Short procedural guideline to identify the functional unit for a product environmental footprint and to delimit the scope of product categories

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2017-03-31

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Introduction

This guideline provides a procedural description to identify the relevant granularity of product groups, through the definition of functional units that express the obligatory product properties in the market segment where the products are sold.

This guideline has been produced as a complement to the PEF guidance (European Commission 2013, 2016).

The guideline is applicable for Product Life Cycle Assessments in general, also beyond the Product Environmental Footprint (PEF) scheme.

Terminology

Functional unit: quantified performance of a product system for use as a reference unit (ISO 14040:2006).

Product category: a group of products that can fulfil equivalent functions (ISO 14025:2006). A product category is thus delimited by its functional unit.

The aim of this guideline

The procedure aims at:

- ensuring comparability of products within each product category, sufficient to fulfil the requirements of ISO 14044, clause 4.2.3.7[1],
- being applicable to all products, intermediate as well as final,
- ensuring modularity, i.e. that a functional unit can be defined for each and any gate-to-gate system (unit process) in a product system,
- describing the identification of functional units in an unambiguous way.

The guideline aims at describing the procedure as clearly and practical as possible. Theoretical explanations and justifications are kept to a minimum. The reader that is interested in the theoretical and legal background is referred to the publications of the Danish methodology consensus-project (Weidema et al. 2004, Weidema 2003) where this procedure was originally developed, and the European Commission notice on the definition of relevant market for the purposes of Community competition law (European Commission 1997).

The guideline includes 3 real-life examples illustrating the application of the procedure.

[1] "the scope of the study shall be defined in such a way that the systems can be compared"

Core idea of the procedure
The core idea of the procedure is that the functional unit shall reflect the substitutability of the product in its *market*, where the product has a functional specification that the customer requires to be fulfilled, also known as the *obligatory product properties.* Only in this way can the comparability requirement be fulfilled.

Thus, the procedure has three steps:

- Step 1: Identify the *market segment for the product,*
- Step 2: Identify the *obligatory product properties* in this market,
- Step 3: Express the functional unit as a *quantity* of the product, as defined by the obligatory product properties.

The PEF requirements
The current PEF Guide (European Commission 2013, 2016) requires the functional unit to be defined in terms of

a) The function(s)/service(s) provided (what)
b) The extent of the function or service (how much)
c) The expected level of quality (how well)
d) The duration/life time of the product (how long)
e) The CPA-codes at minimum 2-digit level

The following procedure covers these requirements but also complements them. Point d) above is covered by the step of temporal delimitation of the *markets* and together with point a) and c) by the step of identifying the *obligatory product properties.* Point b) above is covered by the step of *expressing the functional unit as a quantity*, which also summarises the other points.

The CPA-codes (point e above) can be helpful to identify the relevant products, but often a functional unit will apply to only a part of the products under a specific CPA-code (even at the 6-digit level), or a functional unit will be shared by several – sometimes very different – products, with different CPA-codes.

It should also be noted that the same product might be sold on more than one market (i.e. for more than one purpose and with different functional units). The same product may therefore belong to more than one product category.

Legal aspects
In the context of competition law, a formal procedure for identification of market segments (named "relevant markets") has evolved, which has close parallels to the procedure described here. It is therefore relevant to see this formal procedure as a legal basis also in the context of the PEF scheme and other official contexts in which Product Life Cycle Assessments may be applied. A legal basis is particularly relevant in situations where controversies over comparable vs. non-comparable products may arise. This may be unacceptable comparisons (for example including a stationary bike in a comparison of bicycles, or comparing products with very different price levels) or unacceptable *exclusions* from a comparison (for example excluding smokeless alternatives from a comparison of residential fireplaces).

The European Commission (1997) defines a relevant product market as comprising "all those products and/or services which are regarded as interchangeable or substitutable by the consumer, by reason of the products' characteristics, their prices and their intended use". Further, a relevant geographic market is defined as comprising "the area in which the undertakings concerned are involved in the supply and demand of products or services, in which the conditions of competition are sufficiently homogeneous and which can be distinguished from neighbouring areas because the conditions of competition are appreciably different in those areas".

