sector indicators in 2009

Indicator	Lower limit	Upper limit
Total GHG emissions per pair of shoes	0.91 kg CO_2e /pair	1.34 kg CO_2e /pair
Total emissions of GHG per gross of production	0.04 kg CO_2e /€	0.07 kg CO_2e /€
Emissions associated to energy (fossil fuel and electricity) per pair	0.66 kg CO_2e /pair	1.08 kg CO_2e /pair
Emissions associated to energy (fossil fuel and electricity) per pair	0.03 kg CO_2e /€	0.05 kg CO_2e /€
Emissions associated to final product transportation per pair	0.08 kg CO_2e /pair	0.08 kg CO_2e /pair

3.8 Indicators summary

Table 10 presents a summary of footwear GHG emissions values determined in the case studies reported before.

Table 10. Indicators of GHG emissions per pair of shoes.

Case Study	GHG emissions	Reference year
EEPEX project	2.76 KWh/pair	2008
Timberland	2.49 Kg CO_2/pair	2009
Nike	18.14 Kg CO_2/pair	2009
Puma	0.95 Kg CO_2/pair	2008
Ecoshoes generic	2.02 Kg CO_2/pair	--
Ecoshoes alternative	1.25 Kg CO_2/pair	--
"Portuguese Footwear"	Lower limit: 0.91 Kg CO_2/pair Upper limit: 1.34 Kg CO_2/pair	2009

4. Indeco Energy Performance - Footwear

This point is dedicated to the definition of benchmark for energy performances in footwear sector. For this analyse were used the results of about 200 inventories that were filled up in Portugal, Spain, Romania and Bulgaria, Italy and United Kingdom by footwear manufacturer companies. As referred before this inventory was developed by IND-ECO consortium, integrating 3 set of questions:

- Global characterization of the company (number of employees, working yours, nº of sifts, etc);
- Product & process characterization (type of product and constructions, number of produced pairs, etc);
- Energetic consumption.

4.1 Ind-Eco Inventory results

I - Global Characterization

Despite the simplification of inventories and the interest in the energy saving and energy efficiency issues is was still a hard task to motivate the one company spending some time on filling up this type of questionnaires. In this way the Ind-Eco research partners contacted several footwear companies and supported them in the inventories filling up to assure the quality of data. In total, as referred before, were filled up about 200 inventories. Figure 1 shows the distribution of the company's number (study sample) that filled up the inventory in each country.

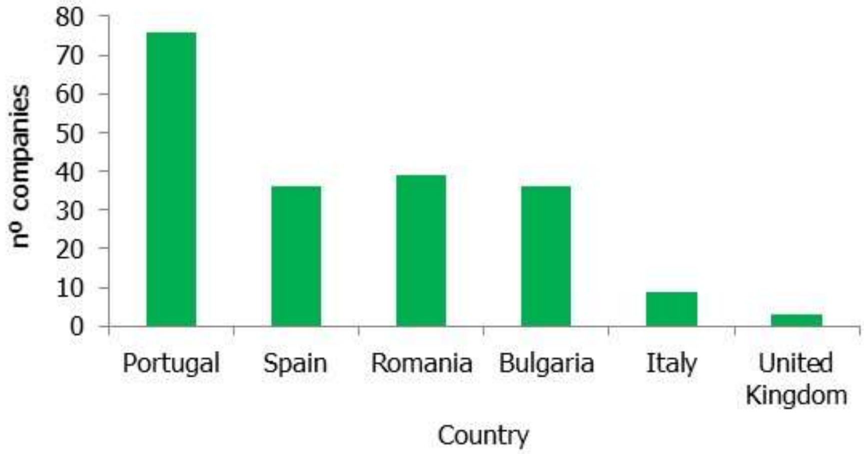

Figure 1. Number of companies that filled-up inventories in each country.

The interest and concerns about energy efficiency is growing among scientific and industrial community mainly due to energy cost increasing and environmental and social impact. Also, worldwide population, mostly in developed countries, are more informed, concerned and conscious about the impact of energy resources consumption and GHG emissions on environment and people healthy.

