Methodology Study Eco-design of Energy-using Products

<u>Final Report</u>

MEEUP

Methodology Report

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SUMMARY

The aim of the underlying Methodology study for Ecodesign of Energy-using Products (MEEUP) is to contribute to the creation of a methodology allowing to evaluate whether and to which extent various energy-using products fulfil certain criteria that make them eligible for implementing measures under the Ecodesign of EuP Directive 2005/32/EC; these criteria are specified in Article 15 and Annexes I and II of the Directive.

Reporting on the study consists of three parts:

1. MEEUP Methodology Report, proposing the intended methodology for an information system that will assist the European Commission with the Consultation Forum to prepare for implementing measures;

2. MEEUP Product Cases Report, illustrating the methodology applied to 10 EuP product cases;

3. MEEUP Project Report, indicating the process and the stakeholder consultations during that process, including minutes of expert meetings and workshop, reviewer's comments, etc.

The underlying report is the **MEEUP Methodology Report**, consisting of 7 chapters and 4 annexes.

The **first chapter** analyses the text of Article 15, identifies the parameters that require further definition and data retrieval and proposes a logical structure for these data. The logical structure, which is elaborated in figure 1 and in more detail in Appendix I, is proposed as a basis for preparatory studies. The structure distinguishes 8 product-specific sections:

1. Product Definition, Standards & Legislation;

2. Economics & Market;

3. Consumer Analysis & Local Infrastructure;

4. Technical Analysis Existing Products;

5. Definition of Base Case(s);

6. Technical Analysis of Best Available Technology;

7. Improvement Potential;

8. Policy, Impact and Sensitivity Analyses.

In addition a number of tools is described to tackle the environmental impact analysis (Chapters 3 to 5), the market analysis (Chapter 6) and methods to assess the improvement potential (Chapter 7).

But before that, **Chapter 2** takes a step back from the legislation and discusses what will be and what can be the scope of implementing measures under the 2005/32/EC. What is the domain of Ecodesign in practice, as an extra dimension to the current research and product development activities? Product developers define the geometry,

select the materials and the manufacturing processes and prescribe the use of the new products. As such they are a major determining factor in the environmental impact that the new products will have, if the legislator succeeds in formulating realistic, clear and accurately defined implementing measures. On the other hand it is obvious that there are limits to the sphere of influence. The product designer can choose amongst materials with different properties and environmental impacts, but the resources consumption and emissions of the individual material production processes are largely outside that sphere of influence. Also the decision where a material is purchased cannot usually be determined by product designer. The same goes for manufacturing processes, where the designer can tune the product's geometry and other properties to the technology employed, but at a certain point the specific resources efficiency and emissions are the domain of production engineers. Looking downstream, the designer can conceive how a product should be used and eventually disposed off, but the actual use may be different. This is especially important as Energy-using Products (EuP) –as opposed to many non-EuP—have by definition a relevant environmental impact in the use phase of the product.

Chapter 3 sets out to prepare the tools for assessing the environmental impact. It takes the environmental indicators from the tender document and the 2005/32/EC Directive as a basis and develops a methodology that defines the system boundaries, partitioning problems, etc. and translates the underlying emissions and resources in a product's life-cycle into these mostly aggregated indicators with appropriate weighting factors. Accepted scientific principles play a role in this process and a very important consideration has been that the methodology needs to be consistent with the existing legislation. Or, to be more precise, the environmental impact assessment methodology should **follow, not precede current environmental legislation** that is developed in the context of international treaties (Kyoto, Montreal, Gothenburg, Stockholm, Århus, etc.) and transposed in appropriate EU legislation with mainly grid-based emission limit values such as the Ambient Air Quality Directives, the Water Framework Directives and others. In that sense, also the handling of the end-of-life phase is in line with a post-WEEE situation.

How the necessary information on the underlying emissions and resources used can be retrieved is the subject of **Chapter 4**. It discusses the data needed, the available data sources and underpins the choice for preparatory legislative documents, such as the IPPC BREFs, and emission/resources data supplied by the materials industry. Furthermore, in the same chapter some specific problems relating to data retrieval for the use phase are discussed. This relates to test standards, consumer behaviour and system analysis.

Building on the foundations of the previous two chapters, **Chapter 5** presents the data and reporting tool that allow the translation of product-specific information (materials, geometry, etc.) into environmental impacts. For around 100 materials and processes a so-called **Unit Indicator table** was built, containing per unit of material (e.g. in kg) or process (e.g. in kWh/ GJ) 14 environmental indicators (and 2 auxiliary parameters) per unit material (in kg) /process (e.g. in kWh). These environmental indicators are Energy, Water (process & cooling), Waste (hazardous & non-hazardous), Global Warming Potential (GWP), Acidification Potential (AP), Volatile Organic Compounds (VOC), Persistent Organic Pollutants (POP), Heavy Metals (to air & to water) carcinogenic Policyclic Aromatic Hydrocarbons (PAH), Particulate Matter (PM) and the Eutrophication Potential of certain emissions to water (EP). Auxiliary parameters relate to electricity use and to feedstock input. Ozone Depletion Potential (ODP) is a 15tht indicator, but sufficient process data for EuP was lacking. Ambient Ozone emissions during the use phase, Materials Depletion, Land Use and Noise are also addressed, but they should be treated on an ad-hoc basis or derived from one or more of the 14 indicators that are quantified.

Furthermore, a reporting tool called **EuP EcoReport** was developed that facilitates the necessary calculations to translate product-specific characteristics into environmental impact indicators *per product*. The intended audience for this tool consists of policy makers, consultants and stakeholder experts involved in the preparatory stages and final decisions regarding implementing ecodesign measures; it might also be used by manufacturers for a preliminary analysis of the environmental performance resulting from the implementation of various design options. The environmental indicators are identical to the ones used in the Unit Indicator table and they enable policy makers e.g. to compare/ rank the products per environmental impact indicator also with respect of EU policy goals. A single value evaluation of the products across all environmental impact indicators was not desired and is not foreseen, as a robust basis for such an evaluation is lacking and policy makers should be flexible in view of changing insights and environmental policy objectives.

Apart from the environmental impact per product, the EuP EcoReport also contains tools to make an assessment of EU totals and the assessment of monetary Life Cycle Costs (LCC).

Chapter 6 deals with the Market Analysis and related subjects, such as the product definitions and classification. Especially for the latter it is proposed to consider the Eurostat PRODCOM classification at 6 or –in exceptional cases—8 digit level. Regarding existing legislation, the chapter gives an overview of the worldwide labelling and Minimum Efficiency Standards for EuP that should be taken into account during the preparatory studies. In terms of hard data on sales and stock of particular EuP it is recommended to use both the PRODCOM data for more generic trade and production data that are consistent with official statistics, but also and primarily use specialist marketing sources to generate sales and stock data that are supported by the industry sectors. The last part of this chapter deals with market trends and the pricing data that serve as an input for the monetary Life Cycle Cost definition.

Chapter 7 sketches the outlines of the methodology to assess the improvement potential. The first step is the definition of one (or more) Base Case(s) that characterize the average new EU product. This sets the reference for improvement. It also bundles all the information from the various environmental, technical and economical information that was assessed in the previous chapters. Apart from the functional parameters, it defines the emissions and resources consumption for the 14 indicators and it determines the Life Cycle Costs, i.e. the monetary cost to the end-user not only for the purchase of the product but also for the discounted running costs. As a next step, the design options need to be identified and for each design option the price increase of the product and the environmental benefit has to be estimated.

In this context, two types of design options need to be distinguished: The ones that also result in lower monetary running costs (energy, water, detergent, etc.) and that need a full Life Cycle Cost assessment and the ones where there is no benefit in lower running costs, where a simple assessment of the price increase would suffice. For the first type, it is appropriate to rank the design options according to Life Cycle Costs and single out the points with the least Life Cycle Costs (LLCC) and the maximum that could technically be achieved with the Best Available Technology (BAT). Also the long term analysis of as yet experimental options, that we have termed BNAT (Best Not Available Technology), serves that same purpose.

As indicated in Annex II of the 2005/32/EC Directive, the LLCC point could serve as a minimum target level in implementing measures. The BAT point indicates the remaining possibilities for product differentiation once such a minimum target is set. For the second type of design options it only makes sense to rank design options if they relate to improvement of the same environmental indicator. In that case the ranking would indicate to the policy makers what design options yields the highest environmental benefit at the lowest costs.

The final part of the improvement potential is an ex-post study of the environmental gains according to several scenario's, the estimated impact on industry and consumers of certain measures and a sensitivity analysis that shows how robust the rationale for implementing measures is in the light of price variations and alternative partitioning methods (e.g. for recycling).

The **Appendices** to the Methodology Report include not only the logical information structure (App. I), ECCP statistics (App. II), the full reference list (App. III) and a list of the stakeholder experts, reviewers, participants and many others that we would like to thank for their interest and contributions (App. IV).

1 INTRODUCTION

1.1 Aim

The aim of the study is to contribute to the creation of a methodology allowing to evaluate whether and to which extent various energy-using products fulfil certain criteria that make them eligible for implementing measures under the Ecodesign of EuP Directive 2005/32/EC; these criteria are specified in Article 15 of the Directive.

The study is governed by the requirements of a detailed and specific tender document and offer by the contractor, drawn up around a year ago (summer 2004). These requirements of both the tender document and offer are given in Appendix III. They are binding for the contract, as much today as they were then.

However, since the summer of 2004 some things have changed: On the 13tht of April 2005 the European Parliament has adopted the Framework Directive on Ecodesign of Energy-using Products (EuP) [1], but with 24 Amendments. Furthermore VHK has had an almost 9 month experience in the underlying methodology project. This calls for first of all an update of the content of the Directive and second a re-appraisal of not the tasks themselves but the order and structure of the tasks indicated in the tender document. Can this structure, on the basis of the experience and the new amended directive, be optimised in the interest of a more coherent methodology?

1.2 Article 15

With the latest amendments[2] the final text of Article 15 has changed and is given below. Amendments are highlighted in bold. Concepts that require definitions, test procedures/standards, etc. are underlined.

> ARTICLE 15
>
> Implementing measures
>
> 1. When an EuP meets the criteria listed under paragraph 2, it shall be covered by an implementing measure or by a self-regulation measure in accordance with paragraph 3b). When the Commission adopts implementing measures, it shall act in accordance with the procedure referred to in Article 19(2).
>
> 2***. The*** criteria ***referred to in paragraph 1 are as follows***:
>
> ***a.*** the EuP shall ***represent a significant*** volume of sales and trade, ***indicatively*** more than 200 000 units a year within the Community according to most recently available figures;
>
> ***b.*** the EuP shall, considering the quantities placed on the market and/or put into service, have a significant environmental impact within the Community, as specified in Community strategic priorities as set out in Decision No 1600/2002/EC;
>
> c. the EuP shall present significant potential for improvement in terms of its environmental impact without entailing excessive costs***, taking into account in particular***:
>
> ***i.*** the absence of other relevant Community legislation ***or*** failure of market forces to address the issue ***properly***;
>
> ***ii.*** a wide disparity in the environmental performance of EuPs available on the market with equivalent functionality.

[1] COM(2003)453final

[2] http://europa.eu.int/comm/enterprise/eco_design/amend.pdf

3. In ***preparing*** a draft implementing measure the Commission shall take into account any views expressed by the Committee referred to in Article 19(1) and shall further take into account:

a. Community environmental priorities, such as those set out in Decision No 1600/2002/EC or in the Commission's European Climate Change Programme (ECCP);

b. relevant ***Community legislation and*** self-regulation, such as voluntary agreements, ***which, following an assessment in accordance with Article 17, are expected to achieve the policy objectives more quickly or at a lesser expense than mandatory requirements.***

4.In preparing a draft implementing measure the Commission shall:

- ***d.*** consider the life cycle of the EuP ***and all its significant environmental aspects, inter alia energy efficiency. The depth of analysis of the environmental aspects and of the feasibility of their improvement shall be proportionate to their significance. The adoption of eco-design requirements on the significant environmental aspects of a EuP shall not be unduly delayed by uncertainties regarding the other aspects.;***
- e. carry out an assessment, which will consider the impact on environment, consumers and manufacturers, including SMEs, in terms of competitiveness ***including on markets outside the Community***, innovation, market access and costs and benefits;
- f. take into account existing national environmental legislation that Member States consider relevant;
- g. carry out appropriate consultation with stakeholders;
- h. prepare an explanatory memorandum of the draft implementing measure based on the assessment referred to in subparagraph (b);
- i. set implementing date(s), any staged or transitional measure or periods, taking into account in particular possible impacts on SMEs or on specific product groups manufactured primarily by SMEs.

5. Implementing measures shall meet all the following criteria:

a. there shall be no significant negative impact on the functionality of the product, from the perspective of the user;

- j. health, safety and the environment shall not be adversely affected;
- k. there shall be no significant negative impact on consumers in particular as regards the affordability and the life cycle cost of the product;
- l. there shall be no significant negative impact on ***industry's*** competitiveness;
- m. in principle, the setting of an ecodesign requirement shall not have the consequence of imposing proprietary technology on manufacturers;
- n. no excessive administrative burden shall be imposed on manufacturers

6. Implementing measures shall lay down ecodesign requirements in accordance with Annex I and/or Annex II. Specific ecodesign requirements shall be introduced for selected environmental aspects which have a significant environmental impact. Implementing measures may also provide that no ecodesign requirement is necessary for certain specified ecodesign parameters referred to in Annex I, Part 1.

7. The requirements shall be formulated so as to ensure that market surveillance authorities can verify the conformity of the EuP with the requirements of the implementing measure. The implementing measure shall specify whether verification can be achieved directly on the EuP or on the basis of the technical documentation.