Procedural step 1. Identify the market segment for the product

The market is where the product reaches its customer. It is thus via purchases on the market that the customers can express their requirements to the product from which we can identify the obligatory product properties that that we use to define the functional unit. Therefore, it is important to be precise in describing the market for the product, in terms of its delimitation in space and time, and in terms of the customers in the market.

Geographical segmentation

In general, the geographical segmentation of a market may be caused by differences in:

- Natural geography (climate, landscape, transport distances etc.),
- Regulation or administration (regulation of competition and market transparency, barriers to market entry, legislative product requirements, regulatory barriers arising from public procurement, product standards, packaging regulations, quotas, taxes, subsidies),
- Consumer culture.

Geographical segments can be identified and documented by the lack of imports of the product across the geographical boundary. However, if the actual trade patterns are suspected to reflect recently removed regulative or administrative barriers, the wider geographical market expected from future market integration should be considered. Also, for products with significant transport costs, lack of trade between distant areas A and C does not necessarily prove that these are separate markets, when producers in a central area B can supply the areas of both A and C. The same reasoning of chain substitution may apply to other aspects of market segmentation than geographical location.

For the PEF scheme, it will generally be relevant to describe the geographical boundary as that of the European single market. For some products a global market may be relevant. Deviations from this, i.e. more narrow geographical boundaries, shall be justified and documented in relation to the above.

Temporal segmentation

Customers require products to be available at specific points in time. Temporal segmentation of markets is therefore often relevant for service products (e.g. peak hours and night hours in electricity consumption, rush hours in traffic and telecommunication, seasons in the tourist industry). For physical goods, markets are generally only segmented temporally when adequate supply or storage

capacity is missing, either due to the nature of the product (e.g. food products), or due to immature or unstable markets (e.g. some recycled materials).

The temporal requirement is part of the obligatory product properties and can also significantly influence which products and producers that can fulfil the functional unit.

Customer segmentation
Customer segments are generally defined in terms of clearly distinct function-based requirements, i.e. based on the needs that the products fulfil rather than the physical products in themselves. Very similar products may serve different needs and hence serve different markets. And very different products may serve the same need (= have the same obligatory properties), thus being in competition in the same market.

Differences in customer requirements may be based on differences in the purchase situation, the use situation, customer scale, age, sex, education, status, "culture", attitudes etc.

To have a practical relevance, customer segments must be of a size that can provide adequate revenue to support a separate product line. Furthermore customer segments must be clearly distinct and with a minimum of overlap to other segments, so that substitution between segments can be neglected, and all products targeted for a segment are considered substitutable by the customers of this segment.

It is possible to further subdivide market segments into market niches. A *market niche* is a further sub-category of a market segment, where a part of the customers consider only niche products substitutable, although the majority of the customers allow substitution between products from the niche and other products in the segment. Thus, the difference between a segment and a niche is that between segments substitution is negligible, while a large part of the customers in a segment will allow substitution between niche products. The generic market segmentation will typically be sufficient for delimiting the scope of product categories, while the further subdivision into market niches may be relevant for specific comparisons.

Customer segmentation can be unnecessary in situations where the suppliers are able to switch production between various qualities of products in the short term (i.e. without need for significant changes in production equipment) without incurring significant additional costs or risks, and thus without significant differences in unit costs and prices, even if the different qualities are not regarded as substitutable by a given group of customers. In such situations, the different qualities should anyway be grouped into one product market and category. For example, meat producers may easily shift between different cuts of meat in response to changes in supply and demand. Because of this supply substitutability, these different cuts can be regarded as belonging to the same market and product category, even though the consumers may not regard the

different cuts as substitutable. The same reasoning may be used to avoid unnecessary geographical market segmentation.

Information on market segmentation can typically be obtained from the marketing departments of the enterprises supplying products to the market. If information cannot be obtained directly from the market suppliers, possible secondary sources are:

- Retailers, which cover more than one segment,
- Industrial associations,
- Industrial research institutions and industrial consultants,
- Marketing and consumer research institutions.

Procedural step 2. Identify the obligatory product properties

The purpose of this step is to identify – out of all the properties that a product may have – those properties that shall be included in the functional unit. These properties are called *obligatory properties*, namely those that the product *must have* in order to be at all considered as a relevant alternative.