Footwear manufacturer companies are taking the first steps in the field of energetic efficiency and carbon footprint. Footwear sector is aware to the importance and the potential impact of the rational of energy on cost savings and environment. They also are conscious that it is necessary to make some investments, have qualified people, monitoring, etc.

Table 11 presents the number of companies in each country that has a person responsible for energy efficiency and that meet the standards ISO 9001, ISO 14001 and EMAS.

Table 11. Number of companies that has a person responsible for energy efficiency; ISO 9001, ISO 14001 and EMAS.

Country	Person responsible for energy efficiency	ISO 9001	ISO 14001	EMAS
Portugal	5	6	1	0
Spain	1	1	0	0
Romania	3	9	2	0
Bulgaria	0	2	0	0
Italy	0	0	1	0
United Kingdom	1	0	0	0

In Europe, footwear and allied trade (materials and components) are traditional industrial sectors that involve a large majority of perseverant SME's that in the last two decades reinvented their business models and are today modern companies that need to innovate continuously to offer to their clients and consumers adequate goods. Table 12 shows the distribution of footwear companies by number of employees. About 78 % of the companies have between 0 - 100 employees.

Table 12. Distribution of footwear companies by number of employees in Portugal, Spain, Romania and Bulgaria, Italy and United Kingdom.

Nº employees	Nº Companies					
	Portugal	Spain	Romania	Bulgaria	Italy	United Kingdom
0 - 50	18	30	18	23	6	0
51 - 100	32	5	9	8	2	1
101- 150	15	0	2	3	1	1
151 - 200	6	0	6	2	0	0
> 200	4	0	4	0	0	0
TOTAL	**75**	**35**	**39**	**36**	**9**	**2**

In table 13 is presented the average, maximum and minimum numbers of employees of footwear companies calculated in each country. The range of number of employee's is very large, being higher in Portugal (between 12 and 404) and Romania (6 – 358).

Table 13. Number of employees of footwear companies in Portugal, Spain, Romania and Bulgaria, Italy and United Kingdom: Average, maximum and minimum.

Country	Nº employees				
	Average	Median	Maximum	Minimum	Companies Number
Portugal	95 ± 71	78	404	12	75
Spain	35 ± 20	33	100	8	35
Romania	88 ± 86	69	358	6	39
Bulgaria	53 ± 47	34	185	10	36
Italy	44 ± 37	25	120	12	9
United Kingdom	95 ± 35	95	120	70	2

The average number of working days per year in each country varies between 225 and 250. The average working hours and number of shifts is 8 and 1, respectively in all countries (Table 14).

Table 14. Average of working days per year, working hours per day and number of shits in Portugal, Spain, Romania and Bulgaria, Italy and United Kingdom.

Country	Average of Nº working days/year	Average of Nº working hours/day	Average of Nº Shifts
Portugal	226 ± 0	8	1
Spain	225 ± 27	8	1
Romania	238 ± 23	8	1
Bulgaria	250 ± 16	8	1
Italy	230 ± 13	8	1
United Kingdom	231 ± 2	8	1

II - Product and process

European footwear companies are mainly dedicated to high quality added value products and Asia to massive production and lower price products. In value, Europe represents around 38 % of the world leather footwear export and Asia has a 40 % share.[1] The European Footwear industry consists of more than 20.000 enterprises, about 90% SME's, approximately 300.000 employees and a turnover of around €25 billion.

European footwear companies are predominantly dedicated to the production of fashion and comfort quality shoes, mainly man and women shoes, with upper material in leather. The results obtained in this study are in this line. The footwear companies that integrate this study produce about 57 % of woman shoes and 32 % of man shoes (Figure 2), using bonded and stitched production constructions, about 62 % and 32 %, respectively (Figure 3). More than 80% of the footwear is using leather as upper material (Figure 4). These results are calculated based on the percentages indicated by the companies in the inventory without count the number of pairs produced by each company.