8. Implementing measures shall include the elements listed in Annex VII.

9. Relevant studies and analyses used by the Commission in preparing implementing measures should be made publicly available***, taking into account in particular easy access and use by interested SMEs.***

> 10. Where appropriate, an implementing measure laying down eco-design requirements shall be accompanied by guidelines, to be adopted by the Commission in accordance with Article 19(2), on the balancing of the various environmental aspects***; these guidelines will cover specificities of the SMEs active in the product sector affected by the implementing measure. If necessary and in accordance with Article 13 (1), <u>further specialized material</u> may be produced by the Commission for facilitating the implementation by SMEs.***

Methodologically speaking, this requires the definition of:

- Significant volume of sales and trade (“Task 2” of the assignment);
- Significant environmental impact (“Task 1”);
- Significant potential for improvement (“Task 3”).

Identification of and target values incorporated in:

- Relevant Community legislation;
- Relevant self-regulation (such as voluntary agreements);
- Relevant current and future actions of market forces and their possible outcome.

Definitions, test standards/ procedures, tolerances and indicative benchmarks for:

- Equivalent Functionality (of EuPs);
- Wide disparity (in environmental performance).

Article 15(4) and 15(5) add the necessity to define and interpret (“significant negative impact)

- Competitiveness (including markets outside the Community, including SMEs);
- Innovation;
- Market Access;
- Costs and benefits, affordability and life cycle costs;
- Health, safety and environmental standards;
- “Significant” environmental aspects (which in principle can only be established ex-post, i.e. after an analysis of all aspects has taken place. But hopefully our case-studies will give enough guidance for future studies);
- “Excessive” administrative burden.

and identify

- Existing proprietary technology.

Article 15(6) refers to Annex I (generic ecodesign requirements) and Annex II (specific ecodesign requirements; limit values). The amended introduction to Annex I specifies:

ANNEX I

Method for setting generic eco-design requirements

Generic ecodesign requirements aim at improving the environmental performance of EuPs, focusing on significant environmental aspects thereof without setting limit values***. The method according to this Annex will be applied <u>when it is not appropriate to set limit values</u> for the product group under examination.*** The Commission shall, when preparing a draft implementing measure to be submitted to the Committee referred to in Article 19, identify significant environmental aspects which shall be specified in the implementing measure.

In preparing implementing measures laying down generic ecodesign requirements pursuant to Article 15 the Commission will identify, as appropriate to the EuP covered by the implementing measure, the relevant ecodesign parameters from among those listed in part 1, the information supply requirements from among those listed in part 2 and the requirements for the manufacturer listed in part 3.

This means that criteria and indicative values would be required to assess:

- When it is more appropriate to set limit values (instead of applying Annex I).

Furthermore, the above introductory paragraph makes an explicit reference to "significant" environmental aspects. This —the difference between "significant" and "other" environmental subjects— is again subject of another amendment of Annex I in Part 3 (paragraph 1):

Addressing the environmental aspects identified in the implementing measure as <u>capable of being influenced in a substantial manner through product design</u>, manufacturers of EuPs will be required to perform <u>an assessment of the EuP model throughout its lifecycle</u>, based upon <u>realistic assumptions about normal conditions</u> and <u>purposes of use</u>. ***Other environmental aspects may be examined on a voluntary base.***

On the basis of this assessment manufacturers will establish the EuP's ecological profile. It will be based on environmentally relevant product characteristics and inputs/outputs throughout the product life cycle expressed in physical quantities that can be measured.

The above paragraph of contains a number of concepts that need to be defined and/or identified:

- Capable of being influenced in a substantial manner through product design (referring to the domain of influence of product design);
- Realistic assumptions about normal conditions and purposes of use (referring to ambient settings and consumer behaviour).

This last point refers to consumer behaviour, which is also the subject of the newly added Article 14 on consumer information, requiring information on:

- The role of consumer behaviour in bringing about sustainable use ("Good Practice").

Article 14

Consumer Information

In accordance with the applicable implementing measure, manufacturers shall ensure, in the form they deem appropriate, that consumers of energy-using products are provided with

- the requisite information on the role that they can play in the sustainable use of the product;
- when required by the implementing measures, the ecological profile of the product and the benefits of eco-design.

After Annex I also Annex II, point 1 is amended by the European Parliament:

ANNEX II

Method for Setting the level of Specific Eco-design Requirements

1. A technical, environmental and economic analysis will select a number of representative models of the EuP in question on the market and identify the technical options for improving the environmental performance of the product, keeping sight of the economic viability of the options and avoiding any significant loss of performance or of usefulness for consumers.

The technical, environmental and economic analysis will also identify, for the environmental aspects under consideration, the best-performing products and technology available on the market.

The performance of products available on international markets and benchmarks set in other countries legislation should be taken into consideration during the analysis as well as when setting requirements.

On the basis of this analysis and taking into account economic and technical feasibility as well as potential for improvement, concrete measures are taken with a view to ***minimising*** the product's environmental impact.

Concerning energy consumption in use, the level of energy efficiency or consumption will be set aiming at the life cycle cost minimum to end users for representative EuP models, taking_into account the consequences on other environmental aspects. The life cycle cost analysis method uses a real discount rate on the basis of data provided from the European Central_Bank and a realistic lifetime for the EuP; it is based on the sum of the variations in purchase price (resulting from the variations in industrial costs) and in operating expenses, which result from the different levels of technical improvement options, discounted over the lifetime of the representative EuP models considered. The operating expenses cover primarily energy consumption and additional expenses in other resources (such as water or detergent).

A sensitivity analysis covering the relevant factors (such as the price of energy or other resource, the cost of raw materials or production costs, discount rates) and, where appropriate, external environmental costs, ***including avoided greenhouse gas emissions,*** will be carried out to check if there are significant changes and if the overall conclusions are reliable. The requirement will be adapted accordingly.

A similar methodology could be applied to other resources (such as water or detergent).

This again leads to a question about the definition, identification and/or measurement of concepts that have not been mentioned above:

- Representative models of the EuP (the “Base Case” in this study);
- Technical options;
- Best performing products and technology available on the market (“Best Available Technology” BAT in this study);
- Benchmarks set in other countries legislation;
- A sensitivity analysis covering “relevant factors”;
- Where appropriate, external environmental costs, including avoided greenhouse gas emissions;

- Life cycle cost minimum to end users ("Least Life Cycle Cost" option, LLCC, in this study).

Furthermore, this paragraph already defines Life Cycle Costs, by mentioning:

- Real discount rate;
- (Variations in) purchase price;
- Operating expenses.

for which an assessment is needed.

Finally, the previous Annex VII, which is also referenced by Article 15, has been expanded with a new Annex VIII specifying the prerequisites for self-regulation. Without citing the whole new annex, the new text requires amongst others a definition and/or identification of:

- Added value (more than "business as usual") in terms of the improved environmental performance of the EuP covered [3] (hinting at a long-term Scenario Analysis to prove the point);
- An affordable and credible way to monitor compliance, using clear and reliable indicators;
- Appropriate dates for evaluation, taking into account speed of technological progress.

1.3 Structuring

The overview in the previous section of the new Article 15 and its references is not complete[4] and focuses on the amendments. Nonetheless, it is clear that the legislator requires a host of data that need to be defined, identified and/or measured with appropriate harmonised standards.[5]

To an extent these parameters fall outside the scope of the underlying study: First of all, what is "equivalent", "wide", "significant", etc. will ultimately not be decided by a methodology but —as the directive indicates— by the European Commission after the appropriate consultation with the stakeholders and the Consultation forum (art. 18). In short, the methodology can indicate "how much" in many different ways[6], but the politics decides whether it is "significant".

Second, the assessment of a number of parameters is "out-of-scope" for budgetary reasons. The product case-studies cover already a large number of parameters, but the purpose is not a detailed and comprehensive study on each product but an illustration and demonstration of a methodology.

Having said that, there are of course many parameters that are part of the assignment and that are an integral part of the main scope of the study, i.e. the development of a methodology for the assessment of a "significant environmental impact" (Task 1), "a significant volume of sales and trade" (Task 2) and a "significant improvement potential"(Task 3). Furthermore, even if the assessment of certain parameters is out-of-scope it is important for a sound methodology to recognize that they exist and are structured alongside the rest.

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[4] For instance, Annex I also contains a host of parameters that need proper definition, measurement standards, etc.

[5] New Approach

[6] E.g. as absolute values, in relative values as percentage of the total impact in a category, in a relative value as percentage of "distance-to-target" in an impact category, etc. Naturally, if 80-90% of the total environmental effect is determined by one technical parameter, then it is probably clear to everyone that this is "significant"; but in case a parameter contributes only 1 to 2% -say the recycling fraction- then there may be a debate on "significance" that is beyond the scope of a methodology.

In that context we have tried to streamline what is incorporated in the legislation into a structure that would be logical for any researcher that has to retrieve and analyse the parameters in a certain order because the assessment of one parameter serves as an input for another. For instance, for the legislator the environmental impact of a product may have first priority, but in order to establish that impact you would first need to define the building blocks, test standards, etc.

As mentioned before, large part of this structure is already in the tender document, but was optimised. The complete proposed structure can be found in Appendix I but Figure 1 gives a fairly complete summary.

Figure 1 also indicates the parameters that are product-specific (Box 1 to 5) and the parts that are universal/ not product-specific (Box A and Circle B). Although many of the product-specific parameters need clear definition[7], these universal parts are the core of the new methodology that needs to be developed:

A. The definition of the scope, mainly indicating what is within the domain of influence of the product-design(er), and

B. A universal methodology and database for the environmental impact assessment, translating technical and consumer parameters into environmental impacts.

[7] They will be treated in the final report

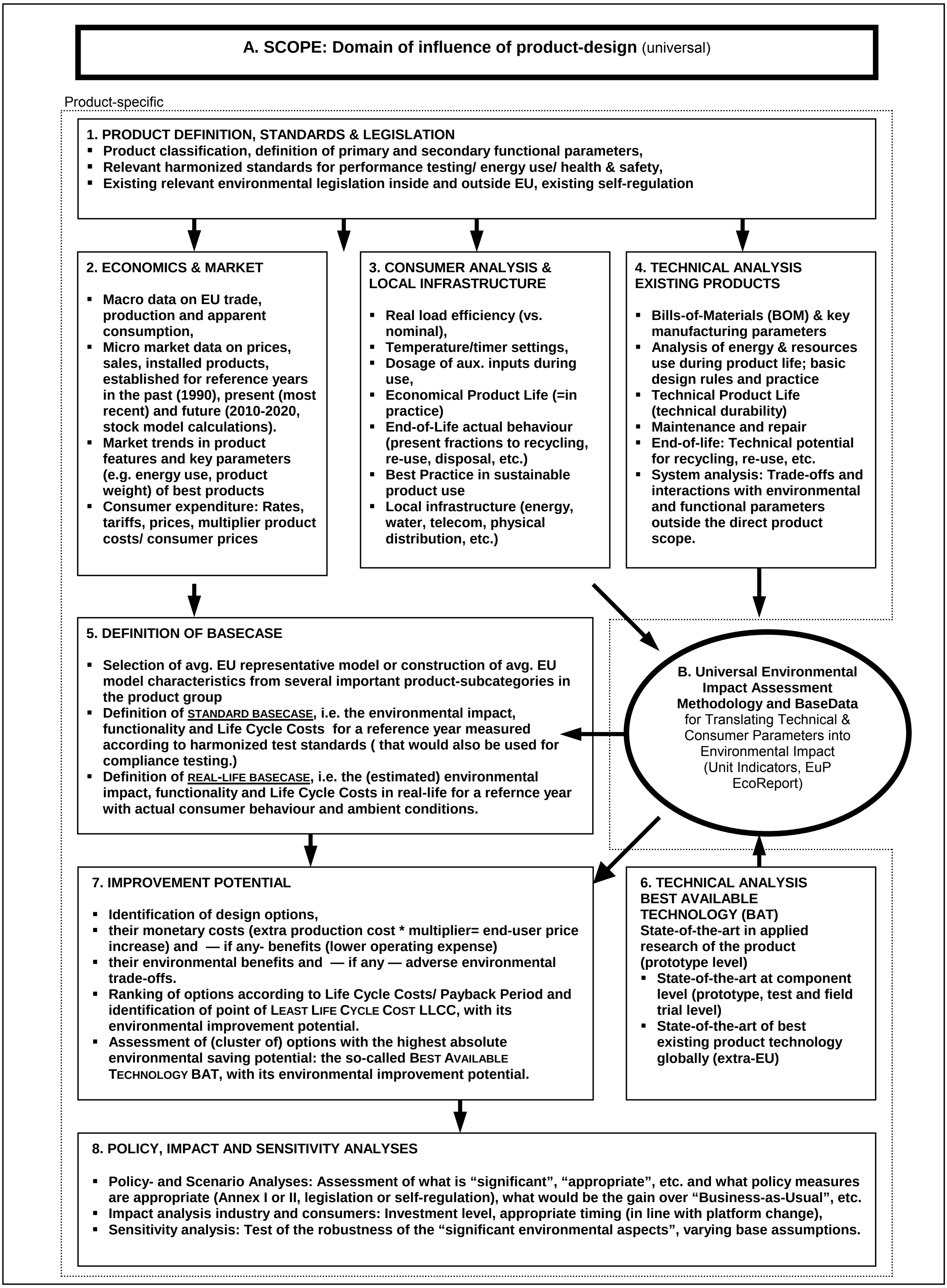

Figure 1. Structure of key parameters needed for Ecodesign of EuP directive, Art. 15.

1.4 Reporting

The underlying first chapter provides the basic structure of the methodology.

Chapter 2 discusses the domain of eco-design and sets the boundaries to this study (Part A). This subject may not seem so important now, but at the outset of the study there was uncertainty with stakeholders as to the extent of control that the directive would require. Companies were concerned that the directive would demand control of upstream parameters, e.g. to register where their steel was produced (with specific emissions) or that it would demand control over downstream parameters, such as certain consumer behaviour. Chapter 2 describes in detail the boundaries of what product-design can and cannot do.

In Chapters 3 to 5 the discussion concentrates on Part B: The methodology, data availability and a "Unit Indicator" database for the translation of technical and consumer parameters during the product life cycle into environmental impacts using —amongst others— the EuP EcoReport form. For Part B it is important to note that the European Commission in its tender document already indicated on which elements from Annex I of the directive, i.e. which environmental impact categories, product-specific data on the impact categories needed to be provided. This was the basis of the development. This table is given below (Table 1).