Obligatory product properties are typically related to:

- functionality, associated with the main function of the product
- technical quality, such as stability, durability, ease of maintenance/repair,
- additional services rendered during use, recycling or disposal,
- costs related to purchase, use, recycling or disposal,

which can all be described in quantitative terms, typically as intervals with minimum and/or maximum values.

A quantitative description can thus be given, covering at least the functionality (what), the expected level of quality (how well) and the duration/life time of the product (how long).

Environmental properties may also be included as obligatory when expressed as specific properties, for example the compliance with a specific threshold value for a specific toxic compound in building materials. It is not meaningful to include general non-quantifiable properties as ”environment-friendly” or ”non-toxic” as obligatory.

Other product properties, such as aesthetics and image, that cannot be measured directly, are typically positioning properties, i.e. properties that are considered *nice to have* by the customer and which may therefore *position* the product more favourably with the customer, relative to other products with the same obligatory properties. Because these properties are not obligatory, i.e. not excluding the product from being considered as a relevant alternative, these properties *shall not* be included in the functional unit.

The same product property may be obligatory in one market and not obligatory in another market. For example, in the market niche for men’s leather footwear, it is an obligatory property that the shoe upper material is genuine leather, while in the generic market for men’s casual and town footwear, the upper material may also be leather substitutes.

Information on obligatory properties for a specific market segment can be obtained from:

- The marketing departments of the enterprises supplying products to the market segment,
- Retailers,
- Industrial organisations,
- Industrial research institutions and industry consultants,
- Regulating authorities and standardisation bodies,
- Marketing and consumer research institutions.

The information will often be of three kinds:

- Issues regulated in national and international legislation and standards,
- Evidence from market events or shocks in the recent past
- Information from market surveys.

When available, recent evidence from market events or shocks, where changes in quantities demanded can be observed in response to changes in relative prices or launches of new products (all else being equal), will normally be preferable in comparison to information from market surveys. There are a number of quantitative analytical measures that have specifically been designed for the purpose of identifying substitutability. These include cross-price-elasticities (the percentage change in demand for one product per percentage change in the price of another product), measures of similarity or convergence of price movements over time, and measures of causal relations in price series. Such analyses will normally only be required if the existence or lack of substitutability is the subject of a controversy.

Market surveys are especially useful if they ask for what competing products the customers have considered, and/or what properties/attributes are regarded as obligatory/mandatory for a purchase. More advanced surveys may use choice experiments, where consumers are asked for their preference for goods with different levels of different properties/attributes. Price is often included as one of the properties.

For the identification of obligatory product properties, it is *not* necessary to have access to the resulting numerical information of willingness to pay, cross-elasticities or diversion rates. All that is needed is the information that a specific property or product has a positive cross-elasticity, i.e. that an increase in price of one product or property leads to an increase in sales of the other product with a different property. From this it can be concluded that the two products and properties are regarded as substitutable, at least for a part of the customers.

When seen together, the obligatory properties should give a good description of what is required for products to substitute for each other.

For intermediate products, components, or products that are dependent on other products, there is a risk of choosing a too-narrow product perspective and thereby overlooking obligatory properties that are defined outside of this

perspective. For example, for the product group ”chairs” it may be relevant to consider whether other ways of providing seating support are available, or if there are external constraints because the chairs are only one component in a complete interior solution for the office.

Procedural step 3. Express the functional unit as a quantity of the product
In this step, the extent of the function or service (i.e. the “how much” and “how long”) is defined. Since the market segment and the obligatory product properties were already identified in the previous two steps, this step is limited to define the functional unit in terms of a quantity of the product as defined by its obligatory product properties required in the market segment.

The functional unit should as far as possible relate to the functions of the product rather than to the physical product. For example, rather “minimum 7 years of computer workstation seating support” than “1 office chair”. In this way, it is ensured that all obligatory properties – as well as the duration of the product performance – are addressed.

The precise size of the functional unit has no importance for the interpretation of the results, as long as the information is used for small-scale decisions. Thus, the only concern is that the size should be as easy as possible for the intended audience to compare the size to something well-known. Often, industries will have a typical unit applied for e.g. industry statistics. Otherwise, the size of the functional unit may be set equal or close to the annual per capita consumption of the studied product in the studied market segment.

