Leather Carbon Footprint

Review of the European Standard EN 16887:2017

Leather – Environmental footprint – Product Category Rules (PCR)

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Acknowledgments:

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Editorial assistance by H. Beachcroft-Shaw and formatting by S. Hochwallner is gratefully acknowledged.

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FOREWORD

UNIDO was among the very first international organizations that turned its attention to the rather controversial issue of carbon footprint and its relevance to the leather sector. Considering the consequences already felt by the trade, tanners simply could not afford to ignore this topic. Particular pressures came from leading international brands eager to prove the green credentials of their suppliers.

Within this context, the study titled *Life Cycle Assessment, Carbon Footprint in Leather Processing* prepared for and presented by F. Brugnoli during the XVIII Session of UNIDO Leather and Leather Products Industry Panel in Shanghai in 2012 provided detailed explanations, definitions and terminology pertaining to leather's carbon footprint.

It also contained specific suggestions on how to proceed in addressing this issue. Subsequently, it was not only extensively discussed by eminent international leather specialists, but it has triggered a series of activities involving different regional and global establishments.

The essence of that paper, reactions to it and some other views were reflected in a special chapter in UNIDO's comprehensive study *The Framework for Sustainable Leather Manufacture*, a chapter dealing with carbon footprint aspects of leather processing.

That chapter is now here presented as separate paper for the benefit of readers primarily interested in the carbon footprint considerations.

In addition to earlier content, the paper also presents the main features of the European Standard EN 16887 (approved in Nov 2016, published in March 2017, applicable not later than Sept 2017) Leather – Environmental footprint – Product Category Rules (PCR) – Carbon footprints. It is quite likely that the European norm will prevail globally.

By establishing mandatory norms, especially concerning the vital issue of the system boundaries, EN 16887 effectively, at least for the time being, ends some of the old disagreements.

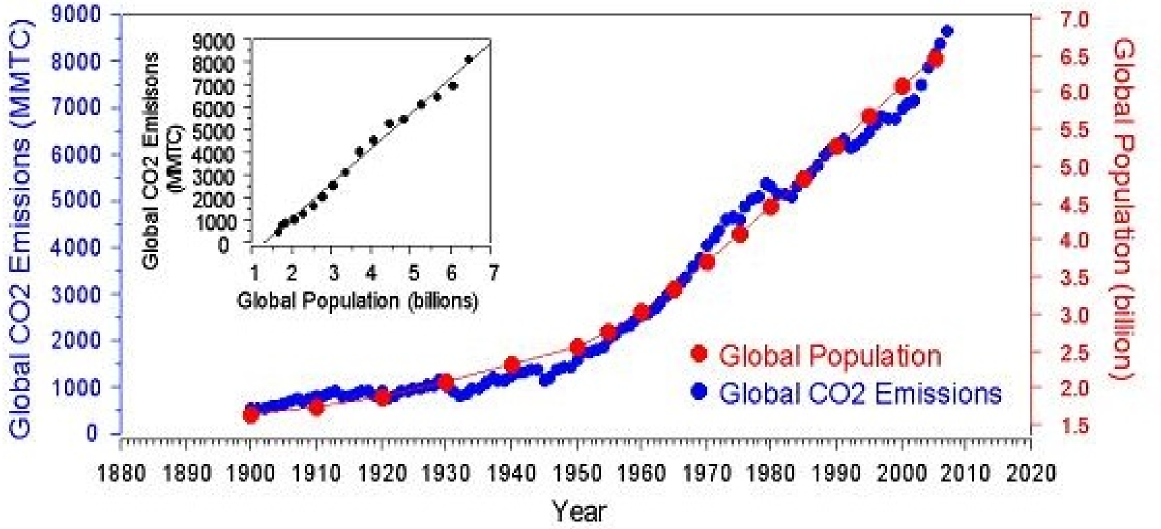
Accordingly, the large part of the earlier paper could now appear superfluous; yet it has been retained as it is felt that recalling arguments and dilemmas confronted by the leather sector only a few years ago might not only help better understanding of the European Standard EN 16887, but also facilitate future discussions on many unresolved issues within this specific topic.

After all, there are still strong differing views in the leather industry and associated scientific circles about the (comparative) relevance and priority attached to the carbon footprint topic as such.

1. GENERAL

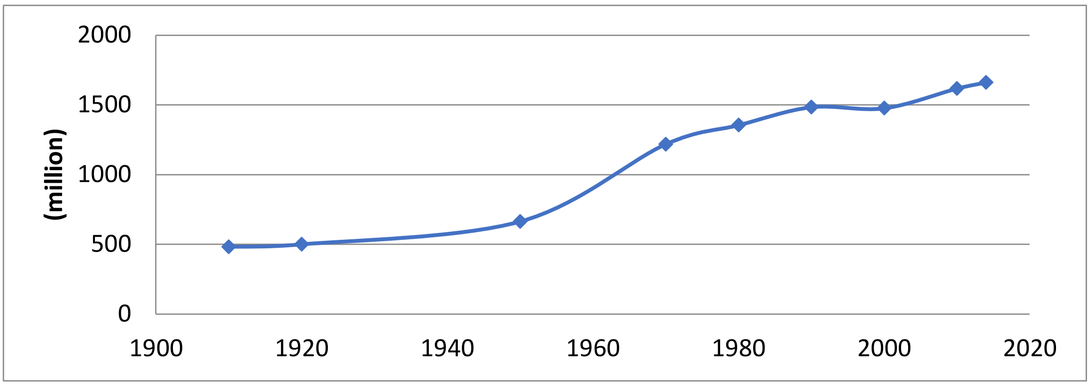
Climate change(s), the greenhouse effect, carbon footprint and related topics are very present on the global media scene; there is no shortage of reports, statements, debates and opposing claims. Political decisions with strong financial implications are already being implemented.

Figure 1. Evolution of global population (red) and global carbon dioxide emissions (blue) since 1900.



The figure/insert shows the tight relationship between population and CO_2 emissions[1].

Figure 2. Cattle stock population



Source: FAO, 1985, 1996, 2005; Reich et al, 2007

As it is already widely known, an important part of CO_2 emissions emanates from the livestock (cattle) population, and this is certainly of interest to the leather sector. For an illustration, Figure 2 shows cattle stock since 1910 - it can be assumed that a leather production increase over the last 100 years has followed a similar pattern.

[1]*Population data are from the U.S. Census Bureau, and CO_2 emissions data are from the Carbon Dioxide Information Analysis Center (CDIAC).*

Since GHG emissions are one of the main environmental challenges, it is very likely that figures on GHG or CO_2 emissions will be part of mandatory information on any product and will be "taxed" to encourage the use of more sustainable products. For some products (e.g. cars) such taxes are already introduced in some regions.

Apart from a brief "refresher" about the rather specific terminology related to these topics, this paper will only deal with issues closely related to the tanning industry; and although the leather industry is not a major contributor to CO_2 emissions, it cannot afford to ignore this issue. Therefore, the leather industry needed to develop suitable tools to reduce CO_2 emissions and globally agree on a methodology to measure and to report on CO_2 emissions.

2. GLOSSARY AND BASIC CONCEPTS

CF	**Carbon Footprint**
CF-PCR	Carbon footprint product category rules
CO2e	Carbon dioxide equivalent
GHG	**Green House Gasses**
GWP	Global Warming Potential
ILCD	International Reference Life Cycle Data System
IPCC	Intergovernmental Panel on Climate Change
IPP	INTEGRATED POLLUTION PREVENTION
IPP	Integrated Product Policy
ISO	International Standard Organisation
LCA	**Life Cycle Analysis or Assessment**
LCI	**Life Cycle Inventory Analysis**
LCIA	**Life Cycle Impact Assessment**
PCF	**Product Carbon Footprint**
PCR	Product Category Rules
TOE	Tonnes of Oil Equivalent
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WBCSD	World Business Council for Sustainable Development

Source: F. Brugnoli-UNIDO

2.1. Terms and Definitions (FROM ISO DIS 14067)

For easy understanding, the most important terms and definitions are reported here. For additional terms and definitions, please refer to ISO DIS 14067 (1 & 2), from which the following definitions have been taken:

- **Carbon Footprint (CF):**

The weighted sum of greenhouse gas emissions and greenhouse gas removals of a process, a system of processes or a product system, expressed in CO_2 equivalents.[2]

- **Product Carbon Footprint (PCF):**

The carbon footprint of a product system.