Table 1. Proposed selection of impacts, related to the environmental priorities as listed in (the table of) the Call for Tender.

	Raw material acquisition	**manufacturing**	**distribution** (incl. packaging, transport)	**use** (incl. Installation and maintenance)	**end-of-life**
Energy consumption					
primary Gross Energy Requirement in MJ					
electricity share (converted to primary)					
Water consumption					
in m³					
Material use (in kg), incl. recycling credits					
Metals (St, Al, Cu)					
Bulk polymers (PE, PP, PS, etc.)					
Technical plastics (PA, PC, etc.)					
Others (glass, electronics, etc.)					
Waste generation					
to landfill					
to incinerator					
Hazardous waste generation					
RoHS substances					
non-RoHS substances (to be specified)					
Emissions to air					
greenhouse gases					
acidifying agents					
volatile organic compounds					
ozone depleting substances					
persistent organic pollutants					
heavy metals					
fine particulate matter					
suspended particulate matter					
Emissions to water					
heavy metals					
substances affecting oxygen balance					
persistent organic pollutants					
Other product specific					

Chapter 6 provides the basics for the market analysis (Task 2 of the assignment) and Chapter 7 (task 3) describes the methodology for the assessment of the improvement potential and the impact analysis.

The Appendices are an important part of this Methodology Report: Appendix I lists the complete methodology structure illustrated in Figure 1. Appendix II gives an analysis of energy-related CO2-emissions from the ECCP report, supplemented by VHK for missing sectors and scenarios. Appendix III gives over 700 references of sources used in the work. And finally the report ends mentioning the people and organisations that have given input into the process.

Please note, that for more background information on the process and the arguments for the methodology in the underlying report, there is a separate **"MEEUP Project Report".** Its focus is on the process to arrive at the methodology. It contains the VHK assignment/tender, a description of the general methods for data retrieval, a general discussion of the data availability, dissemination of the information and consultations, minutes of MEEUP stakeholder expert meetings and the MEEUP Commission Workshop, a review of the first drafts of the methodology by experts (LCA-practitioners, ecologists) and our answers, some guidance for those who are interested in single- or double value environmental evaluations, etc.

For an extensive illustration of the methodology, there is a separate **"MEEUP Product Cases Report".** It follows the structure of the methodology proposed here, applied to 10 Energy-using Products (EuP): Gas- & Oil-fired Central Heating (CH) Boilers, Room Air Conditioners, CH Circulators, Street Lighting, Refrigerators/ Freezers, Dishwashers, Vacuum Cleaners, Copiers, Televisions and Personal Computers. The case reports were conceived with limitations regarding budget/time. All reported data should therefore be verified/ updated/ expanded and the structure re-examined in the preparatory studies with full stakeholder consultation. Having said that, a considerable effort has gone into the case reports, not only by the contractor but also by the stakeholder experts, and they should therefore at the very least not be disregarded as an input for most parts of the verification process.

2 SCOPE: DOMAIN OF ECO-DESIGNER

Before discussing methodological problems related to the specific tasks, this chapter will try to define the scope and target group for this study and the EuP directive in more detail. The target audience for this study follows from the assignment given in Chapter 1: Policy makers who are looking for a methodology to help with the selection of products that are important enough to be included in the scope of the EuP directive. 'Important' is to be defined in terms of environmental impact (task 1), market relevance (task 2) and improvement potential (task 3). We will discuss the scope of the policy maker in more detail in a following chapter.

However, at the very latest when discussing the 'improvement potential' it should be clear that there is another important audience involved, namely the actors that have to realize this improvement potential.

The draft text of the directive refers broadly to *manufacturers and their products*, but the rest of the directive indicates that a limited set of industry-decisions is addressed, namely those that are dealing with the design of EuP. In this chapter we will try to explore what are the scope, the reach and the limitations of these decisions, if not for any other reason, in order to be able to make an assessment of the improvement potential later on.

2.1 Products

First of all, the directive deals with ***product features***: Not with production, not with sales, not with finance, but with products. This already sets it apart from policy measures like EMAS, IPPC, Green (public) procurement, etc. that target other activities within the companies. All these policy measures will at some point in some way influence Eco-design and vice-versa, but it is not their main focus.

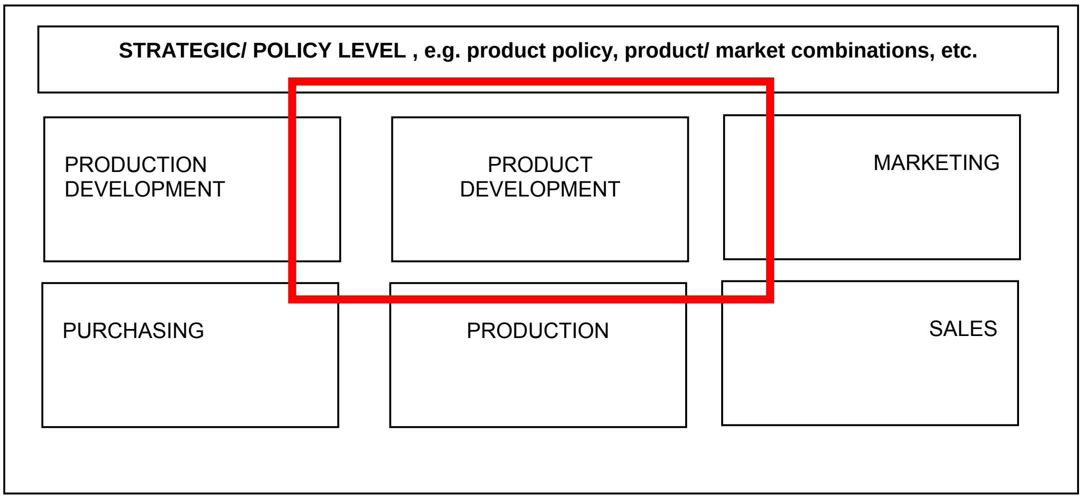

Figure 2. Eco-design domain at company level

2.2 Product development

Secondly, the directive deals with ***new products***, i.e. it aims to have an impact on product development: Not on the current products and their production, sales, etc. This sets it apart from policy measures dealing e.g. with the end-of-life of current products. This also sets the actors, the product developers, apart from company divisions that are dealing with *new production technology* and the development of *new markets.* Although ideally there is a strong interaction between product developers, production, R&D and marketers, the typical area of responsibility is different.

For instance, the product developer is not responsible for the energy efficiency or waste reduction of a piece of machinery within the company, but he is to a large extent responsible —through the choice of materials, functionality, geometry, etc.— whether this type or another type of production technology is required. Likewise, the product developer is not responsible for the distribution strategy, but —through volume, shape, weight, packaging, etc.— he or she can influence the environmental impact considerably.

As an illustration (there is more than one way to describe the process) the diagram by Eekels on the next page shows the various stages and domains of a company's activity geared towards new products.

At the very top of the diagram we find the company's definition of goals. This concerns questions like *'The business we are in'* or whether or not a company wants to be a leader regarding environmental issues. On a more profane level it deals with objectives regarding turnover and profitability, which usually give the impetus for the research of new products, production facilities or markets. Eventually this process, also defined as *'goal finding'* results in the selection of new ideas for e.g. new product/market combinations.

These ideas initially can have a very general scope, like '*a modern bicycle for the elderly*' or '*a dishwasher for small households'*. During the development process that follows, this scope is very much narrowed by the product developers and the marketers, working on a long *List of Specifications* that take into account the wishes and demands of all stakeholders in the process. These are internal stakeholders within the company itself e.g. regarding the use of internal production facilities, tooling, investments, etc. and external stakeholders like the buyers/users/consumers, the legislators[8], the suppliers, the distributors, etc. Only after this initial stage, where the List of Specifications has been agreed upon, technical development will start. This process of strict product development will then result in the product design, i.e. a definition of the new product in terms of (electronic)-drawings and models defining the geometry of the product and its components, a *Bill of Materials (BOM)* defining the type and quantity of materials, a description of the production processes required and finally a '*user manual'* indicating the intended use of the product. The development of a new product, i.e. a product for which the company is prepared to re-define its production-line ('technology platform'), takes around 3 years in most industry sectors.

Finally, after the development process, the implementation stage comprises production, distribution, use and disposal of the products.

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[8] In fact, this will be the stage where the EuP directive will have the most impact

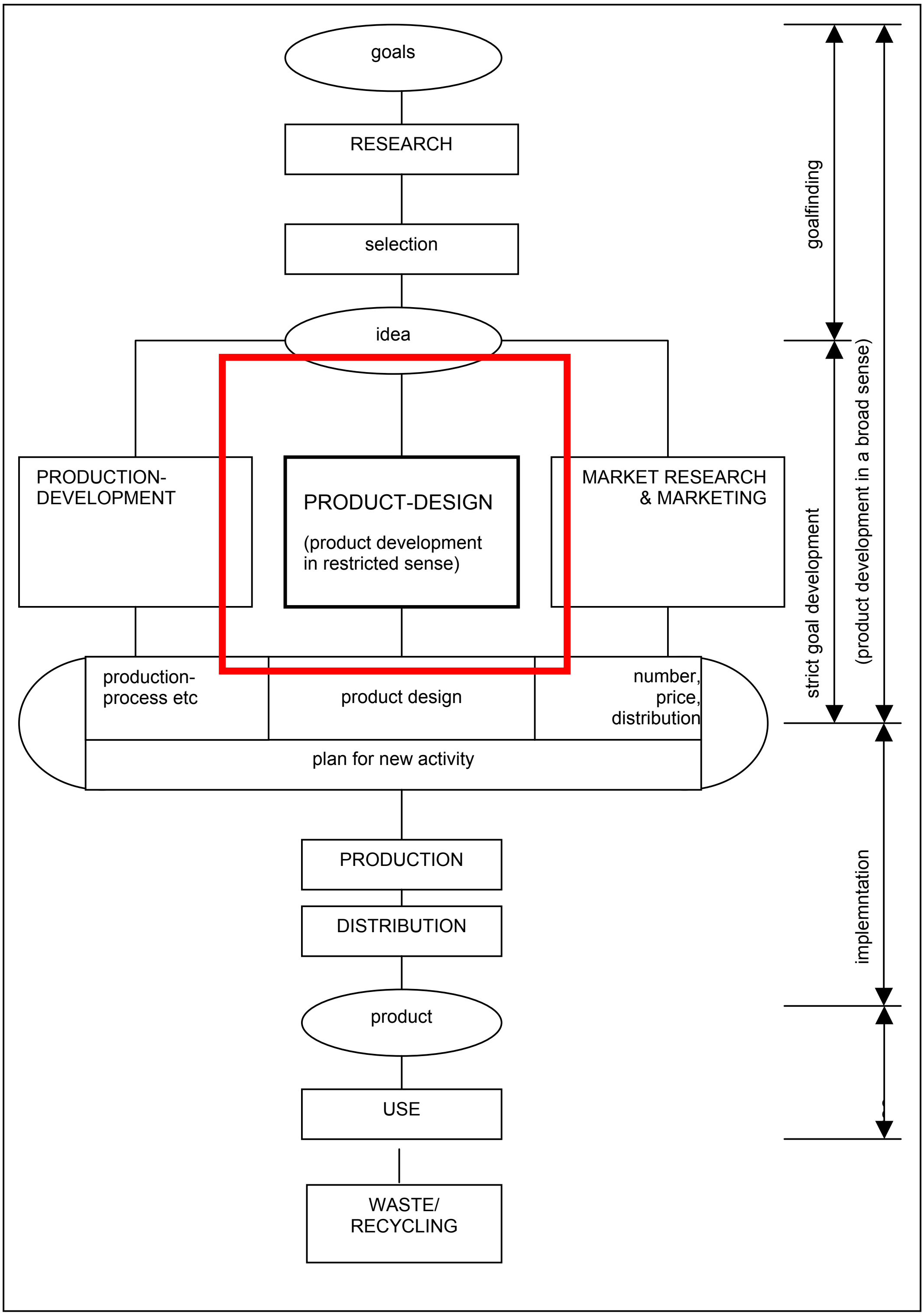

Figure 3. Eco-design domain in the process of creating new products. **[source: Eekels, J. and Roozenburg, R., *Ontwerpmethodolgie*, DUT, Delft, 1976]**

2.3 Energy-using Products

Thirdly, ***energy-using*** products (EuP) or parts are the subject of the directive: Not building materials, textiles, beverages, food-stuffs, furniture, services, etc. This sets them apart from the other subjects within the IPP-scope. It also makes them very special from a methodological point of view because they are by definition products actively consuming scarce (energy) resources during product life. Furthermore, many of them not only use energy resources during product life but also detergents (dishwashers), paper and toner (copiers), etc. And there may be an interaction whereby e.g. building materials and a building construction determine the load profile for heating boilers.