Examples

Example 1. Food

This example has on purpose been formulated at the widest possible level, reflecting the maximum substitutability between meals and their components. This allows a description of the hierarchical nature of the markets and their corresponding product groups, justifying that "Food" can be regarded as a generic product category, which can then be further specified according to the different market conditions. This also illustrates the modularity of functional units, where a functional unit can be defined for each unit process in the supply chain for a specific food item, as it enters into the preparation of specific components of a meal, to the serving of the overall meal, and finally its role in the generic customer requirement for "food".

Procedural step 1. Identify the market segment for the product

The consumption of food is an indispensable need for all humans, and the consumption typically takes place daily at a specific time of day, in the form of a *meal*, with the option of interspersing consumption of *snack*, each of which can be regarded as separate markets and product categories within the generic "Food" market.

The market for meals can be subdivided *temporally*, illustrated by the fact that meals suppliers typically change their menus depending on the time of day, so that the same supplier can have different breakfast, lunch, and dinner menus. Substitutability between meal types and between meals and snacks is possible, which justifies regarding all as belonging to the same generic product category. In practice, the pattern of consumption, the *meal pattern*, is relatively stable for a specific person.

Besides the temporal division, the market for meals can be subdivided in three, based on the location and type of meal supplier, as shown in *Table 1*. This subdivision is supported by cross-elasticity studies; see e.g. Okrent & Alston (2012). Substitutability between the three markets is typically limited by transport distance, and sometimes by rules of compulsory attendance, e.g. in the case of public institutions (schools, hospitals, military, prisons, etc.). Nevertheless, some substitutability is given by the options of households to choose between a home cooked meal and a restaurant meal, and options of employees to choose a restaurant meal instead of a company canteen (institutional) meal.

It is obvious that the markets are quite geographically limited, and that it would not make sense to define these markets at the European level. Nevertheless, some aspects of these markets can be generalised, as will be described in the following.

The three markets differ in the freedom they give for further customer influence on further segmentation, as indicated in Table 1. In the market for restaurant meals there will typically be a choice between alternative restaurants, while the

supplier is fixed in the case of home cooked and institutional meals. Restaurant meals also provide more options for customers to choose meal type and courses, while home cooked meals give the customer more influence on course composition, portion size and ingredients. For all three markets, the further decisions on ingredients suppliers (not included in Table 1) are typically left to the meal supplier. The market for dinner meals is delimited from the more specific markets for meal type, courses and ingredients, by the difference in customer influence indicated in Table 1: The market for meals is delimited to the points where it is the meal customer that takes the decision, while for the other markets, it is the meal provider that is the customer (decision maker).

Table 1. Three market segments for meals with indication of supplier and customer influence on key characteristics of the product. Customer is here understood as the person eating the meal, and household is the household that the customer belongs to.

Product	**Home cooked meal**	**Restaurant meal**	**Institutional meal**
Meal supplier	Household kitchen	Restaurant kitchen	Institutional kitchen
Diet planning by meal supplier	Optional	No	Yes (typically)
Alternative meal suppliers	No	Household choice	No
Decision on meal type and courses	Meal supplier (possibly with some household influence)	Household or customer choice	Meal supplier (possibly with limited customer choice)
Decision on course composition	Meal supplier (possibly with some household and customer influence)	Meal supplier (possibly with limited customer choice)	Meal supplier
Decision on portion size	Meal supplier or customer	Meal supplier (except for buffet service)	Meal supplier (except for buffet service)
Decision on ingredients	Meal supplier (possibly with some household and customer influence)	Meal supplier (possibly with limited customer choice)	Meal supplier (possibly with limited customer choice)

The large influence of the meal supplier on the majority of the decisions outlined in Table 1 implies that there is no need for further market segmentation in the case of home cooked meals and institutional meals. However, in the case of restaurant meals there is a larger customer influence on choice of supplier (alternative restaurants), meal type, and courses. So it is reasonable to consider further *customer segmentation* of the market for restaurant meals.

For restaurant meals, an obvious data source for customer segmentation is the categories used by Internet search portals, such as Tripadvisor®. These divide restaurants according to:

- Price level,

- Cuisine, typically divided by region, nationality or typical ingredients (e.g. seafood), dishes (e.g. pizza, steakhouse), preparation methods (e.g. barbeque, sushi) or presentation methods (e.g. buffet), and
- Dietary restrictions (vegetarian, halal, etc.).