- **Product Category Rules (PCR):**

A set of specific rules, requirements and guidelines for developing environmental declarations for one or more product categories.

- **Carbon Footprint Product Category Rules (CF-PCR):**

A set of specific rules requirements and guidelines for developing carbon footprint declarations for one or more product categories.

- **Product System:**

A collection of unit processes with elementary and product flows, performing one or more defined functions and which models the life cycle of a product.

- **Life Cycle Assessment (LCA):**

The compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.

- **Life Cycle Inventory Analysis (LCI):**

A phase of the life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.

- **Functional Unit:**

The quantified performance of a product system for use as a reference unit.

- **Products:**

Any goods and services

- **Primary Data:**

The quantified value originating from a direct measurement or a calculation based on direct measurements of a unit process of the product system at its original source.

- **Secondary Data:**

Quantified value of an activity or life cycle process obtained from sources other than the direct measurement or calculation from direct measurements.

- **Greenhouse Gas (GHG)[3]:**

A gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds.

- **Global Warming Potential (GWP):**

The factor describing the radiative forcing impact of one mass- based unit of a given GHG

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[2] *Another good definition of CF: A carbon footprint is the total amount of CO_2 and other greenhouse gases, emitted over the full life cycle of a process or a product. It is expressed in grams of CO_2 equivalents.*

[3] *GHGs include among others carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).*

relative to an equivalent unit of carbon dioxide over a given period.

- **Carbon Dioxide Equivalent (CO_2e):**

A unit for comparing the radiative forcing of a GHG to carbon dioxide.
Source: *FB-UNIDO*

2.2. Environmental Footprint

Several different standards are available today to footprint products and companies' activities – here are their main approaches and characteristics to provide a general overview and to identify potential commonalities for harmonization purposes.

The analysis is based on the framework outlined by the EUROPEAN COMMISSION JOINT RESEARCH CENTRE, Institute for Environment and Sustainability (Ispra, Italy, November 2011) titled *Analysis of Existing Environmental Footprint Methodologies for Products and Organizations: Recommendations, Rationale, and Alignment.*

ISO 14040:2006 Environmental management - Life Cycle Assessment - Principles and framework

It describes the principles and framework for a Life Cycle Assessment, including: a definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and the conditions for the use of value choices and optional elements. It also covers life cycle assessment (LCA) studies and life cycle inventory (LCI) studies. It does not describe the LCA technique in detail, nor does it specify methodologies for the individual phases of the LCA.

ISO 14044: Environmental management - Life Cycle assessment - Requirements

It specifies requirements and provides guidelines for life cycle assessment (LCA) including: a definition of the goal and scope, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review, limitations, the relationship between the LCA phases, and the conditions for use of value choices and optional elements.

ISO 14025: Environmental labels and declarations - Type III environmental declarations - Principles and procedures

It establishes the principles and specifies the procedures for developing Type III environmental declaration programmes and Type III environmental declarations. Type III environmental declarations as described in ISO 14025:2006 are primarily intended for use in business-to-business communication, but their use in business-to-consumer communication under certain conditions is not precluded.

Ecological Footprint

The Ecological footprint (EF) standard was developed by Global Footprint Network. The EF provides measure of the extent to which human activities exceed biocapacity. Specifically, the EF integrates the area required for the production of crops, forest products and animal products, the area required to sequester atmospheric CO_2 emissions dominantly caused by fossil fuel combustion, and the equivalent area estimated to be required by nuclear energy demand.

Product and Supply Chain Standards Greenhouse Gas Protocol (WRI/ WBCSD)
The World Resources Institute (WRI) and the World Business Council on Sustainable Development (WBCSD) started to develop their Product and Supply Value Chain GHG Accounting and Reporting Standard in September 2008. The GHG Protocol Corporate Standard provides standards and guidance for companies and other types of organizations preparing a GHG emissions inventory. It covers the accounting and reporting of the six greenhouse gases covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). The Product Standard builds upon the ISO 14040 series of standards.

3. CARBON FOOTPRINT, LIFE CYCLE ANALYSIS (LCA) DEFINITIONS FOR LEATHER

Carbon Footprint definition:
A carbon footprint is the total amount of CO_2 and other greenhouse gases, emitted over the full life cycle of a process or a product (e.g. leather); it is expressed in grams of CO_2 equivalents.

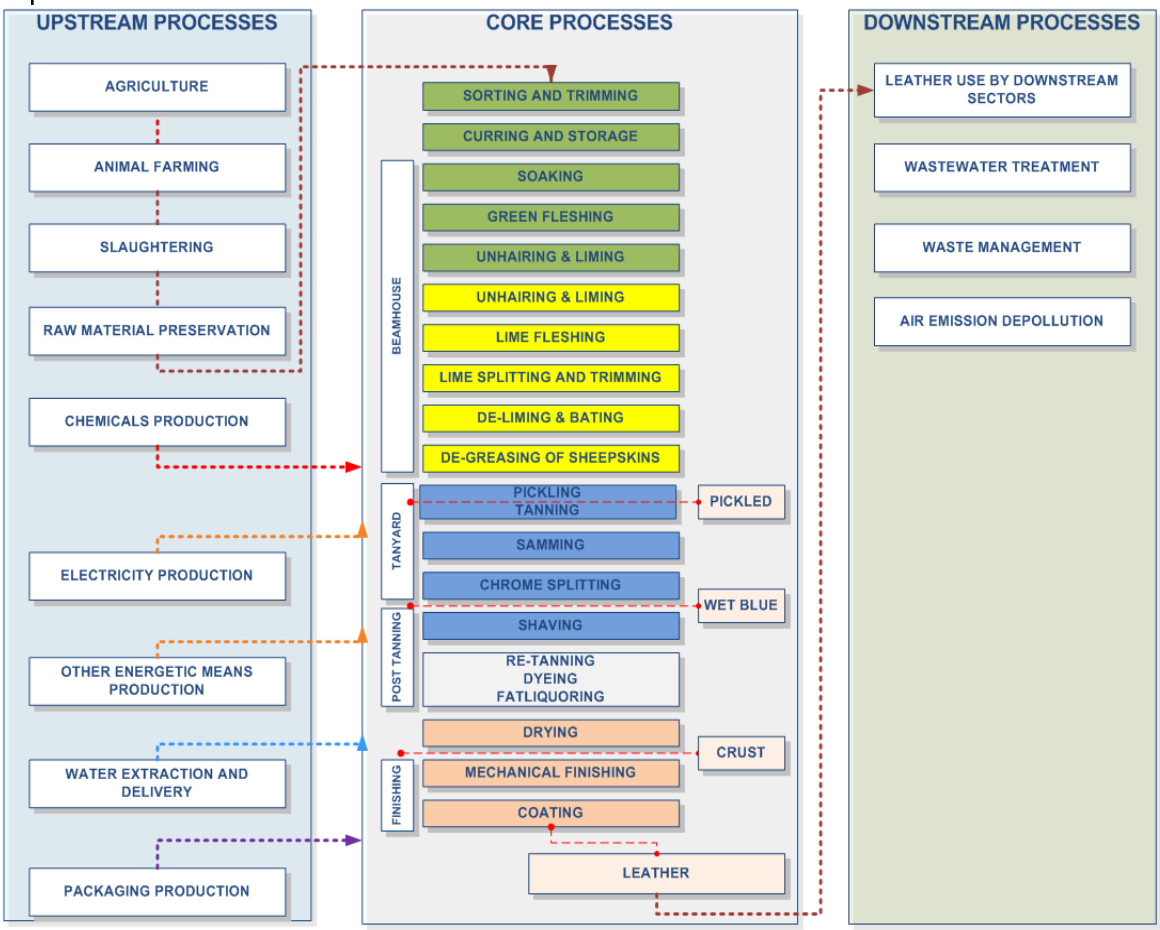

Figure 3. Overview of leather processing – UNIDO/LCA Brugnoli

The CF for leather includes material and operations from raw materials starting from slaughterhouse and finishing at the end of the leather product life cycle. The issue of boundaries is crucial.