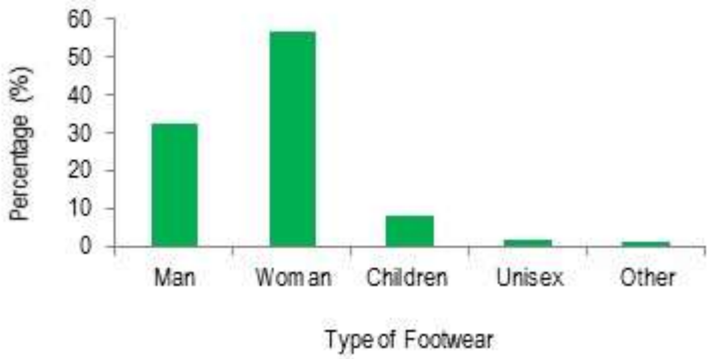

Figure 2. Percentage of produced footwear by type (Man, Woman, Children, Unisex, Other).

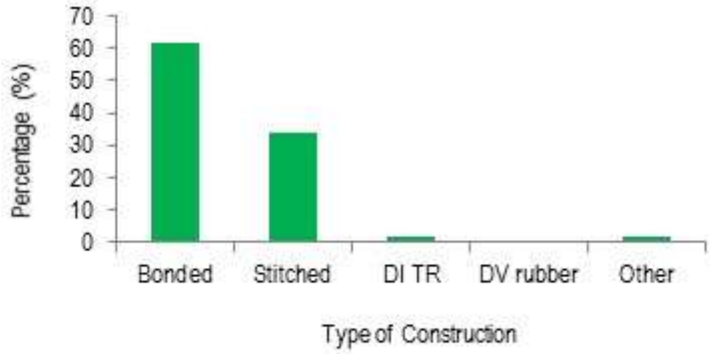

Figure 3. Average percentage of footwear by type of construction.

[1] World Footwear 2012 Yearbook, APICCAPS, September 2012 (www.worldfootwear.com).

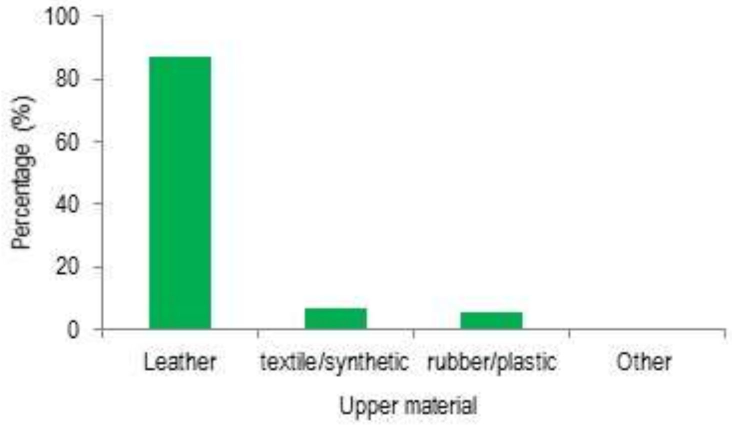

Figure 4. Percentage of upper material used in footwear production.

Additionally, we calculated the global percentage of type of produced footwear, type of construction and upper materials considering the percentages indicated by the companies and taking in consideration the number of produced pairs (Figures 5-7).

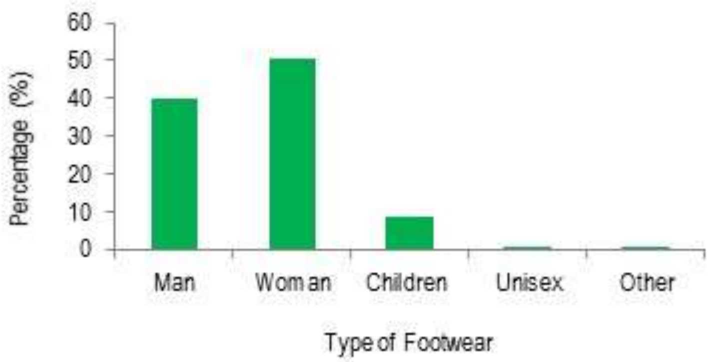

Figure 5. Percentage of produced footwear by type (Man, Woman, Children, Unisex, Other), considering the produced pairs by each company.