Available segments will typically vary widely with the geographical area, reflecting local tastes and socio-demographic characteristics. Suppliers will typically not be able to switch easily between the described segments.

Procedural step 2. Identify the obligatory product properties

The broad definition of food, snacks and meals as product categories points to some of their properties being of a general nature.

The portion size provides the "how much" is consumed in a meal, but will also determine "how long" the customer will feel satiated, i.e. how much time will pass before an additional meal or snack will be demanded. Satiety can be determined by subjective scores but can more reliably be measured as the compensation score, i.e. the relative reduction in energy intake at later meals expressed as a percentage of the energy of the preload meal, where 100% equals perfect compensation. Another option that has not been used extensively is to measure serum levels of ghrelin ("the hunger hormone"), which is closely inversely correlated to satiety (de Graaf 2004). To be fully substantiated for use in claims made for commercially available foods, also the longer-term effects (e.g. after one month chronic consumption of the food) should be measured. When comparing foods with the same energy content, protein and fibre rich foods deliver more satiety than carbohydrate rich foods, while sweet-tasting foods and foods rich in fat delivers less satiety (Chambers et al. 2015, Hopkins et al. 2016). However, appetite control is still a very young research field into a physiologically complex mechanism and most studies do not yet include long-term effects, so it is probably too optimistic and premature to seek to express the results in such simple formulas as that proposed by the FullnessFactor® (see Figure 1), which builds on a multivariate analysis of the very early studies in the 1990'ies. It is nevertheless this kind of quantitative relations (of course with uncertainty) that would be relevant to include in a comparison of meals of different compositions. For two meals of equal composition, the actual portion sizes may be used for comparisons. These are typically determined by tradition, but portion size traditions may be very different between geographical areas and also change over time.

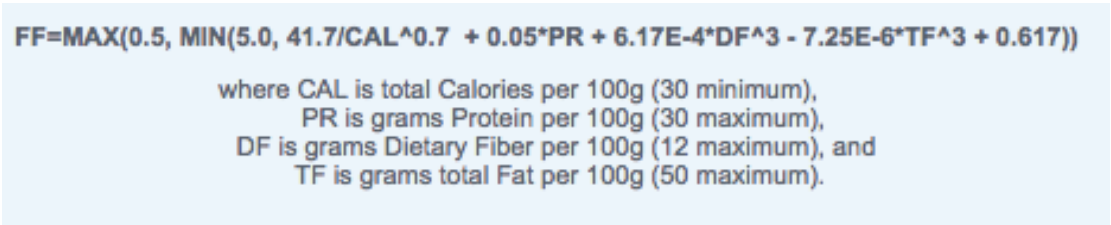

Figure 1. Example of an attempt to reduce the complexity of satiety into a simple formula. Copied 2016-02-14 from http://nutritiondata.self.com/topics/fullness-factor

A “how well” property that is of general relevance for foods is the absence of food contamination and adulteration, i.e. that the consumption of the food does not imply a health hazard, and that the food or its components have not been intentionally substituted or diluted for the purpose of reducing production costs or increasing the apparent value of the product. In practice, this is prevented by requiring a number of preventive procedures to be followed throughout the supply chain and by sample testing, typically regulated by law and enforced by sample testing and inspections of Good Manufacturing Practice (GMP) by national regulatory agencies.

Codex Alimentarius is a collection of international standards on foods (see http://www.fao.org/fao-who-codexalimentarius/standards/list-of-standards/en/) covering both general practice guidelines (e.g. for manufacturing, measurements, and labelling), and standards for many specific foods (canned salmon, preserved tomatoes, etc.). Although legal compliance requirements depends on national implementation, the Codex requirements can generally be seen as obligatory.

Some properties may be determined as obligatory either for the meal or snack as such or as an average over several meals and snacks, i.e. as diet requirements:

- Price range or budget range,
- Health concerns formulated as general rules of exclusion, maximum or minimum inclusion, and in the case of formal meal planning in institutional kitchens as specific nutritional requirements,
- Variation: A minimum time since the same meal, meal component, or snack was served (not applicable to restaurants where the customer makes the choice).