In principle, cleaner and more efficient technologies are very important for the reduction of CO_2 emissions; however, there are also other factors which significantly influence the total leather CF, among them being mainly the following:

i. Transport
ii. Water consumption
iii. Efficiency in use
iv. Energy footprint
v. Nature of raw material
vi. Biodegradability
vii. Use/recyclability

At the moment there is still not a globally agreed methodology for a CF calculation. However, the document *European Standard EN 16887:2017 Leather – Environmental footprint – Product Category Rules (PCR) – Carbon footprints* approved in November 2016, published in March 2017 and applicable not later than Sept 2017 represents a dramatic step in defining the PCR rules and, in particular, in setting the system boundaries for leather. For more details see item 7.9. European Standard EN 16887:2017.

4. OVERVIEW OF SOME CONTRIBUTORS TO CO_2 EMISSIONS IN LEATHER PROCESSING

4.1. CO_2 emissions from raw material transport

The two main factors here are:

i. The means of transportation
ii. Distance

Globalization makes it easy to send goods around the world. The cost for shipping goods has never been as low as now. However, the choice of the means of transportation and distance severely influences the amount of CO_2 emitted due to the transportation of goods.

Table 1.The amount of CO_2 (in grams) emitted per metric ton of freight & km of transportation

Air plane (air cargo), average Cargo B747	500 g
Modern lorry or truck	60 - 150 g
Modern train	30 - 100 g
Modern ship (sea freight)	10 - 40 g
Airship (Zeppelin, Cargolifter) as planned	55 g

The means of transport chosen largely depends on the country of origin, destination and the infrastructure available. From that point of view, ideally, tanneries should be near the source of raw material whenever possible; obviously, this would also help avoid the negative impact of (long-term) preservation.

4.2. ***Energy and CO_2 emissions***

In the case of liquid fuel used for the preparation of hot water, the emission is approx. 3 kg CO_2/l of combusted fuel. Thus, for example, the CO_2 emissions for a tannery with a daily input of 10 tons of wet salted (w.s.) hides are as follows:

Liquid fuel emission kg CO_2/l	Liquid fuel l/t of raw hide	CO_2 emission		
		kg CO_2/t of raw hide	kg CO_2/d	kg CO_2/y
3	230	690	6900	2518000

The CO_2 emissions related to electric energy consumption depend on the primary source (or the source mix) of the electric energy, which is varies greatly for different countries.

According to Poncet[4], for example, for the source mix in France consisting of 80% nuclear energy, 10% fossil energy and of 10% from renewable resources (mainly hydroelectric) the emission is 0.059 kg CO_2/kWh.

If some thermal energy saving occurs, for example when using solar energy instead of fuel, the CO_2 emission decreases proportionally. Using self-produced electric energy from photovoltaic cells and wind, the direct CO_2 emission would be practically zero. CO_2 emissions for different energy sources are presented in the next table.

Table 2. Carbon dioxide emissions for energy from different sources

Source	CO_2 emission, Kg/m^2
Coal	2.14
Liquid fuel	1.51
Gas	1.28
Photovoltaic	0.14
Wind	0.11
Nuclear	0.01
Hydro	0.007

The ways and means to reduce energy consumption are described in more detail in the chapter on energy; below are only a few important points:

i. Use of efficient equipment (e.g. low speed drums)
ii. Green fleshing
iii. Splitting in lime
iv. Use of natural light

As CO_2 emissions depend on the source of electrical energy (fossil, renewable etc.), this should be taken into consideration. In some regions a customer/tannery can choose the supplier and the source of energy. However in many countries, especially in developing

[4] Poncet

countries, a tannery has no influence whatsoever on this important factor, although, for example, emissions from fossil fuels can be 40 times higher than from a hydroelectric source.

Table 3. Summary of Lifecycle of GHG emissions intensity for various electricity generation sources

Technology	Mean	Low	High
	grams CO_2e/kWh		
Lignite	**1,054**	790	1,372
Coal	**888**	756	1,310
Oil	**733**	547	935
Natural Gas	**499**	362	891
Solar PV	**85**	13	731
Biomass	**45**	10	101
Nuclear	**29**	2	130
Hydroelectric	**26**	2	237
Wind	**26**	6	124

Source: WNA, Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Sources, 2011

4.3. *Thermal energy*

Most of the thermal energy in a tannery is needed for water heating and, in temperate climates, for the heating of the premises. Thermal energy is usually provided by a central boiler with the fuel used having significant impact on the level of CO_2 emissions.

Table 4. The amount of CO_2 emitted per GJ of energy for various fuels

Source	kg of CO_2/GJ
Coal (anthracite)	109.3
Coal (bituminous)	98.3
Coal (lignite)	102.9
Coal (subbituminous)	102.4
Diesel fuel & heating oil	77.1
Gasoline	75.1
Propane	66.4
Natural gas	55.9

As in the case of electricity, CO_2 emissions depend not only on the type of fuel source but also on the efficiency of the heating system and heat exchanger.

In countries with sufficient insolation, a very attractive (supplementary) source of energy can be a Solar Water Heating System (SWHS), which not only reduces CO_2 emissions but also operational costs. That is why it is very attractive from both an economic and an environmental point of view.

4.4. *Waste Water Treatment*[5]

Effluent treatment with aerobic biological activated sludge directly emits CO_2 into the atmosphere through the conversion of carbon contained in the organic matter in the waste water. This organic matter does not have a defined formula and differs from case to case. The content of the organic matter in the effluent is expressed as COD, or BOD_5. The content of organic carbon in effluent is expressed as Total Organic Carbon (TOC). The relation of the TOC to COD is approx. 1 : 3, and BOD_5 approx. 1 : 1.4, and the TOC calculated from the accepted value before biological treatment for COD (60 kg COD/t of raw hides) is:

$$\frac{COD}{3} = \frac{60}{3} = 20\,kgC/t\,of\ raw\,hide,$$

or calculated from accepted value for BOD_5 (25 kg BOD_5/ t of raw hide) is

$$\frac{BOD_5}{1.4} = \frac{25}{1.4} = 18\,kgC/t\,of\ raw\,hide\cdot$$

The mean value is 19 kg of the organic C/t of raw hide. The equivalent value of the CO_2 to C is 3.67.

According to these values, the quantity of the CO_2 emitted from the biological treatment due to conversion/oxidation of the organic matter is approx. 19 x 3.67 = 70 kg CO_2/t of raw hides (or, about 700 kg CO_2/d, or 255.5 t CO_2/y for a tannery with a daily input of 10 tons of w.s. hides).

The anaerobic waste water treatment produces biogas (methane, not CO_2), but due to later combustion of methane, ultimately CO_2 is emitted.

Evidently, consumption of electric energy in the course of effluent treatment is (indirectly) a cause of CO_2 emissions.