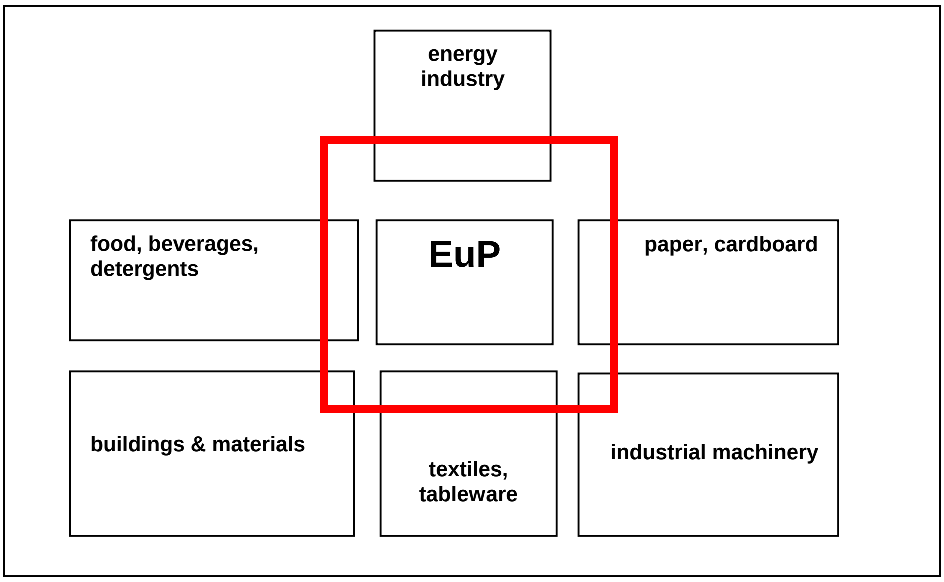

Figure 4. Domain of Eco-design of EuP and adjacent products relevant for the use phase of EuP

Quite a few products can be improved significantly in terms of their energy- or resource efficiency during product life. This may lead to higher purchase prices, but the improvements are very often advantageous when looking at the overall economical Life Cycle Costs (= purchase price + lifetime running costs[9]): consumers will actually be saving money. At the same time the manufacturers will also increase their turnover, thus creating a '*win-win*' situation.

With most non-EuP products[10], there is no such clear trade-off between a higher purchase price and lower running costs. At best, when confronted with a higher purchase price of e.g. shoes, clothes or furniture, the consumer can hope to gain economically because of a longer product life. But this is highly uncertain, because product life is not

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[9] also corrected for inflation and interest.

[10] The only non-EuP products that have a similar, immediately gratifying reward for paying a higher purchase price, are some building materials. A more effective insulation of the walls, high-efficiency double glazing, etc. will immediately impact the heating costs of the house.

purely a technical matter[11] and the moment that the consumer can actually see the proof of this advantage lies many years from the moment of purchase. Other distinguishing features of EuP are:

- Large number of components and sub-assemblies (50 to a few 1000);
- Large number of different material fractions used, covering the complete range from ferro- and non-ferro metals, rare metals like palladium, silver and gold (in electronics), bulk-plastics (PE, PP, PS), engineering plastics, glass (lights, displays) and ceramics;
- Functional complexity, because each EuP has at least one interface with the energy source, an energy conversion process and a control mechanism;
- Important influence in the environmental profile of emissions from combustion of fossil fuels: greenhouse gases (CO_2, CO, methane), acidification (SO_2) and eutrophication (NO_x). (see MEEUP Product Cases Report);
- Relatively less important influence of emissions of hazardous or toxic substances for most products. These are more typical —in larger quantities— of non-EuP's like pesticides, fertilizers, paints, pharmaceuticals, etc. (see MEEUP Product Cases Report);
- Because of the relevance of the use phase, the design strategy for improvement of many products will presumably focus more on Design for Energy Efficiency, Fuel Switch, etc. whereas for non-EuP —apart from a relatively minor impact for maintenance (e.g. paints)— the environmental impact of the products during the use phase is relatively insignificant;
- Whereas with non-EuP the Design for Longevity is an important tool to decrease the overall environmental impact, with most large EuP a design strategy leading to a longer product life may also have a negative impact on the environment if it slows down the adoption of more resources-efficient new models by the market (see also Chapters 3 and 4);
- Very important environmental impact of the consumer behaviour, not only regarding the purchase and disposal/recycling decision (as with non-EuP), but especially during the use of the product.

2.4 EuP Industry

The ***manufacturers of EuP*** are the prime focus of the directive. In a legal context (Art. 92, CE-mark, etc.) this is probably clearly defined. However, in terms of the influence on the 'improvement potential' this needs some clarification. For instance, looking upstream, the environmental impact of raw material production and the manufacture of half-products or even some components is only the responsibility of the EuP-industry in as much as it can be influenced by design decisions. Simply put, at a given time the environmental impact of producing 1 kg of aluminium extrusion profile or 1 kg cold-rolled steel-sheet is a given for the EuP-industry. Naturally the EuP-designer can influence the environmental impact by lowering certain material requirements regarding corrosion resistance (influences the exact alloy) or the surface quality (e.g. influences the percentage of recycled material that can be used), but basically he or she is just a critical consumer in a huge materials shop with fixed prices (for the environment).

The same goes for small components; very few EuP-manufacturers make there own nuts, bolts and fasteners or will be inclined to put any design effort in.

[11] also depending on fashion, culture, etc.

For general components like electric motors, compressors, power supplies, computer hard disks, etc. the responsibility of the EuP industry becomes more fuzzy. True, on the short term it is merely a consumer. Nowadays, with globally operating, specialised producers for these general components, most EuP-industry would not be competitive, nor would it have the technical know-how, to have these components produced completely client-specific. Having said that, as a client of these specialized OEMs[12] the EuP-industry can influence the design on the medium and long term significantly: If it tells the OEMs that it is prepared to pay a certain price and purchase significant volumes of an OEM-product with certain environmentally advantageous, this will certainly trigger the R&D with the OEM.

Like it or not, this trend towards *'co-makership'* has been so successful, that a large part of the EuP-industry has reduced their R&D capacity —not only for the general components but also for the core components— to the bare minimum (and beyond), only drawing up the specs and leaving the actual R&D to the OEM. This, however, does not make the EuP-industry less responsible for the design decisions.

Looking downstream, the environmental impact of the actions of retailer, consumer, waste collectors, recyclers, etc. is only relevant in as much as they are influenced by product features.

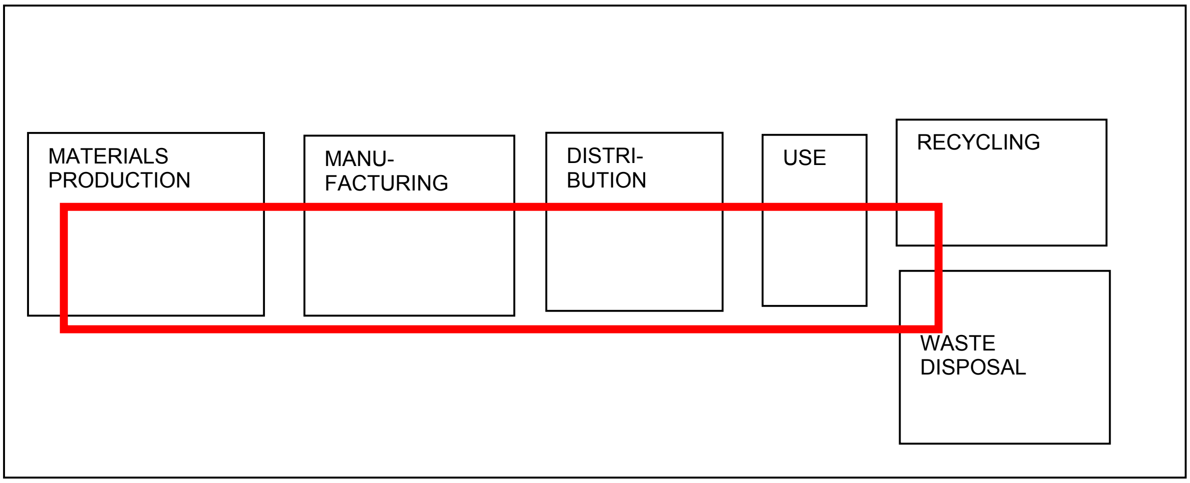

Figure 5. Domain of influence of Eco-design of EuP

Summarizing, an EuP-producing company is not responsible for the environmental impact of e.g. a steel or aluminium plant, but it is responsible —provided the product specifications allows it— for the choice between steel or aluminium[13]. Likewise, the product design includes a range of intended uses of the product, as described in the user manual or can be derived from appropriate labels or even the morphology of the product. However, the industry —if it has taken appropriate measures to ensure proper use— cannot be held responsible if the consumers shows unexpected behaviour once the newly designed product is on the market.

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[12] Original Equipment Manufacturer (component supplier)

[13] In this context Art. 10 of the draft EuP directive is relevant, stating that *'adequate basic information (e.g. on material composition, consumption of energy, etc.) will have to be provided to the equipment manufacturer if needed for the establishment of the ecological profile. It should be clear that unless implementing measures are adopted, no legal obligations flow from the framework Directive for manufacturers.'*

Eco-design affects the decisions listed hereafter:

> **At company policy level:**
> The product developer assumes shared responsibility — with production and market developers — for the product policy and the definition of new product/market combinations
>
> **At tactical level:**
> The product developer is responsible for
>
> Selection of materials
> Design of the geometry
> Selection of the type of production processes to realize the geometry
> Prescription of the way that the product should be used.

2.5 Integrated Product Policy

The EuP directive aims at ***integrated*** product policy for companies, producing competitive products.[14] Although this statement is self-evident, it has quite a few implications. It stresses the need to incorporate functional parameters defining the product performance into the equation. It stresses the need to integrate eco-design requirements in the list of specifications for the new product in a very practical way, close to the current engineering practice and design methodology. In other words, there should be no such thing as "eco-design" as a separate activity, but it should be one of the many disciplines —alongside materials science, mechanics, electronics, and aesthetics— to flow into the design process. Only in that way it can be ensured that it will lead to competitive and innovative products, not only satisfying policy goals regarding the environment and security of energy supply but also regarding the promotion of innovation (Lisbon agenda).

The diagram below shows the basic product design cycle, which is typical of most development processes. Although many outsiders mistake this cycle to be typical of the stages in the design process as a whole, it occurs —explicitly or implicitly— numerous times in the design process at various levels of aggregation.

[14] the proposed EuP directive '*...aims to create the framework for improving the environmental performance of energy-using products while preserving and enhancing a sound economic environment for this significant sector of activity with regard to the free movement of goods within the EU and the competitiveness of industry.*'

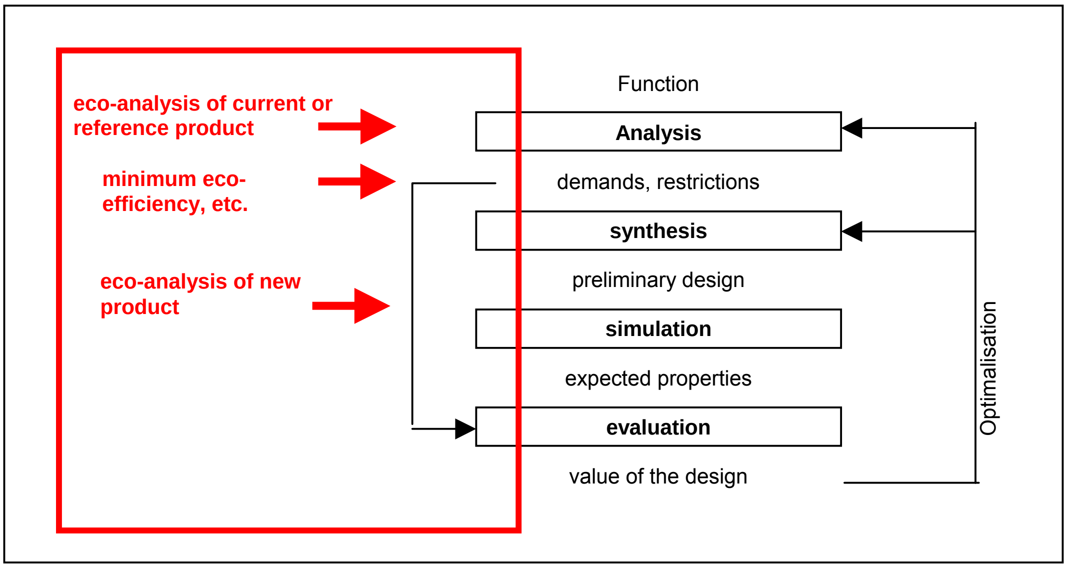

Figure 5 . Domain of Eco-design (in red) within the basis product design loop *[after Archer, Technological Innovation, 1973]*

The design process as a whole is described by Eekels (see par. 2.2) as 'a concentric, goal-finding action', whereby the design loop first occurs at a strategic level of finding the appropriate new product idea, then it occurs at the level of concept development and engineering.

At the strategic level of generating ideas for new products, the notion of eco-analysis of the current products, the environmental goals one is trying to reach and the notion of how new products would be an improvement can be qualitative and abstract. At such a level a company may decide for instance that an all-in-one imaging centre is more environmentally friendly than a single copier, a single printer, a single fax machine and a single scanner. The eco-design dimension, as one of the many factors that are taken into consideration, can be an inspiration and guidance.

But once this product idea is fed into the product development department, the eco-design requirements have to be very precise and verifiable. This is elaborated in the next paragraph (indicators).

2.6 Indicators for Designers

The call for tender requires the development of ***easy and understandable*** indicators.

What this means, may be very different for the target group of policy makers, who have to make a selection of products to be tackled under the new framework directive, and the audience of product developers who have to realize an environmental improvement potential in practice. For the former it may be sufficient to work with highly aggregated parameters e.g. properly defined product groups represent X% of the total environmental emissions in certain categories, that they represent at least Y% of consumer- or business expenditure and that there is an improvement potential of roughly Z% for several environmental categories.

However, for the main stakeholders, the EuP-industry and their suppliers, this may not be *'easy and understandable'* at all if they cannot translate this back to the indicators that they are used to in the product development process that they will have to go through in reaching this *'Z% improvement'*.

To give a general idea, for product developers, easy and understandable indicators should ideally:

- refer to a clearly defined functional product category;
- be numerical or Boolean (yes/no);
- be up-to-date (e.g. not relating to legacy parameters);
- when numerical they should:
    - preferably be absolute rather than relative;
    - preferably relating to physical/chemical parameters;
    - have clearly defined tolerances (with respect of a threshold value);
- relate to measurement standards that are:
    - accurate (using clear unequivocal definitions, permitting small tolerances on measurement of all relevant parameters);
    - reproducible (complete/ comprehensive — > comprising all relevant parameters);
    - realistic (e.g. duty cycle rather nominal);
    - economic (acceptable testing/procedural costs);
    - harmonized (e.g. EN/ISO standards, etc.).