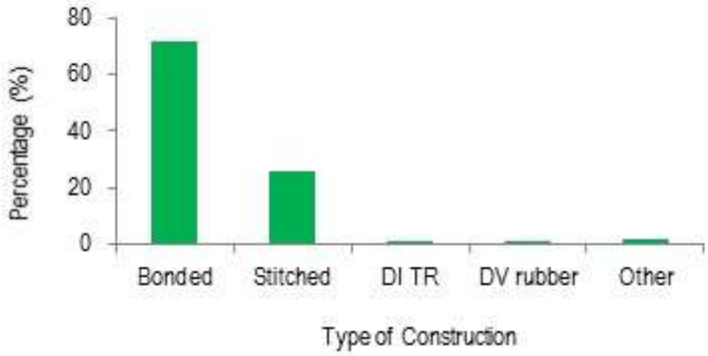

Figure 6. Percentage of upper material used in footwear production, considering the produced pairs by each company.

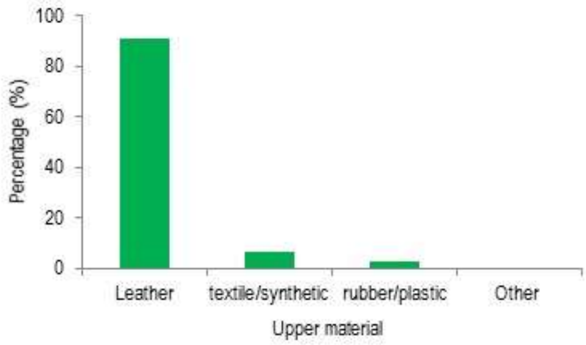

Figure 7. Percentage of upper material used in footwear production, considering the produced pairs by each company.

Table 15 shows the type of footwear produced by each country, considering the produced pairs by each company.

Table 15. Percentage of footwear by type in Portugal, Spain, Romania and Bulgaria, Italy and United Kingdom, considering the produced pairs by each company.

TYPE OF FOOTWEAR	Bulgaria	Italy	Portugal	Romania	Spain	United Kingdom
Man (%)	40.0	58.5	46.8	36.9	14.3	99.3
Woman (%)	47.9	41.5	43.7	47.7	78.0	0.7
Children (%)	3.2	0.0	8.9	15.1	7.7	0.0
Unisex (%)	9.0	0.0	0.5	0.4	0.0	0.0
Other (%)	0.0	0.0	0.1	0.0	0.0	0.0

III - Energetic Characterization

Electricity was identified as the major energy source in footwear companies. The energy consumption and CO2e emissions were determined by pair for the companies in each country. To calculate the energy consumption, footwear companies were aggregated by type of production process, namely: total production; total or partial subcontracting of cutting and stitching; cutting; stitching and cutting & stitching; and other (Tables 16 to 22). CO_2 emissions were determined by using the conversion factor defined in each European country for the year of 2009.[2] The energy consumption values and CO_2 emissions are in the following tables. The outliners were eliminated from the study.

Table 16. Energy consumption (kWh/pair) and CO_2 emissions (CO_2e/pair) – Bulgaria.

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)	Cutting	Stitching	Cutting & Stitching	Other
Average (kWh/pair)	**1.2 – 3.6**	**5.9**	--	--	--	--
kg CO_2e/pair	0.5 – 1.7	2.7	--	--	--	--
Maximum (kWh/pair)	**4.6**	**5.9**	--	**4.8**	--	--
kg CO_2e/pair	2.1	2.7	--	2.2	--	--
Minimum (kWh/pair)	**0.4**	**5.9**	--	**0.3**	--	--
kg CO_2e/pair	0.2	2.7	--	0.1	--	--
Companies number	30	1	--	2	--	--

Table 17. Energy consumption (kWh/pair) and CO_2 emissions (CO_2e/pair) – Italy.