Under the same conditions valid for the tannery, the CO_2 emissions from the (C)ETP operations are:

185 x 0.059 = **11 kg CO_2/t of w.s. hide**

The total CO_2 emissions, direct and indirect, are: 70 + 11 = **81 kg CO_2/ton of w.s. hide**

It means that, for example, operations of a tannery with a daily input of 10 tons of w.s. hides are responsible for 700 + 110 = 810 kg CO_2/day or 255.5 + 40 = 295.4 t/year.

The direct CO_2 emission from the production of electric energy from photovoltaic cells and wind is practically zero.

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[5] *Contribution by M. Bosnić*

Solid waste

Disposal of solid waste also contributes to the CO_2 emissions allocated to leather, which is why it is important that all fractions of solid wastes are re-utilized whenever possible.

Table 5. Estimated CO_2 emissions from solid wastes in a well-managed solid waste disposal site

Waste	CO_2 kg/t
Putrefied hides / skins	624
Raw trimmings	624
Salt	624
Hair (pasting)	373
Lime sludge	455
Lime splits	624
Fleshing	624
Wet blue trimmings	221
Chrome splitting (bovine)	221
Chrome shavings	221
El/crust shavings*	221
Buffing dust*	221
Dyed trimmings*	221
Sludge (35% dry matter)	455

It is estimated that yearly CO_2 emissions from solid waste decay can be 10-20 times higher than those from a properly designed and managed landfill disposal site.

4.5. *Product use and End of Life (EoL)*

CO_2 emissions during product life (shoes, leather goods, upholstery, etc.) are beyond the tanners' control.

Possible re-use of leather and/or incineration can be considered. In most cases it is disposed of.

Product life span should be taken into consideration when leather is compared with other materials.

5. CASE STUDY, BANGLADESH: SOLAR WATER HEATING SYSTEM IN A TANNERY

The results of the operations and impact of the Solar Water Heating System (SWHS) in Dhaka, Bangladesh:

Performance/energy produced per day: 18 – 30 MJ/m^2.

One square metre of the solar panel reduces carbon footprint by 5 – 8.3 kg CO_2/ day.

6. ANALYSIS AND RECOMMENDATIONS (BRUGNOLI, UNIDO 2012)[6]

- The ten hottest years on record have all occurred since 1998. Eighteen out of the last 21 years are among the 20 warmest years since 1880. The common conclusion is that the long-term trend is one of global warming.
- The increase in global average temperature since the mid-20th century is very likely due to the rise in anthropogenic greenhouse gas concentrations, specifically Carbon Dioxide, CO_2.
- It is estimated that industry and manufacturing contribute for 19% of all GHG emissions.
- The total amount of GHG produced during various stages in the life cycles of products is referred to as Product Carbon Footprints (PCFs).
- The Carbon Product Footprint (CFP) is defined as the "weighted sum of greenhouse gas emissions and greenhouse gas removals of a process, a system of processes or a product system, expressed in CO_2 equivalents" referring to a product system.
- The aim of the technical report is to provide a robust overview of publications, standards and papers relevant for the calculation of the Product Carbon Footprint of the product "Finished Leather" with recommendations for harmonization related to the main elements needed to define system boundaries.
- In the case of finished leather, the carbon footprint should obviously be expressed as: **Kg of CO_{2e}/m^2 of finished leather.**
- Currently, there is no single methodology and no agreement has been reached internationally on Leather PCF calculation methods.
- The inherent complexity and lack of exactness of carbon footprint analyses contrasts with the need to communicate the results in a simple, clear and unambiguous way.
- After analysing other options/methodologies, ultimately for our case the following methodologies/frameworks were adopted:

  - Carbon Footprint of Products: ISO DIS 14067
  - Life Cycle Assessment: ISO 14040/44)
  - Environmental Labels and Declarations: ISO 14025

- Similarly, to ensure a common approach to be followed in future activities the following aspects are of particular importance:

  - **Functional unit**

  Used in LCA and CFP analyses to provide a reference to which environmental impacts are related; it should be consistently measurable and correspond to the basic unit used in the trade. The recommendation is to use **1 m^2 of finished leather**, including an indication of the thickness of the material.

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[6] *Although in the meantime broad consensus has been achieved and most points listed here are even regulated, it might be of interest to recall dilemmas confronted at that time.*

- **System boundaries:**

It is important to recognize the implications of the different conceptual approaches to raw hides and skins as raw materials for the tanning industry: in particular, whether they are to be considered as a waste, as a by-product or as a co-product of the milk and meat industries. If the raw hides and skins are considered as waste of the milk and meat industries, the whole environmental impact (and therefore of the CO_2 equivalent content) has to be allocated to the main product of the economic value chain (i.e. milk and meat). This implies that agriculture and animal farming, as processes of the upstream module, are excluded from the System Boundaries of LCA studies on leather.

In the case that raw hides are considered as a by-product or co-product of the milk and meat industries, some may argue that part of their environmental impacts (and therefore of the CO2 equivalent content) have to be allocated to the co-product itself, on the basis of different allocation criteria. Accordingly, for raw hides and skins coming from animals raised mainly for human feeding purposes, such as milk and meat production (and therefore, bovines, sheep, goats and some other), the system boundaries are to start in the slaughterhouse.

- **Quantification**

The different approaches reviewed show a certain similarity converging in the subdivision of leather production in individual processes and quantifying the emissions from each process. The harmonized methodology proposed, in order to obtain Kg of CO_{2e}/m^2 of finished leather, lies in the quantification of CO_{2e} content of all the different products and material entering the tannery (UPSTREAM PROCESSES), adding CO_{2e}produced in the tannery itself (CORE PROCESES), as well as CO_{2e} emanating from water and air purification and waste recycling/disposal (DOWNSTREAM PROCESSES).

- **Allocation**

Choosing an allocation rule conditions the environmental impact distribution between economic actors from the same value chain. Economic allocation seems to be rather vague due to factors contributing to it (market price of raw hides, value of the animals during their lifespan) and it should be avoided whenever possible; if unavoidable, the allocation should be made according to the physical relationship within the single process under consideration.

It would be necessary to set up a specific working group involving participants in the processes within the system boundaries such as slaughterhouses, chemicals producers, suppliers of energy and water, tanneries and effluent and waste treatment plants. They should possess the competence concerning:

- Harmonised Product Category Rules for LCA and PCF of Leather, including the conclusions of the present report
- Life Cycle Inventory (compilation and quantification of inputs and outputs for processes within the leather system boundaries) at pilot scale, including needed key actors
- Practical guidelines for LCA and PCF calculations, deriving from the Life Cycle Inventory work
- Harmonised data quality and calculation requirements along the value chain

Finally, it is recognized that at the moment the LCA – Carbon Footprint topic is primarily of interest to tanners in industrialized countries, especially those in the EU; however, it is felt that also those in BRIC and even Least Developed Countries should be aware of the current environmental impact assessment and protection trends and be ready to apply them at the appropriate time as required. It is hoped that in the meantime better standardized methodologies and at least some blueprints will also be made available.

7. SUPPLEMENTARY INFORMATION FROM VARIOUS SOURCES

7.1. *System expansions to handle co-products of renewable materials*

B. P. Weidema, *Institute for Product Development, Denmark, LCA Case Studies Symposium SETAC-Europe, 1999*

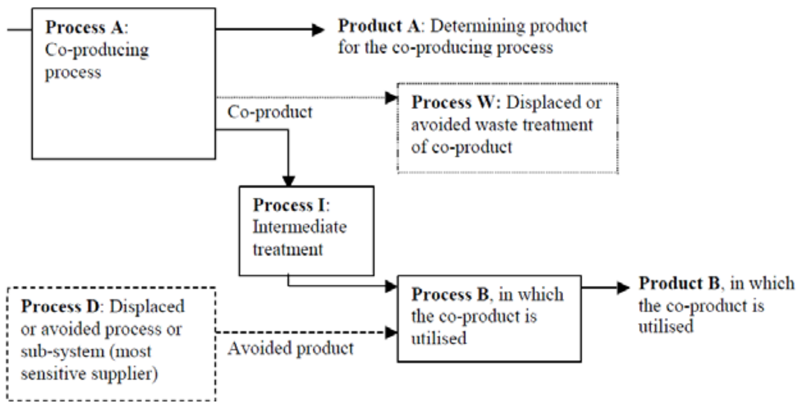


Figure 4. A model for system expansion and delimitation in relation to co-production

1) The co-producing process shall be ascribed fully (100%) to the determining product for this process (product A).