In other words, these are indicators at the lowest possible aggregation level. As such they can be incorporated directly in the list of demands/specifications for the new product and thus become a part of the many restrictions and demands that apply in the product development process.

3 ENVIRONMENTAL IMPACT: METHODOLOGY

3.1 Introduction

The methodology for the assessment of the environmental impact of a product through the unit processes involved in its production, distribution, use and end-of-life is to a large extent already given by some important boundary conditions related to

- The assignment
- The Ecodesign of EuP Directive and
- The fact that this Directive has to be coherent and consistent with existing legislation.

After consulting numerous scientific and legislative documents, discussing with many stakeholder experts and having the first drafts reviewed by LCA-scientists and practitioners (Appendix II) we are more and more convinced that these boundary conditions are in fact strict and the area for VHK to propose the requested methodology is limited.

3.1.1 Assignment

In the tender document the European Commission requires the quantitative assessment of a number of specific parameters (emissions and resources) for the stage of product-life. Deliverables of the contract are quantitative values for clusters of emissions to air and water such as “greenhouse gases”, “acidifying agents”, “heavy metals”, etc. From this an aggregation level is given: The Commission does not expect a list of 1000 individual emissions and usage values per product-stage, nor does it expect a single value eco-indicator. It is also obvious that the set of parameters represent a minimum that should be given. Therefore, suggestions to use “POCP” as an impact category instead of “VOCs” or that “Waste” is superseded by the emissions from waste disposal may be scientifically correct but do not lift the obligation of the contractor to deliver data for the “VOC” and the “Waste” categories. In other words, the European Commission has taken its own responsibility for the contract, presumably trying to strike a balance between parameters and clusters that are practical and at the same time can (just) meet consensus.

3.1.2 Directive

The Ecodesign of EuP Directive itself has a clear influence on the methodology. First of all, it addresses a broad collection of environmental issues, suggesting that all these aspects are potential subjects for implementing measures. Therefore, it is not relevant to suggest that the implementing measures should be restricted to Global Warming Potential or Ozone Depletion Potential or that otherwise the EU would meet big trade problems. The Framework Directive is approved and —until there is a ruling to declare the Framework Directive invalid in view of international trade agreements— it is not useful to consider that VHK should place this type of limitations.

A second limitation of the Framework Directive is the time factor. Already within two years of approval the European Commission has to propose implementing measures for a specified number of specific sectors. Obviously, because these proposals also have to be preceded by detailed studies, the methodology should be in place well before that. In other words, it is no use to suggest that long scientific studies have to be conducted to further the insight and consensus in certain areas of toxicity or similar: These studies are extremely useful for the medium- and long term, but what exists today, will have to suffice for what we propose.

3.1.3 Existing legislation

But the most restrictive —or the biggest source of inspiration to put it positively— is the requirement that the methodology has to be coherent and consistent with existing legislation. Over the last decades the European Community has created an impressive collection of environmental Directives, Regulations and Decisions with the help of scientific findings worldwide, worldwide treaties like Montreal, Kyoto, Gothenburg, Stockholm, inputs from Member States and international bodies, industry, trade, consumer and NGO stakeholders, decision making by National and European Parliaments, etc. It has involved thousands of experts and policy makers. In terms of accumulated tax money from all these contributors there may be many millions of Euros invested in research and achieving consensus.

At first sight, the collection of laws and regulations, e.g. presented in the previous chapter, may seem ad-hoc. But in reality —with all differences in legislative quality— there is a structure and hierarchy.

3.1.4 International Treaties

Starting point of environmental legislation is the awareness of a problem from symptoms (e.g. accidents, disease, dying vegetation, etc.) and scientific modelling. This may at first lead to ad-hoc national or EU-legislation but ideally then leads up to international negotiations in e.g. UN-context —again with the help of scientific models— and eventually international agreements on emission ceilings, bans, reduction targets and monitoring mechanisms. The assessment of emission ceilings already incorporates weighting factors: Kyoto has its Global Warming Potential (GWP in CO_2 equivalent), Montreal its Ozone Depletion Potential (ODP in R11 equivalent), Gothenburg its acid equivalent, etc. The monitoring mechanism is usually based on a combination of measurements (e.g. emissions measured in a global or regional grid) and modelling (e.g. extrapolation of point sources emissions).

3.1.5 EU Air and Water Quality Framework Directives

Within the EU-legislation the international agreements lead to ratification in so-called Council Regulations, which are mainly administrative documents, but most of all they lead to new appropriate legislation or the extension of existing legislation with measures and monitoring obligations that would allow the EU to comply with the international treaty. This may start by simply passing on the obligations to the Member States in the form of National Emission Ceilings. A recent example is the NEC Directive following the Gothenburg Protocol. Parallel to this, the EU sets out to create a framework directive to facilitate harmonised measures regarding the substances involved and to prescribe monitoring and reporting of the Member States to the Commission. Examples are the Ambient Air Quality Framework Directive (AAQD) and the Water Quality Framework Directive (WFD).

These directives, subject to the approval of European Parliament and Council, incorporate the weighting factors and the basic monitoring mechanisms of the international treaties, but usually are more explicit and may add future-oriented information (e.g. long term objectives).

In any case, it is inconceivable that a proposed methodology for Ecodesign of EuP would propose weighting factors and limit values that are different from what is in the international treaties and (thereby) in AAQD or WFD directives. Should there be (enough) scientific evidence and scientific consensus that the modelling factors for Kyoto, Montreal, Gothenburg treaties are wrong or incomplete, then the proper procedure would be to address the designated bodies responsible for modelling. For instance for Global Warming the factors are modelled by the Intergovernmental Panel on Climate Change (www.ipcc.ch) and any changes —e.g. what happened with fluorinated greenhouse gases— should go through this body.

The reason why we mention this so explicitly is because quite a few comments/ reviews on the first draft of the methodology seem to suggest that we have a freedom of choice here, whereas —up to this level of EU-legislation— there is no choice.

EU Directives for Point Source Emissions

This is different for EU-legislation at the next level, i.e. the level where the EU prescribes emission limit values for point sources of emissions like large combustion plants, large industrial processes, waste incineration plants, etc. This also goes for the monitoring mechanisms for these point sources like EPER[15]. Here the weighting factors from the international treaties play a role, but they are not the only consideration. Technical feasibility, costs, local environmental effects of relatively short-lived emissions, local health effects on workers, etc. are also important considerations. Here the relative values of emission limits can be different from AAQD and WFD values. This doesn't mean they cannot be used at all, because many of the emission limit values for point sources are still surprising close to what is mentioned in international treaties, but with caution[16] and only for substances that are not already regulated in the AAQD or WFD or similar.[17] In general terms this will be the case if the substances involved are very similar to the AAQD/ WFD substances and if leaving them out would seriously distort the eco-profile of a material. For instance, for this reason we have included emissions of the heavy metals Cr III, Cu and Zn in our methodology. And as a weighting factor we primarily looked at the most generic (least technology-specific) point-source legislation, which in this case entailed the threshold values for reporting under EPER. Furthermore we checked whether these EPER emissions are in line with what the LCA-databases propose that are in line with the basics of the international treaties. In this case, we looked at EcoIndicator95 and CML values that are based —as the heavy metals that are incorporated in the AAQD and WFD — also on WHO[18]-factors. In the next sections of this chapter we will explain explicitly if, why and how certain emission limit values from point-source legislation can be included in our methodology.

3.1.6 Non Regulated Substances

As the ultimate consequence of being consistent with existing legislation we do not include in the quantitative part of our methodology substances that ***are*** reported by some LCA-sources and where quantitative information ***is*** mostly existing, but that are ***not*** part of EU-legislation or only part of reporting obligations. Examples are some chlorinated compounds, hydrocarbons and some metals. The fact that they haven't been regulated (yet) and therefore not included in our methodology does not imply a judgement, but merely that the legislator has not provided us with sufficient grounds to deal with them quantitatively. It is recommended that they should be dealt with qualitatively e.g. using the ECMA-341 Ecodesign standard and the EIA list of Materials of Interest. Furthermore it is recommended to the European Commission to include them in the quantitative part of the methodology if and as soon as there is legislation that would allow that.

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15 EPER is the **European Pollutant Emission Register** - the first European-wide register of industrial emissions into air and water. http://eper.cec.eu.int/eper/default.asp

16 I.e. with analysis and considerations why they could be used in a similar fashion as the AAQD, WQD values.

17 For instance, the RoHS directive banning amongst others the 3 heavy metals from the Århus protocol (Cd, Hg, Pb) for electric and electronic equipment (EEE) can also be seen as a directive at that level, only it is not very helpful in terms of weighting factors.

18 World Health Organisation

Finally, it has to be mentioned that the quantitative part of the methodology is looking at emissions and resources that occur over a wide range (more than one) of different product groups. This makes sense, because the methodology is supposed to discriminate between the environmental impact of different product groups. However, certain emissions are specific for just one product group, for instance ozone emissions of certain types of imaging equipment or radiation from certain types of televisions/ monitors. For practical reasons it is proposed to include those specific emissions, if there is a legislative basis, on an ad-hoc basis.

3.2 Parameters Required

The tender document and contract specifies the identification of the following parameters:

- Total Gross Energy Requirement, in MJ primary;
- Electricity, in MJ primary or kWh_e;
- (for plastics only:) Feedstock energy, in MJ primary;
- Process Water, in litre;
- Cooling Water, in litre;
- Hazardous Solid Waste, in g;
- Non-Hazardous Waste, in g.

Unfortunately a subdivision between Waste To Landfill and Waste To Incinerator was not possible for the majority of materials. The above parameters do not require an aggregation to an environmental impact category; the physical units can be used directly. This is different for the emissions to air and water. For this the European Commission would like a subdivision according to:

(Emissions To Air)

- GWP, Global Warming Potential, in CO_2 equivalent;
- ODP, Ozone Depletion Potential, in CFC-11 equivalent;
- AP, Acidification Potential, in SO_2 equivalent;
- POP, Persistent Organic Pollutants, in this case only dioxins and furans and can be expressed in I-Teq;
- VOC, Volatile Organic Compounds, in mg;
- Heavy Metals, in Pb-equivalent. In this category the European Commission has also made legislation allowing the incorporation of other substances detrimental to human health, like PAHs (Polycyclic Aromatic Hydrocarbons), aromatics like benzene and carbon monoxide (CO).

(Emissions To Water)

- EUP, Eutrophication Potential, in PO_4 or P_2O_5 equivalent;
- Heavy Metals, in Pb-equivalent.

The Commission also suggests incorporating emissions of Persistent Organic Pollutants to water. However, in the extraction and production cycles for plastics and metals these POPs, which mainly relate to pesticides, do not play a role[19].

[19] Bioplastics and biodiesel, where they would play a role, are not included because they play a negligible role in EuP practice.

The following sections discuss each parameter. The first section on Energy is used to explain and illustrate the general methodology. In general the discussion will be shorter when there are little methodological problems and there are clear references explaining the basics. However, in cases that the general methodology is less clear or less developed, the discussion will be more extensive. This is the case where certain categories require the assessment of weighting factors, as explained in the introduction.

3.3 Energy

3.3.1 Introduction

The guiding principles for performing energy analysis in a policy context have been well established some 30 years ago through the IFIAS Workshops in 1974[20] and 1975[21]. In 1978 they were firmed up in a NATO/CCMS[22] report and a comprehensive methodology to use them in the energy-conscious design was introduced as early as 1980 at Delft University (NL)[23]. Furthermore, energy analysis has played an important role in the development of the first ecodesign methodology in the 1980s by Delft University and Leiden University CML.

The roots of energy analysis go back to the 1950s when energy analysis, i.e. the assessment of energy carriers set apart in terms of their enthalpy rather than in money units or kg of different types of fuel, was used in the process and energy industry to optimise the economy of a specific process. The notion that energy analysis could be used in ecology stems from the Odum brothers in the 1960s[24] and became known more broadly in 1971 through publication of "Environment, Power and Society" by Howard T. Odum[25] , often cited as the founding father of modern ecology.

3.3.2 Accounting Unit and Auxiliary Parameters

The accounting unit to be used in energy analysis practice, according to IFIAS conventions, is the combustion value of the fuels used in Mega Joules (MJ, million Joules). This combustion value varies according to the type and the quality of the fuel used, but also depends on whether one takes into account the potential energy of the water content of the flue gases (upper heating value or gross calorific value) or not (lower heating value or net calorific value). For solid fuels the upper and lower heating values are roughly the same, but for liquid fuels there is a difference of 5-6% and for gaseous fuels there is a difference of typically 11%.

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[20] **IFIAS**, *Energy Analysis Workshop on Methodology and Conventions*, no. 6, Guldsmedshyttan, Sweden, International Federation of Institutes for Advanced Studies, Aug. **1974**.

[21] **IFIAS**, *Workshop on Energy Analysis and Economics*, no. 9, Guldsmedshyttan, Sweden, International Federation of Institutes for Advanced Studies, **1975**

[22] **NATO/ CCMS**, *Energy Analysis Methodology*, Industrial International Data Base, Report No. 75 by the Committee on the Challenges of Modern Society, Long, T.V. (ed.), Technical Information Center US Dept. of Energy, **1978**

[23] **Kemna, R.B.J.,** *Toepassing van Energie Analyse in het Ontwerpproces* (application of energy analysis in the design process), Thesis with prof. Dr. J.M. Dirken, other mentors: Eekels, J., den Buurman, R., van Gool, W., Delft University of Technology, Faculty Industrial Design Engineering, **1980**

[24] **Odum, Eugene P.**, *Fundamentals of ecology*, Philadelphia, Saunders, **1959**

[25] **Odum, Howard T**., *Environment, power, and society*, New York, Wiley-Interscience [1970, c **1971**]

IFIAS recommends taking the upper heating value as a basis, because it illustrates most clearly the maximum energy to be extracted from the fuel and the energy efficiency of a combustion process can thereby never be higher than 100%. However, in policy documents and product-related legislation like e.g. the Boiler Directive, the lower heating value has now become the most popular. Also the default combustion values used by the Intergovernmental Panel on Climate Change (IPCC) are the lower heating values. Therefore, in order to comply with existing legislation, we also propose to use the lower heating value. As a consequence, however, this may lead for condensing appliances to efficiencies higher than 100%. For gas appliances the maximum achievable is around 111% and for oil appliances it is 106%.