Some properties may be obligatory for specific dishes or components:

- Shelf-life
- Serving temperature range
- Ranges of flavours, flavour strength, and texture properties, with several measurement methods specific to different foods, mainly applicable to food ingredients with standardised brands

Niche markets may furthermore specify obligatory requirements for:

- Cultural and ethnic food preferences
- Special dietary needs
- Special occasions

In the further disaggregation of the food market into ingredient-specific product categories, and especially when existence or lack of substitutability is the subject of a controversy, it may be useful to apply cross-price elasticity data (see e.g. Okrent et al. 2012, Huang 1993). For example, the positive cross-price elasticity between beef and pork implies that these meats are substitutes and therefore have a common market and should be placed in the same product category (which still allows to define additional niche-markets where customers in specific segments will regard beef and pork as separate non-comparable products). Also, a negative cross-price elasticity, for example for coffee with

respect to milk, shows that milk is a complement to coffee, so that although they belong to different non-substitutable product groups, milk should be included as a complementary product in a life cycle assessment of coffee and coffee substitutes.

Procedural step 3. Express the functional unit as a quantity of the product

As an example, a functional unit for an institutional meal could be:

> "Dinner meal with a satiety-weighted energy content of 1500 kJ, with protein quality not less than 80% of the DIAAS adult reference value, with no less than 3% of the energy in the form of linoleic acid, with a purchase price range between 4 and 6 EUR for the sum of meal ingredients, including minimum two fresh vegetable ingredients with a total minimum weight of 225 gram of which maximum 50% can be juice, with all measurements, ingredients and preparation procedures fulfilling all relevant Codex Alimentarius requirements, and fulfilling all further requirements specified for the product categories of each specific meal component and ingredient."

References for the food example

Chambers L, McCrickerd K, Yeomans MR. (2015). Optimising foods for satiety. Trends in Food Science & Technology 41(2):149-160.

de Graaf C, Blom WAM, Smeets PAM, Stafleu A, Hendriks HFJ. (2004). Biomarkers of satiation and satiety. American Journal of Clinical Nutrition 79(6):946–961.

Hopkins M, Blundell J, Halford J, King N, Finlayson G. (2016). The Regulation of Food Intake in Humans. https://www.ncbi.nlm.nih.gov/books/NBK278931/

Huang KS. (1993). A Complete System of U.S. Demand for Food. Washington DC: U.S. Department of Agriculture Economic Research Service. (Technical Bulletin 1821).

Okrent AM, Alston JM. (2012). The Demand for Disaggregated Food-Away-From-Home and Food-at-Home Products in the United States. Washington DC: U.S. Department of Agriculture Economic Research Service. (Report 139).

Example 2. Footwear upper material
This example illustrates that the procedure is also applicable to an intermediate product. It again illustrates how requirements are defined at the generic level, across materials and applications, while more specific thresholds for each of the generic requirements, as well as additional requirements, are added for each more specific application area.

Procedural step 1. Identify the market segment for the product
The market for footwear upper material is basically global, as is the footwear industry itself. Europe can be seen as a separate market due to import duties, but there are still significant imports.

There are many different types of footwear that are not substitutable, generally divided by gender and age and by use, such as sportswear, casual, formal, cold weather, fashion, protective, and indoor footwear. The requirements to the upper materials vary with the intended use, but with the exception of materials for very special-purpose footwear, suppliers are generally able to shift between the different qualities in the short term (i.e. without need for significant changes in production equipment) and without incurring significant additional costs or risks. Further subdivision of the market for general-purpose footwear upper material is therefore unnecessary.

Procedural step 2. Identify the obligatory product properties
ISO/TR 20879 (ISO 2006) establishes the performance requirements for uppers components for footwear, irrespective of the material, in order to assess the suitability for the end use. The requirements are divided in essential requirements (= obligatory) and additional requirements that can be placed by specific customers. Three properties are obligatory for all types of uses: flex resistance, tear strength, colour fastness, but with different threshold values. For infant footwear also abrasion resistance is an obligatory property, and for cold weather footwear also water resistance and thermal insulation. Each property is additionally defined in a separate measurement standard, e.g. ISO 17694 for flex resistance.