2) Under the conditions that the non-determining co-products are fully utilised in other processes and actually displaces other products there, product A shall be credited for the processes, which are displaced by the other co-products, while the intermediate treatment (and other possible changes in the further life cycles in which the co-products are used, which are a consequence of differences in the co-products and the displaced products) shall be ascribed to product A.

If the two conditions stated in rule No. 2 are not fulfilled, rule No. 3 and 4 apply, respectively.

3) When a non-determining co-product is not utilised fully (i.e. when part of it must be regarded as waste), but at least partly displaces another product, the intermediate treatment shall be ascribed to product B, while product B is credited for the avoided waste treatment of the co-product.

4) When a non-determining co-product does not displace other products, all processes in the entire life cycle of the co-product shall be fully ascribed to product A.

7.2. *BASF (China), September 2014*

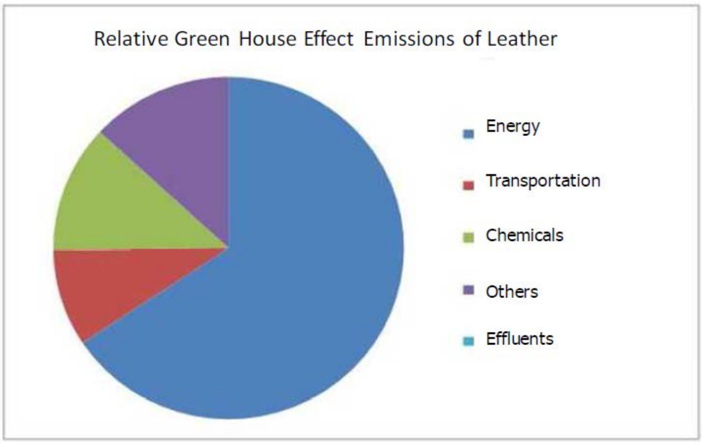
- ✓ The impact/reduction of leather weight/thickness on CO_2 emissions from car upholstery is insignificant
- ✓ Corporate Carbon Footprint, CCF (Knoedler) of finished leather in cars is estimated at 1.4 – 6.4 kg of CO_2/m^2 of finished leather (without chemicals, breeding and ultimate leather disposal after use)
- ✓ The higher the complexity of the chemical, the higher the CO_2 emission
- ✓ Accordingly, the main impact is from retanning, while impacts from the beamhouse and finishing are minor
- ✓ Powdered products are higher in CO_2 emissions than liquid

7.3. Eco-Design: Life Cycle analyses show that energy is a key factor for the environmental impact of leather and might save money, T. Poncet et al., XXXI IULTCS, Valencia

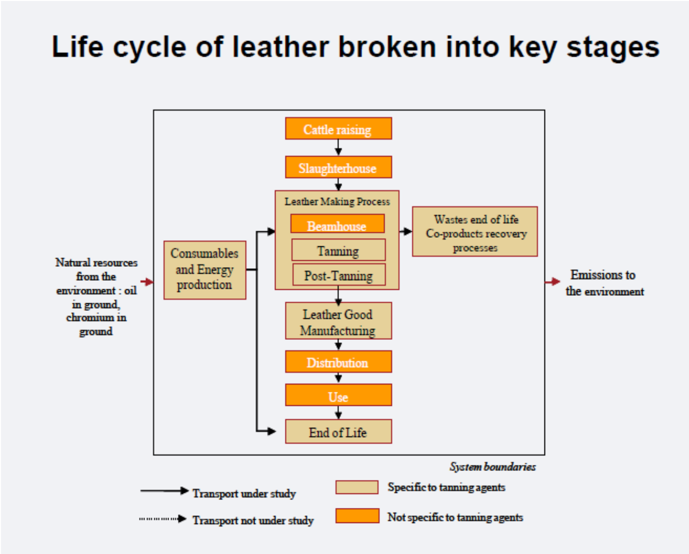
When considering the important criteria that characterises the environmental impact of leather ("eco-leather"), energy is a key issue for:

- abiotic depletion,
- greenhouse effect,
- acidification,
- photochemical pollution.

The chart below shows the relative parts of CO_2 emissions due to energy for the production of leather through a Life Cycle Analysis. It takes into account energy use of the tannery, the production of chemicals used in the tannery and transportation.



7.4. BLC



The complication for leather is whether the calculation aims to allocate a proportion of the footprint from the raising of the animals from which the hides and skins arise. If this aspect is included in the footprint for leather, it has been calculated that animal husbandry represents around 85% of the total footprint for leather production.

An important contribution to this discussion is the recent UNIDO report *Life Cycle Assessment, Carbon Footprint in Leather Processing*. A key issue in the report is the "system boundary" or where the line is drawn around the process. The report adopts the concept of the "determining product" which says that the product that determines the volume of production should bear the carbon footprint.

In the case of leather, the consequence of applying this concept is that since animals are raised essentially for meat or milk, and not for the hide or skin, then the calculation of the carbon footprint for leather should start at the abattoir, where the hide is first produced as a separate product. It is expected that this debate will continue within the leather sector.

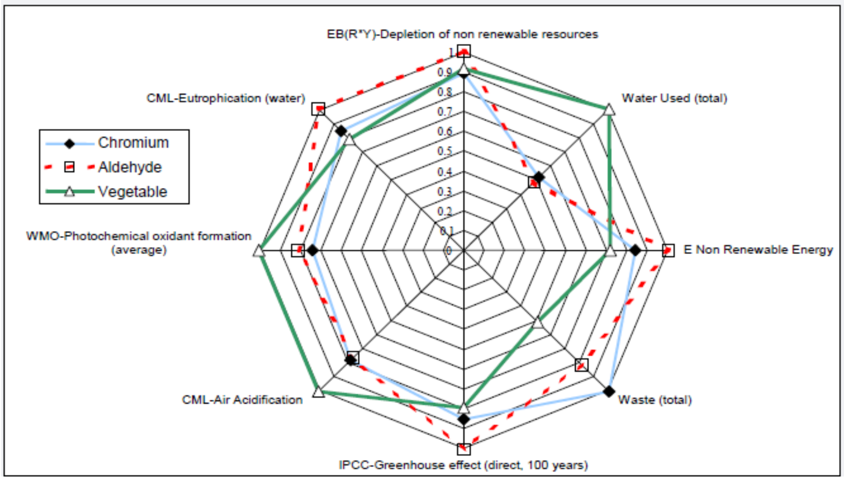


Figure 5. Baseline results for each tanning technology, general LCA impacts[7]

What is the most environmentally advantageous tannage (chrome, vegetable, aldehyde)?[8] There is no clear answer; each has specific environmental strengths. What happens to shoes, sofas and wallets when thrown away?

- Post tanning operations have the greatest influence on the overall impact
- Aldehyde and chromium are very similar in terms of environmental impact
- Vegetable tanning shows strengths and weaknesses compared to both chrome and aldehyde tanning
- There are advantages and disadvantages to all three

End of life:

- Incineration (chrome III to VI)
- Landfill (the risk of leaching)
- Gasification
- Biofuels[9]
- Composting

The share of tanning methods, worldwide

Chrome	80%
Vegetable	15 – 18%
Chrome free	2 – 5%

Stability, in descending order[10]

Vegetable
Chrome
Chrome free
Chamois (easily degraded, small share)

A good definition of CF:

A carbon footprint is the total amount of CO_2 and other greenhouse gases, emitted over the full life cycle of a process or a product. It is expressed in grams of CO_2 equivalents.