In the data retrieval process for the production phase (materials production) it is not always clear if the authors have used the upper or lower heating values. In those cases we have always tried to maintain the original energy data, giving priority to transparency over a possible error of usually (in industrial processes) no more than 5%.

The main energy parameter is the Gross Energy Requirement (GER), which is the primary energy set apart in the various stages of the product-life. An auxiliary parameter —contained in the tender document but also recommended by IFIAS— is the part of the GER that is used in form of electricity. This could have been given in kWh electric energy (kWh_e), but in the Unit Indicator table we use the electricity already converted to MJ primary energy. This allows us to use for some processes, like plastic production, electricity from CHP (Combined Heat and Power), which has a different power generation efficiency (7.35 MJ/kWh_e) than the electricity from the public grid (10.5 MJ/kWh_e).

The electricity use is an auxiliary parameter; it should not be perceived as a form of energy that in itself would have a higher or lower reduction priority than the GER. However, it is an important auxiliary parameter, as it not only creates the link with efficiency of power generation but also with a host of other parameters (emissions, waste, water use) that are relevant at this second system level. Should one of these parameters in the energy industry change, the consequences for the Unit Indicators "across-the-board" would become immediately clear.

Another auxiliary parameter, with a much more limited scope, is the combustion value of the material, usually some 5-10% less than the value of the feedstock. These feedstock values, as given by the various sources[26], are only relevant for the energy recovery of plastics and plastic coatings. This has been discussed in the previous section on end-of-life and recycling.

3.3.3 Process vs. I/O Analysis

IFIAS distinguishes between process analysis and input/output analysis. IFIAS prefers the former, as it is based on physical parameters, but sees the utility of I/O energy analysis, that uses converted money-to-energy parameters for sectors of the economy, in cases where there is no other information available and/or a quick way to addresses the energy requirement of process at the so-called 3rd system level of process analysis, i.e. the energy requirement for capital goods and buildings needed to make a product. At this point the EIPRO study has to be mentioned, which is complementary to the underlying project as far as environmental impact assessment is concerned.

[26] APME for plastics, IPPC BREFs for coatings

EIPRO uses ‘I/O analysis’ for all economic sectors, supplemented by ‘process analysis’ data (e.g. from ECCP) for the use phase of EuP.[27]

3.3.4 System boundaries

The figure below shows the system levels in an energy analysis, which is also mirrored in the ISO 14040 standard on LCA. The first level is the direct energy input into the process. The 2nd level is the primary energy needed to produce this direct energy input (e.g. power plants) and the energy needed to produce the raw and auxiliary materials. At the 3rd level there is energy requirement of the capital goods, as mentioned, but also the energy requirement to produce the energy to produce the materials (again power plants, steam generation, etc.).

In theory, the system levels of energy analysis could go on indefinitely. But as a practical restriction IFIAS proposes to limit the analysis to a level (usually the third) whereby the addition of an extra level would not add more than 10% to the total energy requirement. The reasoning was that already the error in the previous levels would be higher than the extra information from this additional level.

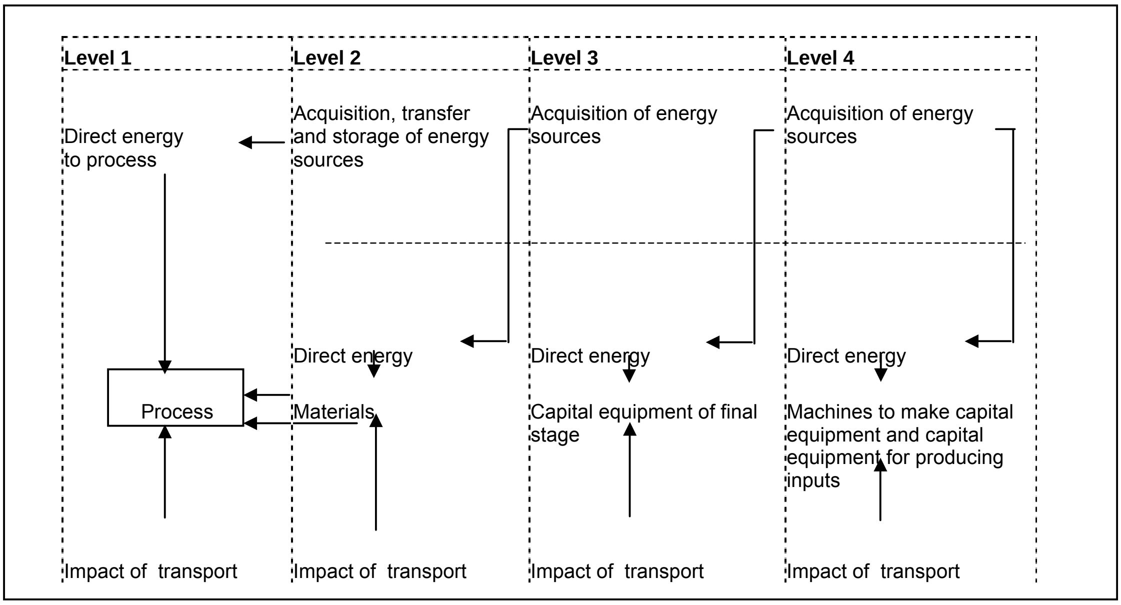

Figure 6. System levels in LCA , illustrated by resources use only (source: IFIAS, 1975)

In terms of ***geographical boundaries*** the underlying study will try to use average values for the resources consumption and emissions in the EU or even global. The Life Cycle Analysis does not refer to the actual geographical origin of materials, processes, etc. In the sense of the ISO 14040-series it would therefore not be called a “Full LCA”, but a “Streamlined LCA”. The reason for this choice is evident from the designer’s perspective, who will have no influence on where the components and materials for the future product will be purchased, nor where it is used, nor where it is disposed off.

[27] The EIPRO stays at a higher aggregation level (product groups), making it less suitable to conclude to implementing measures. On the other hand, EIPRO is very useful in giving policy makers a first insight in the relative environmental impact of EuP versus e.g. food production/ consumption, transportation and the building sector..

3.3.5 Multi-product processes and multi-process products

IFIAS and NATO/CCMS also address the problem of partitioning energy in multi-product processes, i.e. processes producing more than one useful product, and the problem of assessing the societal energy expenditure for multi-process products, i.e. products/materials that can be produced by different process-routes. The proposal for the multi-product processes is to use physical parameters, usually the product weight, to partition the energy and stay clear from partitioning on a money value basis. For equally useful products from one process this is easy, but there are situations where it is not clear whether a product from a process should be regarded as a product or a by-product/waste. A case in point is the production of sulphur compounds from metals processing. The origin of the sulphur is from the sulphuric ore and in old ore processing plants this sulphur would simply be combusted and be emitted into air as SO_2, clearly a pollutant. In a modern plant the sulphur is 'captured' in the form of considerable quantities of sulphur and/or sulphuric acid, which is then sold to the processing industry. Environmentally speaking this is of course a Good Thing, but it leaves the problem of partitioning. Should the sulphuric acid be seen as a product and therefore responsible for a part of the input energy or should it be seen as by-product/ waste with no energy attributed?

The actual answer usually comes from using very strict boundaries for the processes in question. For instance in this case the only energy attributed to sulphuric acid production is the energy needed for the process that converts "waste" sulphur compounds into the useful product "sulphuric acid". Or —in this case— the difference between the process energy emitting SO_2 in the ambient and the process energy with the sulphuric acid as a by-product. This principle not only applies to relatively low-grade by-products, but also to high-grade by-products. For instance, the copper production produces not only copper and nickel, but also a sludge containing small quantities of precious metals (gold, PGM). Not everywhere, but in Europe this sludge is further processed to extract these precious metals from the sludge. However, the partitioning of the energy starts with the extra effort to process the sludge; the main energy input for the copper processing is still attributed to the copper.

Which brings us to the problem of <u>multi-process products</u>. Gold can come from gold/PGM mines but can also (ca. 10% of total) come from processing the "waste" of the copper production, as mentioned above, with a significantly lower energy consumption. Which one to choose? The convention here is not to take some weighted average of the different process routes, but to take the energy requirement of the main process, staying clear of multi-product processes as much as possible. This is of course an abstraction of reality that would lead to an exaggeration if the process analysis were to be used in some sort of global energy accounting. But it is a methodology that is robust and it is consistent with the objective of using energy accounting in Ecodesign, namely energy conservation through influencing the demand of certain less energy-intensive materials per functional unit over more energy-intensive materials per functional unit (c.p.). The reasoning is that when e.g. a metal is faced with a falling or rising demand the main processes will be the first to react: e.g. closing of gold mines (not copper mines) in case of falling demand (=lower gold price) or the exploration/ mining of lower-grade gold deposits in case of a rising demand (=higher gold price). Of course there will be an extra effort to recuperate gold as a by-product from copper processing, but there the effect will be limited because the supply is dictated not by the gold demand but by the copper demand.

As an ultimate consequence even in the case that a metal or chemical is produced only as a by-product of other processes, the energy requirement of a no longer existing or theoretical main process route should be taken as the basis. And this still makes sense, because should the demand for these chemicals or metals rise it would lead to specific mining and production of the main process.

In our data-retrieval we are looking for analyses using the above conventions, also for the broader environmental analysis. But it must be added that the methodological debate on multi-product processes and multi-process products continues, also because there are some vested interests to calculate one way or the other. For instance, for copper producers it would be definitely advantageous to draw the process system boundaries much wider than the individual processes and discount the full credit of gold production —calculated from the main gold producing route— in the copper production. Another —legitimate— reason is when energy analysis is not used in the context of Ecodesign (e.g. materials or resources selection), but in the context of a nation-wide or global energy accounting exercise. In the latter case, in order to make the sums add up, there is no choice but to take a snapshot of the current averages of the different process routes.

3.3.6 Recycling

A related methodological problem occurs with recycling, which is a special case of a multi-process product. In the 1970s, with the aim of stimulating the demand for less energy-intensive over more energy-intensive materials (c.p.), there was a consensus that the energy requirements of secondary materials (post-consumer) and primary (virgin) materials should be made visible from the start and that —depending on the use of the energy analysis— the user of these data should determine the actual use. And in fact there are quite a few studies —e.g. on packaging— that incorporated the current global (thermal) recycling percentage right from the start when comparing alternative materials. By doing so, the actual role of the designer in realizing materials recycling would be appear to be limited[28]. Around 1980 the school of recycling-conscious design (D. *Recyclinggerechtes Konstruieren*) started to change this point-of-view and the designer could only gain recycling-credits if he/she took all precautions to “Design for Disassembly”. The mental model of recycling-conscious design was that of a so-called closed loop: If the designer would succeed in having all the materials recycled, there would be no materials depletion at all.

Both these schools represent extremes. In recent years, there are several authors that have painted a more differentiated picture of the recycling process in an economic reality. For instance, the Danish LCA-expert Bo Weidema has rightfully argued that recycling answers to economic laws of supply and demand and that it is not sufficient to stimulate just the supply-side of post-consumer secondary materials, e.g. through recycling-conscious design, without doing something about the demand-side, i.e. the use of recycled materials in new products.

A classic case in point is the recycling of plastics, e.g. plastic bottles that are now collected in many countries as separate waste. At the outset the concept was that this waste fraction could be recycled into new plastic bottles. In reality, this type of closed-loop recycling did hardly occur as the price of the secondary material was not attractive (comparable to the virgin material) and there were several health concerns, etc. E.g. if recycled plastics are (re-)used in food packaging it is usually with an inner liner of virgin material. Basically the only real closed-loop recycling occurs if the whole product —and not the materials alone— is being cleaned and re-used. Instead of substituting virgin material, the recycled plastics are often used in new low-grade applications that require substantial weight or volume, like outdoor benches, scaffolding materials, etc., where they substitute not plastics but wood. Also recycled plastics are used as road-beddings where they substitute other waste products like nut-shells. But the most popular use of plastics still remains incineration. If the plastics fractions are reasonably pure, like in packaging, this incineration can be effective and if the combustion enthalpy is 30 MJ/kg or higher (see chapter on Waste) they would fall under the non-hazardous incineration. The generated heat can then be used for

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[28] Note that we are only referring to materials recycling. Most of these studies would recognize the role of designer’s materials selection in re-use of the product. In that sense there are several studies comparing plastic cups to (re-usable) ceramic mugs or using one-way packaging with multi-trip glass bottles.

e.g. district heating. Apart from packaging, large housings of EuP that are not contaminated with flame-retardants could follow the same routes as the packaging materials.

This is the situation for relatively clean plastics (from packaging, casings, etc.). However --and also Jaco Huisman's QWERTY approach is making this point-- for the multi-type and "contaminated" plastics from EuP the situation is quite different. Both from an economical but also from an environmental point he claims that the costs of recycling exceed the benefits. Huisman says that in this case incineration with energy recovery is the only environmentally sensible thing to do. However, because of the possible contamination, these plastic fractions would have to be earmarked for treatment as hazardous waste. The enthalpy of these fractions is useful, but on the other hand the energy requirement of the hazardous waste incineration itself (with higher temperatures and post-processing of flue gases and residues) is much higher.

It is hoped that the WEEE and RoHS directives will change the situation and promote that a higher fraction of plastics can be re-used for non-hazardous incineration with heat recovery. On the other hand, without a special closed-loop system, the outlook for plastics recycling without a clear strategy for the demand-side remains bleak.