Based on the differences in the ISO essential requirements, we can identify the following distinct application areas for general-purpose footwear upper materials:

- General sports footwear and school footwear
- Men's town and casual footwear
- Cold weather footwear
- Women's town footwear
- Fashion footwear
- Infants' footwear
- Indoor footwear

In addition to the ISO requirements, there are legal requirements with respect to restricted substances, notably chromium VI, organostannic compounds, azo-dyes, perfluorooctane sulphonate, short-chain chlorinated paraffins and nonylphenol and nonylphenol ethoxylates. Most footwear producers will

additionally require adherence to the more extensive Manufacturing Restricted Substances (CADS RSL) List of the Deutschen Schuhinstitut (2017), which could therefore be seen as obligatory.

Re. durability (the "how long"), a starting point can be taken in the production volume information from the World Footwear Yearbook 2015 (APICCAPS 2015) that 24.3 billion pairs of shoes were sold in 2014. Combined with a global population of 7.26 billion, this means that an average pair of shoes is worn for maximum 7.26/24.3 = 0.3 year or 109 days. With two hours or 10'000 steps of daily walking this would amount to around 1 million steps per pair of shoes. Since some shoes will be used more often than others, the expected durability depends on the application, which is also reflected in the lower requirement for flex resistance of fashion, infant and indoor shoes (15'000 cycles compared to 100'000 cycles for sports footwear).

Procedural step 3. Express the functional unit as a quantity of the product

As an example, a functional unit for upper material for cold weather footwear could be:

> "Upper material for 1000 pairs of footwear, fulfilling the ISO/TR 20879 minimum requirements for cold weather footwear with respect to flex resistance, tear strength, colour fastness, water resistance and thermal insulation, and respecting the current CADS RSL List threshold values."

Note that durability is implicit in the ISO/TR 20879 requirements, but not formulated explicitly as a time period or number of uses.

It is also noteworthy that the functional unit here can be applied across different relevant materials, e.g. for both leather and textiles. This also implies that it would not be meaningful to delimit a specific product group of e.g. leather for footwear uppers, even though some specific niche applications would – additionally to the above – place requirements on the material origin.

References for the footwear upper material example

APICCAPS (2015). World Footwear Yearbook 2015. Porto: APICCAPS.
Deutschen Schuhinstitut. (2017) Manufacturing Restricted Substances List. CADS RSL Stand 1/2017.

Example 3. Office chair
This example was originally published as part of the Danish methodology consensus-project (Weidema et al. 2004). Some information has been updated.

Procedural step 1. Identify the market segment for the product

In year 2000 office chairs sold in Europe were almost exclusively produced in Europe (Weidema et al. 2004), and producers within each country covered large part of the national supplies. This is still largely the case, but there is now an average import of 32% for office furniture, but still only 15% is imported from outside EU (Table 23 in Renda et al. 2014). The EU country with the lowest impart/consumption ratio is Italy with 17% (year 2012; Table 23 in Renda et al. 2014). The market concentration in Europe continued to increase over the last years with top 5 manufacturers currently covering about 21% share of the whole market. Kinnarps is the largest player in terms of turnover, followed by Steelcase with a market share of 6.5% and 6.4%, respectively (Spinelli 2014). Although there is some concern that differences between product information requirements in different EU countries can cause some impediments to trade (Renda et al. 2014), this is not enough to regard the market as nationally segmented. It can therefore be concluded that there is a uniform EU market for office chairs.

Weidema et al. (2004) performed a small survey of a national office chair market by acquiring marketing material from a number of suppliers, by telephone interviews with both suppliers and purchasers and by personal interviews with two leading manufacturers. From this, three well distinguished customer segments were identified, based on and named after the different working situations: 1) the labourer's chair, 2) the computer workstation chair, 3) the manager's chair. The three segments can be described shortly in this way:

The labourer's chair is intended for the labourer, who is sitting on the chair at intervals only and not for many hours at the time, and who has intermittent standing and/or walking working positions. The computer workstation chair is intended for the worker, who is primarily sitting, and who is working behind a visual display unit (VDU), e.g. a computer, for a significant part of the day (at least two hours a day). The manager's chair is intended for the design-oriented person. This person is not working much on computer, writing, or drawing, but rather reading, talking on the telephone and the like. This chair could typically be for the employer or senior employee, to whom design, aesthetics, and image to customers are important issues.

This is much in line with the findings of the market survey, from which it was found that the chairs on the market are targeted to each of the outlined customer types. There is only very little overlap between these groups of customers, as confirmed by one of the leading manufacturers. The probability that a chair targeted for one segment should sell to a customer in one of the other segments is small, so that the product substitutability from segment to segment can be neglected.