[7] *The logic here appears quite arbitrary! Cr consumption used for tanning purposes is only a fraction of the total (metallurgy!).*

[8] *Advantageous in the sense that the nature of pollution of post tanning (hard to treat) is normally underestimated! Otherwise, conclusions are rather inconclusive!*

[9] *Unrealistic, at least for the time being. The same applies to composting.*

[10] *Vegetable tanned leather is stable only if kept dry, not humidity resistant!! Compare with LGR study (Cr vs. vegetable).*

Other greenhouse gases (GHG)[11]

It is often overlooked that in addition to carbon dioxide, CO_2 there are other greenhouse gases as well as ozone depleting substances.

	Greenhouse gas	*Chemical formula*	*100 year GWP*
	Carbon dioxide	CO_2	1
	Sulphur hexafluoride	SF_6	22800
	Methane	CH_4	25
	Nitrous oxide	N_2O	298
Some HFCs	HFC-23	CHF_3	14800
	HFC-32	CH_2F_2	675
	HFC-236a	$CF_3CH_2CF_3$	9810
Some PFCs	PFC-14	CF_4	7390
	PFC-116	C_2F_6	12200

Source: IPCC

Methane production: 550 – 700 litres/cow/day. Methane is about 25 times worse than CO_2!

When considering CF it is important to take into account not only direct emissions from production but also emissions from electricity/power as well as indirect ones from products and services used (e.g. transportation).

To reduce the carbon footprint, consider:

- Sourcing and manufacturing
- Transportation (e.g. by surface instead by air)
- Optimisation of energy efficiency and use of renewable (solar energy) and non-traditional sources (heat pumps)

7.5. UK, Environmental Reporting Guidelines, mandatory GHG emissions reporting guidance, June 2013

The Companies Act 2006 Regulations 2013 requires quoted companies to report on greenhouse gas (GHG) emissions for which they are responsible. Quoted companies, as defined by the Companies Act 20063, are also required to report on environmental matters to the extent that it is necessary for an understanding of the company’s business within their Annual Report, including where appropriate the use of key performance indicators (KPIs). If the Annual Report does not contain this information, then it must point out the omissions.

7.6. Footprint boundaries for leather, D. Tegtmeyer, IUR Commission, IULTCS

✓ An official LCA method for products based on renewable materials was applied on the leather manufacturing process in order to harmonize the calculations and determine a reference standard.

[11] *Incidentally, it is quite amazing to read dramatic, pessimistic forecasts of rapidly approaching draining of world oil reserves some 20 years ago!*

- ✓ Unfortunately, the boundary setting for a system to calculate the environmental footprint is not simple; very different methods refer to different system boundaries.
- ✓ In regard to leather, the big issue is whether to include or exclude the upstream processes such as the breeding of animals as well as the agricultural processes for growing the respective feed.

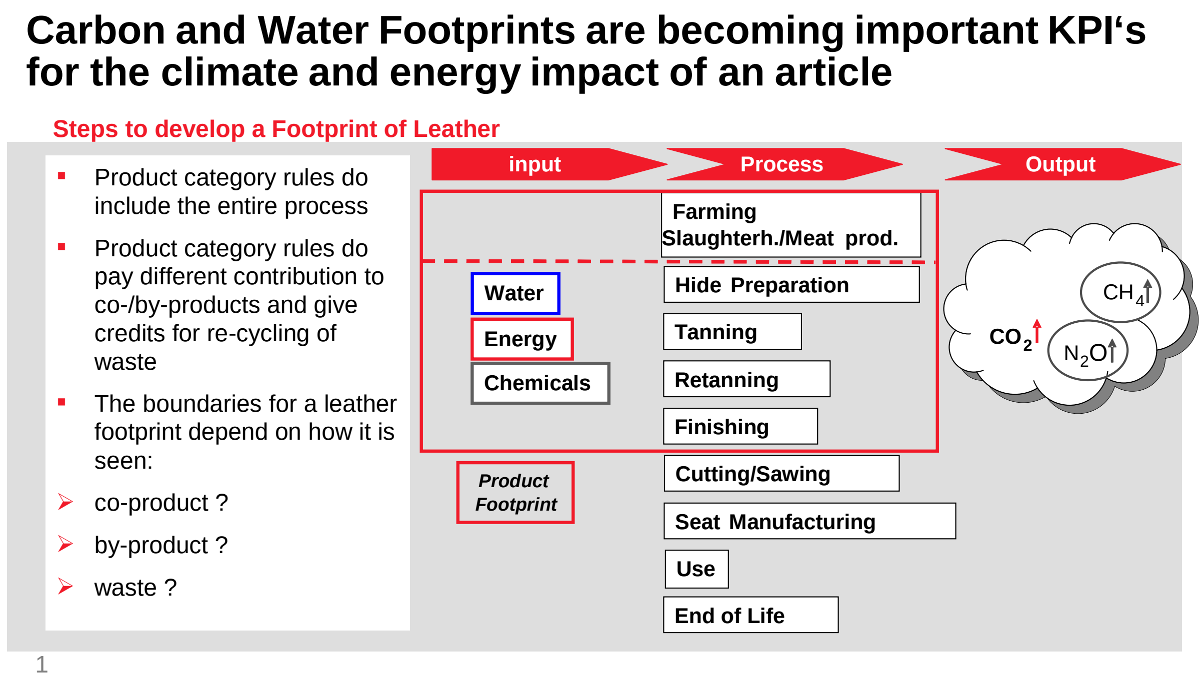


Figure 6. Process chain of leather manufacturing

The LCA methodology proposed by B. Weidema (1999) and based on scientific justification is the most appropriate for leather manufacturing.

From an LCA point of view, while meat and milk are the main products, hides and skins can be classified in three categories:

- ➢ **Co-product**

Has a significant value and cannot be seen independently from the main product; footprint values get shared according to reasonable economic value contributions.

- ➢ **By-product**

A by-product is still a useful outcome of the main process; however use and application has no influence on the production of the main product. It is considered to be a "non-determining co-product". For a footprint calculation normally a partial contribution could be done; however, exceptions are possible and need to be clearly justified.

- ➢ **Waste**

Waste is "left over" with no-to-low value and also zero influence on the mainstream product, which should go into a re-cycling operation or be sent for appropriate disposal. The footprint impact of the treatment will be allocated to the main product.

Leather is generally seen as a by-product of the meat or milk industry.

Recent studies have shown that the carbon footprint of leather can vary between 35 and 320 kg/m^2 for the same article depending on how boundaries are set and what parameters should be taken as a base for the calculation.

Only a very small contribution appears to be allocated to the tannery operation (see fig: 2). In terms of a carbon footprint of 110 kg/m^2 (average value) it is less than 20%, in terms of a water footprint of 16.500 l/ m^2 and it is even less than 1 % of the overall sum.