Whereas plastics recycling is suffering from deficiencies both at the demand and the supply side, with metals recycling most of the problems occur on the demand side. Apart from some simple rules of not mixing certain "enemy" metals, the post-consumer recovery of metals from EuP does not pose too much of a problem from the design point-of-view. According to Huisman and others even shredder-based recycling would recover over 95% of the different metal fractions in a fairly pure state. This could be done in Europe and there would be no need to send the discarded EuP to China or India for largely uncontrolled disassembly activities. This secondary metal, with primary scrap and virgin metal mixed in, can consequently be processed economically into rods and profiles for the construction industry and die-casts that in principle can be re-used in EuP and other consumer goods (cars, etc.). The problem here is on the demand-side and the "fairly pure" state that often is no longer good enough. For instance, designers require their metal sheet to have a high surface quality in order to guarantee a flawless coating. This means that the fraction of recycled un-pure material that can be mixed in is limited (max. 5-10%). Another example is the electronics industry that very often requires 99.999% or more purity for the manufacture of electronics components. At the same time, the traditional industry that is the main consumer of metal die-casts is hit hard by the economic crisis and partially has substituted metal die-cast parts with plastics. Furthermore, the environmental requirements for metal recycling have increased the recycling costs.

The consequence of all this: The USGS is reporting that global recycling rate for relatively scarce metals like copper is falling, from over 35% a decade ago to around 30% today. The main reason is that the demand is low and therefore the price is low and —with increasing costs— this leads to recycling plants shutting down. In such a situation theoretically there are two scenarios. One very unlikely scenario is that the price of secondary copper drops to a level where it can compete with the raw material for electrolytic copper refining and high-purity copper can be economically produced.

Or, what we are proposing, those applications like die-casts and certain profiles that can technologically support up to 80-85% secondary scrap are being promoted over metal applications that can support only 5-10% secondary scrap, like high-surface-quality sheet metal and extrusions.

The two figures below give a quantitative illustration of the supply- and demand side of recycling with a non-EuP product. In the first case the designer "sees" the contribution of the recycling rate in lowering the energy requirement of the material and is more likely to choose materials with a higher recycling rate, thereby creating demand for recycled materials. In the second case, the designer "sees" only the energy requirement of the virgin material and that will be likely to be his/her primary consideration for selection. The reward for recycling comes afterwards (after e.g. 10 years) and depends on the design effort to lower the costs for recycling, thereby increasing the supply of recycled materials. The outcome of both cases is the same and should therefore make no difference, but the perception is different and that is why we are proposing for metals —where the problem is on the demand-side— to use the representation in the first case, i.e. choosing a material of 15.3 GJ (12 + 3.3 GJ) rather than choosing a material of 20 GJ and then trying to recuperate in 4.7 GJ in "design-for-recycling".

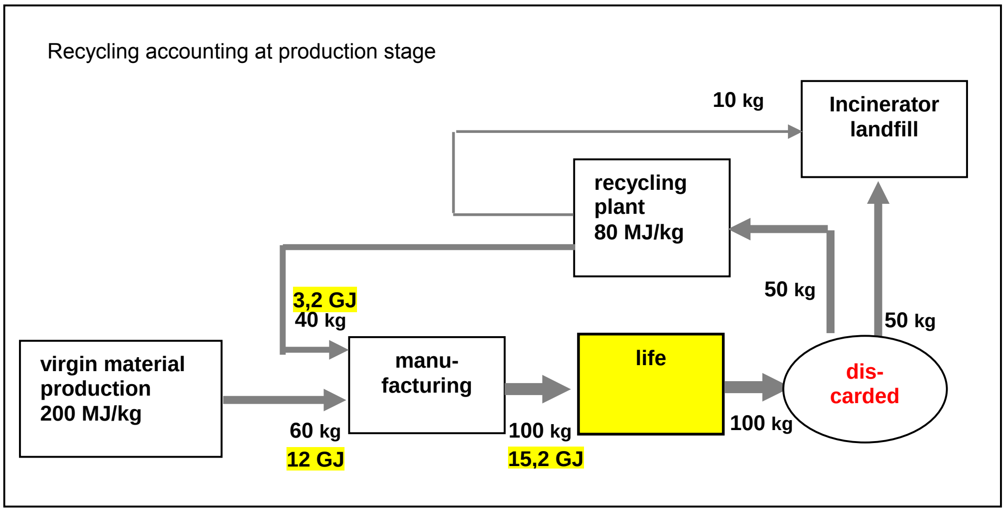

Figure 6. Stimulating demand for recycled materials.

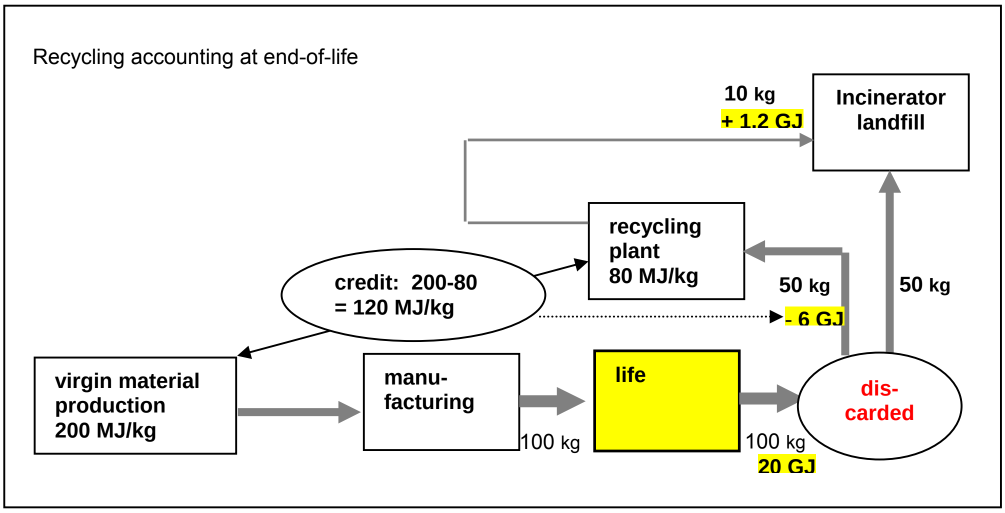

Figure 6. Stimulating supply of recycled materials

It can be argued that it is unusual to include recycling credits at the stage of materials selection, but —as mentioned— there is no standard convention in this respect and the choice depends on the purpose. If the purpose is to make a snapshot of the current production and recycling practice in a certain area in a certain year, our proposal is probably not correct. If, however, the purpose is to make designers choose less energy-intensive options over more energy-intensive options the approach is consistent and coherent with the approach for solving the problem of multi-process products.

Having said that, and as a compromise to a practice that is used to seeing recycling as a pure supply-side problem, in our methodology we will treat those fractions where there is both a demand- and a supply-side problem, e.g. plastics and electronics, as a primarily supply-side problem and incorporate various end-of-life credit options depending on the product design.

The first table below highlights —just for the energy part but the same goes for other parameters— the treatment of metals and plastics in the Unit Indicator table. It shows that we are attributing 0% post-consumer recycling to the GER for plastics, only 0-10% post-consumer recycling rate for sheet metal[29], extrusions and copper wire, whereas e.g. for die-casts we use the technological maximum of typically 85%[30] instead of the current recycling rate (excl. run-around scrap) of 60-65%.

The second table from the same source shows the possible re-use, energy recovery and recycling credits for plastics at end-of-life, subject to certain design measures, and it shows the credit for easy disassembly (<60 s) of the Printed Wiring Board(s) from the product. The latter would allow the PWB to follow a separate shredder route from the rest of the product, enhancing the chance of higher (precious) metal recovery. The credit values mentioned are VHK estimates on the basis of literature. Please note that one of the reviewers in Appendix II, Rolf Frischknecht, mentions that the energy recovery of plastics is much lower than our estimate of 75% of the combustion value. Allegedly no more 25-30% of the combustion value is recovered (data CH). This subject needs further investigation.

Table 2. Recycling rate and Energy Requirement Plastics and Metals (EuP Unit Indicators table, VHK 2005)

Material PLASTICS	Re cyc %	Primary Energy per kg GER (total) MJ	Material METALS	Re cyc %	Primary Energy per kg GER (total) MJ
LDPE	**0%**	78	St sheet galv.	**5%**	34
HDPE	**0%**	77	St tube/profile	**50%**	17
LLDPE	**0%**	74	Cast iron	**85%**	10
PP	**0%**	73	Ferrite	**0%**	51
PS	**0%**	87	Stainless 18/8 coil	**63%**	62
EPS	**0%**	84	Al sheet/extrusion	**11%**	193
HI-PS	**0%**	92	Al die-cast	**85%**	55
PVC	**0%**	57	Cu winding wire	**0%**	143
SAN	**0%**	89	Cu wire	**0%**	117
ABS	**0%**	95	Cu tube/sheet	**60%**	51
			CuZn38 cast	**85%**	38
PA 6	**0%**	120	ZnAl4 cast	**85%**	28
PC	**0%**	117	MgZn5 cast	**50%**	162
PMMA	**0%**	110			
Epoxy	**0%**	141			
Rigid PUR	**0%**	104			
Flex PUR	**0%**	104			

Table 3. Disposal: Env. Benefits of Re-use, Recycling, Heat Recovery (HR), credits per kg materials (EuP Unit Indicator table, VHK 2005)

Metals, **WEEE recycling credits already incorporated in production** (e.g. 85% recycling rate instead of 60-65% for cast metal products)
Plastics, Energy recovery (Thermal recycling): **credit is 75% of feedstock energy & GWP of plastics used** (displaces oil)
Plastics, Re-use/ closed loop recycling: **credit is 75% of all production impact of plastics used**
Plastics, Recycling: **credit is 27 MJ** (displaces wood) **+ 50% of feedstock energy & GWP of plastics (less chance heat recovery)**

[29] Exception is stainless steel coil, where Ni and Cr fractions plus the fact that it is usually uncoated in its final application create a special situation where recycling up to 63% is possible.

[30] Exception is MgZn5, where the casting technology poses more practical limits on the recycling rate.

Electronics: if designed for easy separate shredding **credit is 20% of production impact components and materials**

Please note that we assume a total recovery rate (for recycling, energy recovery, etc.) of 95% of the disposed products. Under this assumption the recycling rates of the metals are valid.

However, if for some reason this recovery rate is deemed to be lower, the recycling credits for metals will decrease proportionally (see EuP EcoReport).

This 95% is higher than what is required as a minimum by the WEEE directive, but we assume this high recovery rate to be the most likely (economical) way in which manufacturers will try to comply with WEEE-recycling rate requirements, given the limited feasibility of plastics and electronics recycling.

Table 4 shows the various WEEE rates and the current processing rates of the plastics fraction.

Table 4. WEEE quota at time of disposal

WEEE quota	recovery quota	recycling quota	% of EuP plastics now
large domestic appliances	80%	75%	33%
ICT & CE products	75%	65%	40%
small dom. appliances (and tools)	70%	50%	28%

Table 5 gives the present situation and 3 waste scenarios for the situation after 2010-2015, when presently designed EuP will be first disposed off and with of course WEEE and other Waste directive requirements. It relates to the average EuP and it is based on VHK estimates and literature (see EGG 2004 proceed.). Three waste scenarios are specified. ***Scenario_A "Business-as-Usual"*** refers to a situation where halogenated compounds and/or substances mentioned in ECMA-standard 341 are still found in the final product. ***Scenario B "Minimum Waste/ Dematerialisation"*** refers to a situation where no halogenated compounds and/or substances mentioned in the ECMA-341 standard, Chapter 6.7 are found, but the design-focus was on dematerialisation through increased use of (re-enforced) plastics and composite materials. The latter makes disassembly and recycling difficult, but shredding plus waste heat recovery from plastics and PWBs the next best option (displacing fossil fuels). In order to receive the credit for the recycling of electronics, Printed Wiring Boards (PWBs) should be easily disassembled from the rest of the device, so that —in a shredder-based recycling scenario— the electronics parts can be shredded separately.

Scenario C "Best Recycling" refers to a situation where the product is designed for disassembly and consequent re-use and recycling, following design rules in ECMA-341, Chapter 6.6 and with documentation of materials fractions following EIA list of materials (incl. 'Materials of Interest') available.

In short —and this is what we are trying to demonstrate— the recovery rate of 95% is a necessity in all 3 scenarios to meet the WEEE-recycling rates. In our proposal for the methodology structure (Chapter 1 and App. I), the end-of-life scenario is to be assessed in subtask 4.5 ('End-of-Life'). In the Product Cases report (App. 2) this paragraph will be largely void, because at the moment the industry sectors are still discussing the various scenarios, and we have usually resorted for a default scenario to make an illustrative EuP EcoReport.

Table 5. Waste Scenarios: 2005 and 3 WEEE Scenarios
A= *Business-as-Usual*, B= *Dematerialisation* and C=*Best Recycling.*

Disposal scenarios	2005		A		B		C	
	kt	%	kt	%	kt	%	kt	%
TOTAL EuP waste	8500	100%	8075	95%	6800	80%	8925	105%
◇ Metals/ Glass fraction	6800	80%	6299	78%	4760	70%	7140	80%
◇ Plastics/ PWB fraction	1700	20%	1777	22%	2040	30%	1785	20%
● Processed	1275	15%	7671	95%	6460	95%	8479	95%
Metals/ Glass	1020		5984		4522		6783	
- Recycled	969	95%	5684	95%	4296	95%	6444	95%
- Landfill	51	5%	299	5%	226	5%	339	5%
Plastics/ PWBs	255		1688		1938		1696	
- Re-use	3	1%	17	1%	19	1%	85	5%
- Recycled	20	8%	152	9%	310	16%	1272	75%
- Energy recovery	0	0%	0	0%	1550	80%	288	17%
- Haz. incinerated	232	91%	1519	90%	58	3%	51	3%
● Not processed								
- Landfill	7225	85%	404	5%	340	5%	446	5%
RECYCLING/ RE-USE	992	12%	5853	72%	4625	68%	7800	87%
ENERGY RECOVERED	0	0%	0	0%	1550	23%	288	3%
WASTE (Haz. inc.& landf.)	7508	88%	2222	28%	624	9%	836	9%

The methodology proposed here for the credits of metal recycling is not uncontested by the steel-industry and aluminium (sheet & extrusion) industry. A point of discussion is our proposal to take the recycled content of half products as a basis for partitioning recycling credits. One alternative is to disregard the fact that this plays a role in the price-forming of the scrap (and thereby the demand) and partition the recycling credits evenly over all half products. Despite the fact that we do not agree, we are willing to incorporate this particular aspect in the (ex-post) sensitivity analysis for those design options where significant fractions of sheet metal or aluminium extrusions are being replaced or are replacing other materials. It would provide the Commission and Consultation Forum with additional information on an aspect where certain stakeholders have a different opinion (see paragraph 7.8.3).