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)	Cutting	Stitching	Cutting & Stitching	Other
Average (kWh/pair)	--	**1.6 – 4.4**	--	--	--	--
kg CO_2e/pair	--	0.6 ± 1,8	--	--	--	--
Maximum (kWh/pair)	**7,1**	**4,9**	--	--	--	--
kg CO_2e/pair	2,9	2	--	--	--	--
Minimum (kWh/pair)	**0,7**	**1,6**	--	--	--	--
kg CO_2e/pair	0,3	0,6	--	--	--	--
Companies number	3	5	--	--	--	--

[2] http://www.eea.europa.eu/data-and-maps/figures/co2-electricity-g-per-kwh.

Table 18. Energy consumption (kWh/pair) and CO_2 emissions (CO_2e/pair) – Portugal.

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)	Cutting	Stitching	Cutting & Stitching	Other
Average (kWh/pair)	**1.1 – 2.9**	**0.8 - 3.0**	**--**	**0.5 – 1.1**	**--**	**--**
kg CO_2e/pair	0.5 ± 1.5	0.5 - 1.5.	--	0.3 – 0.6	--	--
Maximum (kWh/pair)	**4.7**	**5.1**	**0.5**	**1.0**	**0.3**	**1.6**
kg CO_2e/pair	2.4	2.6	0.3	0.5	0.2	0.8
Minimum (kWh/pair)	**0.8**	**0.2**	**0.5**	**0.3**	**0.3**	**0.9**
kg CO_2e/pair	0.4	0.1	0.3	0.2	0.2	0.5
Companies number	21	43	1	4	1	2

Table 19. Energy consumption (kWh/pair) and CO_2 emissions (CO_2e/pair) – Romania.

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)	Cutting	Stitching	Cutting & Stitching	Other
Average (kWh/pair)	**0.5 – 3.9**	**2.2 – 5.6**	**--**	**--**	**--**	**--**
kg CO_2e/pair	0.3 – 2.3	1.1 – 2.9	**--**	**--**	--	**--**
Maximum (kWh/pair)	**6.3**	**6.3**	**--**	**--**	**2.6**	**--**
kg CO_2e/pair	3.7	3.2	**--**	**--**	1.5	**--**
Minimum (kWh/pair)	**0.4**	**2.0**	**--**	**--**	**0.4**	**--**
kg CO_2e/pair	0.2	1	**--**	**--**	0.2	**--**
Companies number	25	5	**--**	**--**	5	**--**

Table 20. Energy consumption (kWh/pair) and CO_2 emissions (CO_2e/pair) – Spain.

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)	Cutting	Stitching	Cutting & Stitching	Other
Average (kWh/pair)	**0.8 – 2.0**	**0.9 – 2.1**	**--**	**--**	**--**	**--**
kg CO_2e/pair	0.4 – 1.2	0.4 – 0.8	**--**	**--**	**--**	**--**
Maximum (kWh/pair)	**4.7**	**2.1**	**--**	**--**	**--**	**--**
kg CO_2e/pair	2.0	0.9	**--**	**--**	**--**	**--**
Minimum (kWh/pair)	**0.5**	**0.9**	**--**	**--**	**--**	**--**
kg CO_2e/pair	0.2	0.4	**--**	**--**	**--**	**--**
Companies number	27	3	**--**	**--**	**--**	**--**

Table 21. Energy consumption (kWh/pair) and CO_2 emissions (CO_2e/pair) - United Kingdom.

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)	Cutting	Stitching	Cutting & Stitching	Other
Average (kWh/pair)	**9.1 ± 0.3**	--	--	--	--	--
kg CO_2e/pair	4.5 ± 0.1	--	--	--	--	--
Maximum (kWh/pair)	**9.3**	--	--	--	--	--
kg CO_2e/pair	4.6	--	--	--	--	--
Minimum (kWh/pair)	**8.9**	--	--	--	--	--
kg CO_2e/pair	4.4	--	--	--	--	--
Companies number	2	--	--	--	--	--

There are not enough or conclusive data to be analyzed in following inventory fields:

(1) "Average of minutes/pair"

(2) "Turnover";

(3) "Energy sold";

(4) "Auto-power consumption".

Companies have the perception that production machines are the main energy consumer and this perception is in concordance with the average weight of energy consumption on each process (Tables 22 and 23).