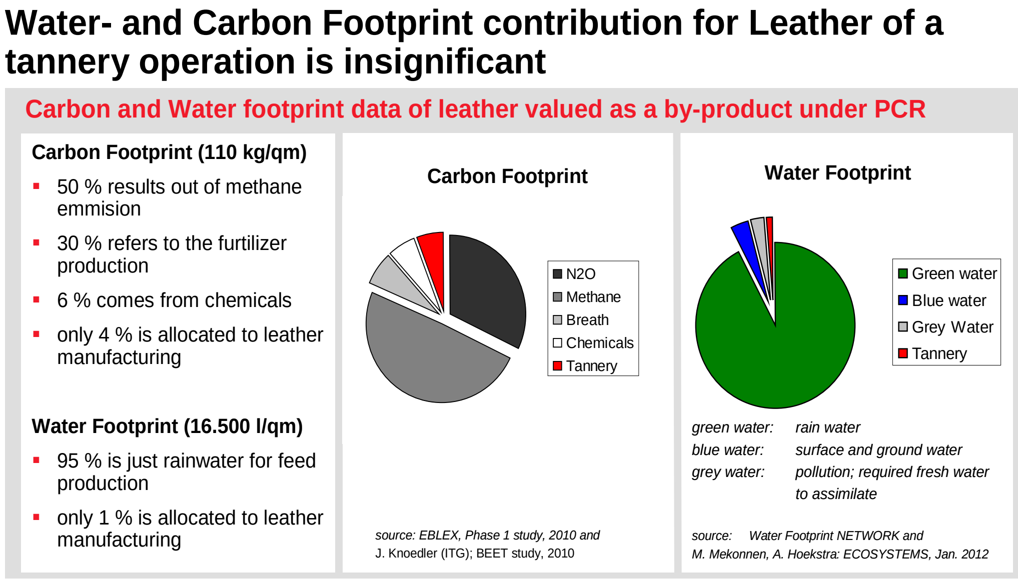


Figure 7. Examples for Water- and Carbon Footprint splits based on traditional Product Category Rules (PCR)

Allocation shall be avoided whenever possible.

A simple and logical methodology with extended boundaries (System Expansion) is the alternative that should be applied for certain products originating from renewable sources and generating several co- or by-products, in other terms “sustainable materials”. The leather manufacturing process fits well to this method, the main conditions of which are:

1. the co-product/by-product needs to be based on a renewable raw material source
2. the co-product/by-product should displace, in its final application, another product based on a non-renewable material
3. the demand for the co-product/by-product has no influence on the production volume of the main product

For leather all the three conditions are 100% valid:

Ad 1) The overall average use of a leather article estimated at approximately 4 years (upholstery ~10 years, shoe ~1 year, leather goods and garments ~ 4 years) is in alignment with the reproduction time of a hide or skin.

Ad 2) Leather is a widely used material for valuable consumer articles such as shoes, furniture seating, garment, automotive seats, etc. If leather wouldn’t be available as a choice of material, the same amount of articles would be produced with alternative substrates. A high amount of them would be based on non-renewable materials such as PU coated substrates or vinyl; these products are actually being displaced by the use of leather. Their avoidance is a benefit for the environment; the corresponding carbon emissions have been avoided because of the valorisation of animal hides and skins into leather.

Ad 3) Meat and milk production are the main upstream processes; in some cases, for footprint calculations even the production of animal food is incorporated into calculations. The volume of the main products is in NO way determined by the demand for leather. Over the last 10 years due to special feedlot practice animal weight has significantly increased, which leads to a lower amount of available hides based on similar meat production capacities.

This methodology fits well for environmental footprint calculations of leather products, regardless of whether it is the water footprint or the carbon footprint. In all cases animal husbandry and agriculture are excluded and the footprint calculation starts in the slaughterhouse.

In order to encourage the use of by-products for sustainable application, when materials based on non-renewable raw materials are displaced, extended system boundaries will be applied even for the upstream processes. The upstream process obtains the credit, and in case this by-product is used according to the rules of a sustainable product, so that it will have no impact, it is carbon neutral. Thus, for a hide or skin converted into leather, the meat industry is credited for the corresponding CO_2 emissions avoided by the displaced products.

The same logic applies for by-products that are generated through the leather manufacturing process; if they are again used as a raw material for a new application, even the leather making process is credited accordingly. It remains to be clarified whether the contribution of the by-product is evaluated according to weight or value.

7.7. J. Knoedler, ITG, Germany

- ✓ Artificial leather: 15.8 kg CO_2e/m^2 (including incineration)
- ✓ Textile (polyester): 20.6 kg CO_2e/m^2 (including incineration)

The basic premises regarding CFP in the tanning industry:

No leather processing/no tanning industry → cattle and livestock not affected
Reduced meat/milk demand & production → reduced cattle and livestock

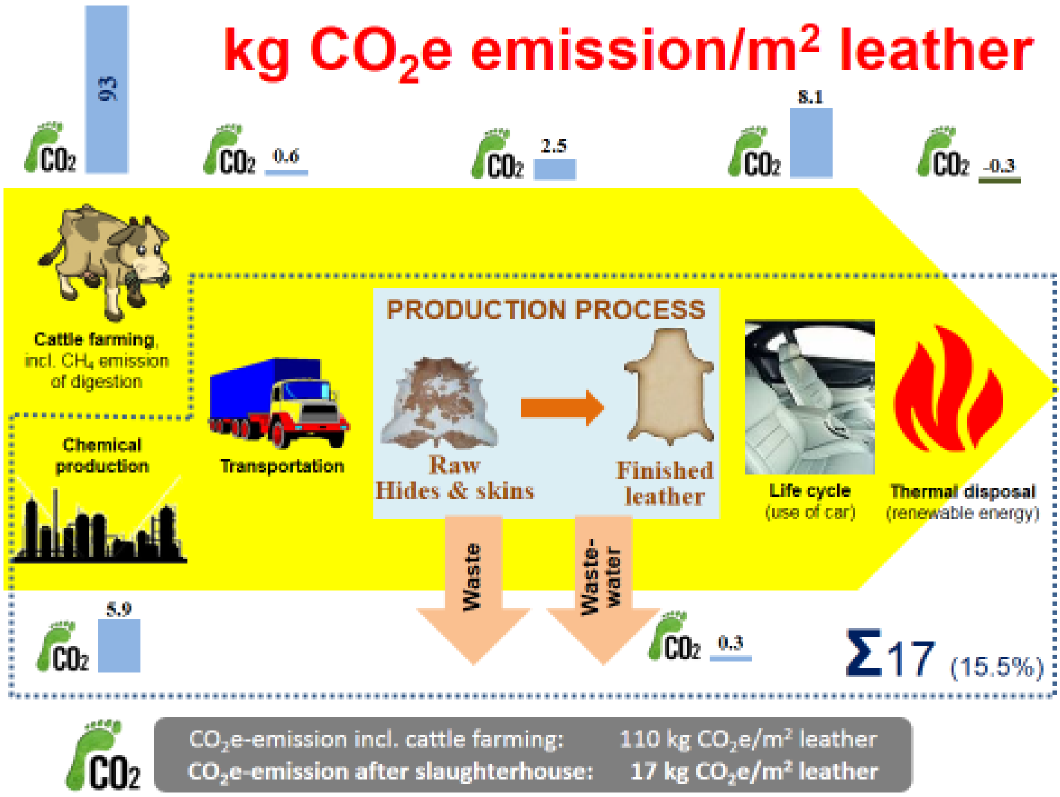
<u>ergo</u>

Animal husbandry not related to the leather industry! →CO_2 emissions from cattle farming belong to the meat/milk industries!

CO_2e/m^2 in the tanning process:

- Transport of raw material and chemicals 0.6 kg CO_2e/m^2
- Processing from raw hide to finish 2.5 CO_2e/m^2
- Waste water treatment, incl. transportation 0.3 CO_2e/m^2

Figure 8. Carbon dioxide, CO_2e/m^2 of leather



The chart by F. Schmel, derived from the presentation by J. Knoedler

- ✓ CO_2e emissions including cattle farming: 110 kg CO_2e/m^2 of leather
- ✓ CO_2e emissions after slaughterhouse: 17 kg CO_2e/m^2 of leather

CO_2e emissions and PCF for leather for car upholstery, "cradle-to-grave", from slaughterhouse:

Life cycle car	45.3%
Production	14.0%
Chemicals	36.5%
Waste and waste water treatment	1.7%
Employee access route	0.4%
Final thermal disposal	1.1%
Transportation	1.7%

UNIDO Shanghai 2012, system boundaries, three preconditions:

- The material (raw hide) needs to be fully based on a renewable raw material
- Any material should at least partly replace a non-renewable substrate in its final application
- The demand for the product does not influence the upstream process

If all three conditions are fulfilled the boundary for the co-products (leather) should exclude upstream processes because it is a sustainable material.