Procedural step 2. Identify the obligatory product properties

There are two European standards that set requirement specifically to office chairs or office chair components. These are:

- EN 12529:1998. Castors and wheels - Castors for furniture - Castors for swivel chairs – Requirements
- EN 1335-2:2009. Office furniture – Office work chair – Part 2: Safety Requirements

The requirements of such standards will normally be regarded as obligatory, especially for products for which the public procurement market is important.

Some EU member states (Austria, Finland, France and the UK) have legislation on flammability, covering also furniture products. The standard BS 7176:2007 on "Ignitability of upholstered furniture" is relevant in this context.

Three other standards specific to office chairs address test methods:

- EN 1335-1:2000 Office furniture - Office work chair – Part 1: Dimensions - Determination of Dimensions
- EN 1335-3:2009. Office furniture – Office work chair – Part 3: Test Methods
- ISO 21015:2007. Office furniture - Office work chairs - Test methods for the determination of stability, strength and durability

Such standards aim at ensuring comparability between claims made by different producers, but do not place specific requirements on the extent of these claims.

EU has been considering a policy initiative on information requirements (Renda et al. 2014), to increase competition on such properties that cannot immediately be observed by the customers at the point of sale. As part of these considerations, Renda et al. (2014) made a survey to all 27 European furniture industry associations, inviting them to retrieve and submit information on mandatory and voluntary schemes and initiatives, adopted in the country where they are based, that require providing consumers with specific information about the characteristics of the furniture. From this survey, it was found that some voluntary schemes in Austria, Czech Republic, Germany, Spain and Sweden have further requirements on durability and resistance to "wear and tear", hazardous substances contained in the product, and weight-bearing capacity. Ecolabelling schemes also have additional requirements, for example some require the availability of spare parts for at least five years or longer and/or set resistance thresholds for particular materials not covered by listed standards. However, voluntary schemes and ecolabels have only limited uptake and their requirements are more likely to concern positioning than obligatory product properties.

Nevertheless, a minimum durability, low maintenance requirements, and absence of hazardous materials, would likely be obligatory properties if information on these properties were mandatory at the point of sale (which is not the case currently). This is confirmed by the high importance given to

information on these properties in a consumer survey performed by Renda et al. (2014).

Weidema et al. (2004) obtained information on the main functional and technical qualities of office chairs, mainly from marketing material and the above-mentioned standards, and summarized the information in a table (see Table 1 below). Note that there are many other obligatory properties related to strength and safety that are not included in the table because they are general for all office chairs.

Table 1. Selected technical properties of office chairs divided in obligatory (O) and positioning (P) in different market segments. Reproduced from Weidema et al. (2004).

Property	Market segment		
	Labourer's chair	Computer workstation chair	Manager's chair
Seat height adjustable	O	O	O
Back rest adjustable	O	O	
Back rest inclination adjustable	O	O	P
Seat inclination adjustable		O	P
Arm rest available	P	O	O
Arm rest adjustable	P	P	
Roller brakes and choice of soft and hard rollers	P	P	P
Angle between seat and back rest adjustable		P	P
Sophistication of chair movement		P	P
Seat depth adjustable and position lockable		P	

For computer workstation chairs, their durability is mostly taken for granted, i.e. a certain minimum lifetime (of 7-8 years) is implicitly considered an obligatory property. The actual lifetime is not considered as a separate property, since the chairs are often replaced for other reasons than technical failure (e.g. office refurbishment or technical developments).

Procedural step 3. Express the functional unit as a quantity of the product

In the previous two steps, three market segments, with each their obligatory product properties were identified. This implies that we should separately describe the functional unit for each of these.

For all three market segments, the product can be defined as providing "Seating support for minimum 7 years, fulfilling the requirements of EN 1335-2:2009, EN 12529:1998, and BS 7176". For each of the three market segments, the specific obligatory product properties may then be added:

- For the labourer's chair: "with seat height adjustable, and a backrest with adjustable height and adjustable inclination".
- For the computer workstation chair: "with both seat and backrest having adjustable height and inclination, and with availability of armrests."
- For the manager's chair: "with seat having adjustable height, and with availability of armrests."

References for the office chair example

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