Table 22. Company perception of biggest energy consumer on Footwear Company.

	nº answers			
Energy Consumer	**1**	**2**	**3**	**Total**
Production process machines	152	39	0	191
Illumination association to the production	16	76	82	174
Compressed air generation	16	57	79	152
Facilities acclimatization	12	16	20	48
Other	0	2	2	4

Table 23. Company perception of weight of energy consumption (%) on Footwear Company

Energy Consumer	nº answers	Weight of the energy consumption on each process / %
Production process machines	89	64,9%
Illumination association to the production	88	18,7%
Compressed air generation	78	13,6%
Facilities acclimatization	23	2,8%
Other	6	0,0%

4.2 Ind-Eco Footwear energy performance Benchmarking

In table 24 are presented the values determined for energy consumption and CO_2 emissions of footwear companies with a complete production process based on the inventories filled in Bulgaria, Italy, Portugal, Romania, Spain and United Kingdom.

Table 24. Indicators of energy consumption and CO_2 emissions of European footwear companies.

Indicator	EUROPE	
	Total production	**Cutting and/or Stitching subcontracting (part or all)**
Average (kWh/pair)	**0.7 – 3.9**	**0.8 – 3.6**
kg CO_2e/pair	0.3 – 1.9	0.4 – 1.7
Minimum (kWh/pair)	**0.4**	**0.2**
kg CO_2e/pair	0.2	0.1
Maximum (kWh/pair)	**9.3**	**6.3**
kg CO_2e/pair	4.6	3.1
Companies number	108	57

Based on the study done the footwear energy performance benchmarking was defined as:

Footwear energy performances benchmarking

1 – 1,2 kg CO2/pair

With benchmarking rules for the EU-PEF Leather Pilot Screening Survey imminent, UNIC proposed a semi-quantitative grading system at the project final meeting in Brussels for the leather benchmark and suggested that footwear benchmark could also include a first approach for a semi-quantitative grading system. Therefore, following the rationale applied for leather, preliminary Gradings for Measured Energy Consumption (EC) and CO2-eq. Emissions - GHGs Emissions (GHG) due to electrical energy consumption are proposed in Table 25. These numbers reflect the electrical energy consumption of the footwear companies but are highly related on the energy carrier therefore should be used as indicative and revised periodically.

Table 25. Grading categories and criteria for Measured Energy Consumption (EC) and CO2-eq. Emissions - GHGs Emissions (GHG)

Grading Code		**Rule / Criterion (proposed and implemented)**
EC	GHG	
EC-A+	**GHG-A+**	Companies with CO2 eq. emissions -EnPIs lower than the low value of the range
EC-A	**GHG-A**	All companies with CO2 eq. emissions EnPIs within the range
EC-B	**GHG-B**	Companies with CO2 eq. emissions - EnPIs higher than the upper value of the range

The following tables present the average ranges obtained in the present study per country and the number of companies considered for the calculation.

Bulgaria

Indicator	**Total production**
Average (kWh/pair)	**1.2 – 3.6**
kg CO_2e/pair	0.5 – 1.7
Companies number	30

Italy

Indicator	**Cutting and/or Stitching subcontracting** (part or all)
Average (kWh/pair)	**1.6 – 4.4**
kg CO_2e/pair	0.6 ± 1,8
Companies number	5

Portugal

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)	Stitching
Average (kWh/pair)	**1.1 – 2.9**	**0.8 - 3.0**	**0.5 – 1.1**
kg CO_2e/pair	0.5 ± 1.5	0.5 - 1.5.	0.3 – 0.6
Companies number	21	43	4

Romania

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)
Average (kWh/pair)	**0.5 – 3.9**	**2.2 – 5.6**
kg CO_2e/pair	0.3 – 2.3	1.1 – 2.9
Companies number	25	5

Spain

Indicator	Total production	Cutting and/or Stitching subcontracting (part or all)
Average (kWh/pair)	**0.8 – 2.0**	**0.9 – 2.1**
kg CO_2e/pair	0.4 – 1.2	0.4 – 0.8
Companies number	27	3

United Kingdom

Indicator	Total production
Average (kWh/pair)	**9.1 ± 0.3**
kg CO_2e/pair	4.5 ± 0.1
Companies number	2

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