7.8. End of life (EoL), UNIDO 2014

Leather is nowadays mainly used for footwear production, automotive and furniture upholstery, garments, gloves and other leather goods production.

The footwear industry over the last years has placed significant effort in improving energy and material efficiency, as well as eliminating the use of hazardous materials during the production phase. However, the environmental gains and energy efficiency made in production are being overtaken by the considerable increase in the demand for footwear products, the so called rebound effect. Moreover, the useful life of shoes is relatively short and progressively decreasing as a result of rapid market changes and consumer fashion trends. This creates a large waste stream of worn and discarded shoes – at the time their functional life has ended most of them are being disposed of in landfills. Producers' responsibility issues and forthcoming environmental legislations, as well as increasingly environmental consumer demands, are expected to challenge the way the footwear industry deals with the EoL of its products.

Currently around 19 billion pairs of leather shoes are produced worldwide every year, and this figure continues to rise. This creates an enormous amount of post-consumer (end-of-life) shoe waste that is currently being disposed of in landfill sites around the world. The footwear industry, over the last years, has placed significant effort in improving energy and material efficiency. Producers' responsibility issues and forthcoming legislation as well as increasing environmental consumer demands are expected to challenge the way the global footwear industry deals with its end-of-life waste.

7.9. European Standard EN 16887:2017

The document European Standard EN 16887:2017 Leather – Environmental footprint – Product Category Rules (PCR) – Carbon footprints was approved in November 2016, published in March 2017 and it is applicable not later than Sept 2017.

The normative references (linkages) are:
EN 15987:2015, Leather – Terminology – Key definitions for the leather trade
EN ISO 2589, Leather – Physical and mechanical tests – Determination of thickness (ISO 2589)
EN ISO 14021:2016, Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling), (ISO 14021:2016)
EN ISO 14025, Environmental labels and declarations – Type III environmental declarations, Principles and procedures (ISO 14025)

CEN ISO/TS 14067, Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and communication (ISO/TS 14067)

In general the document provides the list of terms and definitions used (leather, split leather, sole leather, crust, semi-processed leather, primary/site-specific/secondary data etc.).

The main part is the *Product Category Rules (PCR),* defined as documents that stipulate mandatory requirements for environmental declarations of a certain category of products ensuring transparency and comparability among different environmental footprints of products of the same category.

The key PCR elements are:

- Specification of the product - leather type (e.g. bovine, full grain, flesh split etc.), thickness, process stage (wet blue, crust, finished), type of tanning (vegetable, synthetic, other), intended use (footwear, leather goods)
- Functional unit: 1 m^2 of leather, 1 kg for sole leather
- Bill of materials (BoM)

  Here it is specified that finished leather is composed of stabilized collagen and chemical residuals; that the weight of collagen may vary from 50% (vegetable sole leather) to 85% (chrome tanned); and that chemicals used fall into a category intended to treat the substrate but are not retained in the finished leather (e.g. acids, surfactants, bases) and those which remain in the leather.

  While all chemicals used should be included when calculating the leather carbon footprint, the bill of materials, expressed in percentage ranges (e.g. 0.2 - 0.5%), should include only chemicals from the second category (retained):

  - tannins
  - dyes
  - pigments
  - fatliquors
  - resins
  - salts

Tanners as well as the whole leather industry can be satisfied with the norm set by the European Standard EN 16887:2017 concerning the critical issue of **system boundaries for PCF calculation**: **they start at the slaughterhouse floor and end at the tannery exit gate.** They include waste water treatment, waste and by-products management, but, most importantly, exclude all operations up to and including flaying because they are considered as integral part of the meat production.
Accordingly, collection and preservation of raw material, production of chemicals, production of electricity and other types of energy, water extraction and supply, packaging, as well as the impact of transportation of supplies are classified as *upstream processes*.

Core processes are: beamhouse and tanning, post tanning, finishing, internal mechanical operations, transportation within the tannery (only energy and fuel consumption), factory outlet.

Downstream processes are: treatment of effluent and air emissions, by-products, and (solid?) waste management, including relevant transportation impact.

Waste and possible by-products should be clearly identified; only splits leaving the leather value chain are considered by-products, otherwise they are considered products.

Data quality rules are elaborated in great detail; the following are the most important points:

- All data used for calculation have to be verifiable and auditable
- A correlation of the weight changes along the tanning process should be presented and related to the final unit of measurement (m^2 or kg for sole leather)
- Whenever possible primary, site specific data should be used
- In absence of primary, site specific data, primary data from commonly available sources can be used
- Similarly, if primary data sources are not available, secondary data can be used and documented; the environmental impact of the processes for which secondary data are used should not exceed 10% of the total environmental impact of the product system.

Allocation rules, geographical & time boundaries, boundaries to other products life cycles: some features include:

- Allocation between different products and by-products (e.g. fleshings) are weight based and in proportion to the different products and co-products.
- Allocation between different products and co-products (e.g. splits) are surface based and in proportion to the different products and co-products.
- A minimum of 99% of the total weight of a declared product (1% cut off rule), including packaging, should be included.
- Maintenance activities (proportionally allocated) are included in the impact calculation of the general management function; the recycling process and transportation of the inflow of recycled material should be included whereas for the outflow of recycling material only transportation is included; business travel and staff travel to and from work are not included.
- The data should be representative for the site/region and the year for which the PCF is valid (maximum 3 years).

The Product declaration is expected to contain:

- Reference to European Standard EN 16887:2017, Leather and CEN ISO/TS 14067, Greenhouse gases
- Reference to certification (any); if it is a self-declaration then the reference to EN ISO 14021:2016, Environmental labels and declarations should be included?
- As mentioned earlier, the results are to be expressed in kg of CO_{2e} per m^2 or per kg of sole leather
- The name of the product, the manufacturer and the year of reference

Note:
Annexes provide the guidance on how to calculate the impact of the product together with the list of chemicals used by the tanning industry (Annex A), classification codes for leather and leather products (Annex B) and emissions profile formulae/allocation rules for waste and by-product treatment (Annex C).

It is worth noting that Annex C specifies that a tannery is credited for the difference between CO_{2e} emissions for waste/by-products vs. new materials; it is also credited for CO_{2e} from the heating value of the net produced bio-gas and the heating value of the incinerated material in case of incineration in co-generation plants.

Conversely, the CO_{2e} produced by the thermal plant as well as from landfilling are allocated to the tannery.

8. PRODUCER'S RESPONSIBILITY ISSUES

In most countries, managing EoL waste has long been and, in most cases, still is the responsibility of government agencies and local authorities. Once products reach the end of their functional lives, producers play no role in collection, recycling and/or disposal of EoL products.

This approach has started to change with the emergence of a producer's responsibility concept. This concept was first introduced in Germany with the 1991 Packaging Ordinance, which required manufacturers and distributors to take back packaging from consumers and ensured that a specified percentage was recycled. Producer responsibility legislation was introduced into the EU waste policy with the 1994 Packaging Directive and since then has spread to most industrialized countries. In 2000, the European Commission passed a Directive requiring its Member States to institute a producer responsibility program for end-of-life vehicles (ELV) which also includes leather used in cars and vehicles.

This concept of broadening a manufacturer's responsibility for products beyond their useful life and into the post-consumer phase includes closing the loop on materials used and waste management. This approach should provide a source of financing to offset the cost disadvantage of recycling versus disposal and energy recovery.

In this context, take-back and producer responsibility legislation is expected to affect the footwear sector including leather, similarly to what has happened in the case of cars (ELV).

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