3.3.7 Product Life & Number of Users

As mentioned in Chapter 2, EuP differ from non-EuP regarding the optimisation of the parameter Product Life. With shoes, clothes, furniture, etc. it is obvious that —both from the economical and the environmental point of view— the longer the Product Life, the better. There is no limit.

With many EuP this is different. Especially with larger EuP (heating appliances, water heaters, white goods, etc.) the energy efficiency of the new models has improved significantly over the old models. So much so, that the *average new* refrigerator, washing machine or dishwasher is 30-40% more efficient than the *average new* appliance 10 years ago. And the *best new* white goods today are some 50 to 75% more efficient with energy resources than their *average new* equivalent 10-15 years ago. This progress becomes visible in the EU's energy balance only very slowly, mainly because the adoption of the new efficient appliances is 'blocked' by the long product life of the old models in the market.[31] In other words, for these EuP a longer product life —also taking into account the impact of production and disposal— would not be advantageous for the environment. Depending on the dynamics in product improvement, a design strategy aiming at a longer product life should be treated with caution: There is more likely to be an optimum and with some products and over certain time periods we may have already passed this optimum (see box: simplified example[32]).

Simplified example: Product Life

2 consumers are buying a new EuP in year 0. Let's assume —very pessimistically— that the materials extraction & production phase for this appliance causes 150 kg of CO_2-emissions. The electricity consumption of this EuP is 400 kWh/year and thereby causes some 200 kg CO_2-emissions per year (0.5 kg CO_2/kWh_e).

After 8 years of the initial purchase the *first consumer* decides to replace the EuP with another average new model. This model is 25% more efficient and uses only 300 kWh/year (150 kg CO_2/year). Its production again causes 150 kg of CO_2-emissions. The first consumer continues to use it for another 8 years. After 16 years, he will have caused 2 x 150 kg= 300 kg CO_2 emissions for production and (8 x 200) + (8x150)= 2800 kg CO_2 emissions for the use of the fridge. In total this is 3100 kg CO_2 emissions.

The *second consumer* tries to preserve the appliance as long as possible and succeeds in keeping the refrigerator in use for a full 16 years. After this time, he will have caused 150 kg CO_2 emissions for production and 16 x 200= 3200 kg CO_2 emissions for the use of the EuP. In total this is 3350 kg CO_2 emissions. So, instead of saving on CO_2-emissions, this second consumer has actually caused 250 kg or 8% more CO_2-emissions than the first consumer.

Please note that with a non-EuP the second consumer would have always been by far the most environmentally friendly.

Due to the uncertainty of Product Life prolongation in general and the specific uncertainty in the trade-off between —on one hand— longer Product Life hindering resources-efficient innovation during product life and —on the other hand— the conservation of resources and emissions in the materials loop, it is proposed that for EuP where the environmental impact of the use phase is dominant the Product Life is treated as a constant and that no credit will be given to design measures directed at Product Life prolongation. For small EuP, where the production stage is dominant, the Product Life can be taken into account to some degree.

If we take the national and EU Eco-label criteria as a yardstick, there seems to be consensus on this issue. Most label-criteria would involve the guaranteed delivery of spare parts over a minimum period, but nowhere is the longevity of the product —beyond the current average— an eco-label reward criterion.

The same goes for a possible design-criterion regarding the increase of the number of users per product. In theory this makes sense as most products are discarded long before their technical product life and sharing a product would increase the chance that the real (economical) product life comes closer to the technical life. Furthermore, using robust and state-of-the-art machines at maximum capacity would create a whole new dimension to saving

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[31] CECED 2001 has calculated in a stock model, that decreasing the average product life from 12 to 10 years for these appliances would immediately result in a significant saving of 1 Mt CO2 emissions

[32] The simplification regards e.g. on one hand that we don't take into account the efficiency improvement in electricity production and on the other hand we don't take into account that —through wear and tear— many appliances use more energy the older they become. Also the figures are of course fictitious.

resources. As indicated by Kemna 1981[33], the number of users per product N, could have the same importance as the product-life L in describing the energy efficiency of a product per functional unit $E_{function}$ (in MJ/year.user)

$$E_{function} = E_{production} + E_{use} + E_{disposal} - E_{recycling} \; / \; L * N ,$$

Where $E_{production}$, E_{use}, $E_{disposal}$ are the energy requirements of respectively producing, using and disposal of the product and $E_{recycling}$ constitutes the energy credits for recycling (all in MJ).

Having said that, there have been several studies, e.g. on shared laundry washing[34] or car-pooling[35], showing that there are quite a few social, cultural and health barriers to be expected that have very little to do with the actual product design. Also in the various Eco-label studies of EuP and non-EuP the number of users is never used as a criterion.

Therefore it is proposed to also not reward an increase of the number of users, but instead take the number of users as a given (constant) for the specific product group.

3.3.8 Functional unit

Last but not least, we would like to use this chapter to say something about what the ISO 14040 standards refer to as the "functional unit" in life cycle assessment [36]. This reference unit is of course related not only to the environmental analysis, but it fits that we use this section to complete some general methodological discussions.

At first sight, the functional unit or (quantified) performance of a product is easy to understand. Everyone understands that a fridge should preserve food, lamps should give light, dishwashers should wash, etc. The table below gives some examples of what one can think of in general terms.

However, the product cases will show that the determination of the functional unit of a product (i.e. the quantified performance of a product/-group that will serve as the basis of the assessment) generally is a very complex item (see the examples of imaging, TV and PC product cases). It requires thorough knowledge of the definition of test conditions, measurement standards, functionally different (sub) categories within a product group, reproducibility and accuracy, acceptable tolerances, etc. All these often highly technical items, which are usually the outcome of years of study and tests by members of technical working groups in standardisation bodies, can be of significant influence on the result.

In general terms there is not very much more to say on this subject, but hopefully the product cases will provide some guidance as to how exactly the functional unit per product group has been defined and where relevant data can generally be retrieved. See also Chapter 4.

[33] Kemna, R.B.J., "Energiebewust Ontwerpen" (energy-conscious design), Delft University of Technology, syllabus 1981-1997.

[34] Thesis Robert Den Hoed, Delft University

[35] Ph. D thesis Rens Meykamp, Delft University

[36] ISO 14040:1997, 3.5: Funtional unit = Quantified performance of a product system for use as a reference unit in a life cycle assessment study

Table 6. Examples of Products and (simplified) Functional Parameters

product	functional parameter
heating appliances	kW nominal rating (to be extended to part-load)
water heaters	tapping pattern(s), new CEN/Cenelec standards 2005 according to Commission mandate
lamps	lumen
refrigerators	capacity in litres storage compartment at x ºC, with an ambient temperature of 25 ºC (13 subcategories)
dishwashers	capacity in number of settings, wash performance optically measured from pre-soiled load
display	mega pixels (or effective surface area) at pre-set luminance and other test conditions according to Energy Star 2004 specs
PCs and notebook	Duty cycle (response-time) [new Energy Star 2006, tier 2]
circulator pump	Q-h curve, best-efficiency-point (bep), Load-profile Blue Angel according to WG 13 Europump 2003/ Energy Label proposal 2004
room air conditioner	kW cooling capacity
copiers	new Energy Star 2005 criteria imaging equipment (pages per minute at draft B&W ?)

3.4 Water

Although the conservation of drinking water resources is high on the environmental agenda and, due to the increasing prices, is also high on the economic agenda of many stakeholders, there is no legislation or generally accepted methodology dealing with the accounting of scarce water resources.

In general this accounting could be straightforward, because it seems easy enough to count the water consumption from ones water bill. However, this deals only with what is called “process water”, water from the public grid that is used in a process and is then usually disposed off through the sewage system or as water vapour to air. In fact, most LCA-sources would provide these data for sectors where there is production in the EU. The problem, regarding the data more than the methodology, comes when processes are not located in the EU. For instance, many mining and beneficiation processes for metals consume high volumes of process water but this is not reported.

The problem of incomplete data also occurs with “cooling water”, which often is water from a nearby river that is used to cool an oven or another process and then returned —with a temperature a few degrees higher— to the same river. The impact of this “thermal pollution” is not well defined and therefore many LCA-data-sources do not even consider cooling water. In terms of methodology it seems obvious that the environmental effect of this cooling water use is different from the process water and therefore it is listed as a different item in the Unit Indicator table.

All in all, the water consumption data should be treated with extreme caution. We list both cooling water and process water, but —if we have to choose— we would indicate process water as the primary impact parameter.

3.5 Waste

The tender document specifies the identification of quantities of Waste, hazardous and non-hazardous and (if data are available) split between landfill and incinerated (without heat recovery). Obviously, the Commission considers that the quantities of Waste To Landfill and Waste To Incineration give a sufficient indication of the waste component of a production (the objective is not to be complete in terms of LCA, but to give indicators).

Essentially the assessment of the amount of waste from several processes involved in the various life-cycle stages of a product should be straightforward. There is a general Waste Directive 75/442/EEC that defines types of waste and there are specific directives on Waste to Landfill 1999/31/EC and Waste Incineration 2000/76/EC that specify how to deal with these definitions.

Yet, during the data-retrieval and in comments by reviewers several problems were identified. For instance, Gjalt Huppes (CML) argues that “waste” should not be a separate category in an environmental life-cycle assessment but is superseded by the emissions of waste treatment. For the retrieval of production data from a manufacturer we had to define whether “liquid waste” should be included.

When dealing with the latter question we found that —apart from the legislative definitions— also the definition of system boundaries in practical LCA-sources play an important role in assessing meaningful indicator data.

In case of ‘liquid waste’ the legislation leads to ambiguity. In principle the general Waste Directive 75/442/EEC applies, but also the directives on Waste to Landfill 1999/31/EC and Waste Incineration 2000/76/EC. Directive 1999/31/EC prohibits liquid wastes to landfill. Directive 2000/76/EC excludes certain types of liquid waste from the provisions for hazardous waste, especially those where heat recovery occurs through combustion (i.e. hydrocarbons). When taking the factory gates as the system boundaries this is very relevant, especially when faced with end-of-pipe measures.

However, the methodology that we are proposing —in line with the ISO LCA standards— goes beyond the factory gates to include all (90%) direct and indirect environmental effects. In such a context there is no such thing as "liquid waste". Every litre of what at one stage was defined as "liquid waste" either is concentrated to a sludge (solid waste), combusted (hydrocarbons) or it is diluted enough to be disposed of as waste water ending up in the Urban Waste Water Treatment Plant. In the latter case our "emissions to water" apply with the substances specified. In the first case (sludge) we define this as solid waste and in the second case there are "emissions to air" (combustion gases) + maybe solid waste (combustion of solids) + maybe energy recovery.

So, when we specify "waste" it actually means the final "solid waste" including the solid waste that remains after treatment. There seems relatively little disagreement on this issue amongst LCA-data-sources: If “waste” is indicated it is always intended as solid waste or the solid waste fraction of sludge or similar.

Another definition problem relates to the definition of waste from mining and beneficiation operations near the mines of non-ferro and precious metals. The objective of these processes is to produce from ore with mostly only a few % metal concentrates of 30 to 50% of metal content, which can then be traded and shipped e.g. to the EU. The places where these mining operations occur are very inconspicuous and uninhabitable: jungles, deserts, etc. But the amount of waste rock and chemicals is usually very high. For instance, to retrieve 4 grams of gold from a surface mine some 10 tonnes of rock has to be moved to retrieve 1 tonne of ore, which is then crushed, leached and further processed.

The “waste” is then re-deposited. Gold mines are an extreme example[37], but also a copper mine would generate 20 kg of waste from ore (not counting the stripped rock) to arrive at 1 kg of copper. In that sense it is remarkable that several LCA-data sources are counting the last gram of waste from the metal processes in the EU and ignoring the fact that the raw material is not ore, but ore concentrate.

In our methodology we therefore do take into account the waste from ore and the figures for non-ferro metals do try to reflect the different efforts between materials regarding the ore extraction. The energy data already give an indication of this, but also in the “waste” category we have tried to incorporate this aspect of materials depletion

[37] E.g. the impact on the land use of gold mines is so significant that the enormous pits allegedly can be spotted from the moon.

and land use. In order to allow a fair comparison between the metals, we have deviated from the main (stakeholder) data sources and have used mining data from independent sources.

With the above and the ‘waste’ data in the Unit Indicator Table (Chapter 5), the last word about ‘waste accounting’ and the use of ‘waste’ as an indicator in Ecodesign has not been said. The data in Chapter 5 are the ones available, but much further study is necessary to make them robust and consistent. At the present state-of-the-art, the indicator ‘waste’ should therefore be treated with extreme caution.

3.6 Global Warming Potential [Kyoto]

The legal basis for (the weighting of) greenhouse gases is Council Decision 2002/358/CE of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments there under. In Article 5, sub 3 it says:

The global warming potentials used to calculate the carbon dioxide equivalence of anthropogenic emissions by sources and removals by sinks of greenhouse gases listed in Annex A shall be those accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties at its third session.

This and other articles recognize the authority of the IPPC to supply weighting factors. There is a broad consensus on this issue. This also goes for the reviewers (Appendix II), although David Pennington suggests that a choice for a 100 year time horizon should be justified, possibly through a comparison of the different time horizons offered by the IPPC.

The tables below list Greenhouse Warming Potential (GWP_{100}) weighting factors from IPCC 2001.

Table 7. Greenhouse gases, IPCC 2001 GWP 100a V1.1

Carbon dioxide CO_2	**1**	Methane, bromochlorodifluoro-, Halon 1211	1300
Carbon monoxide CO	**1.57**	Methane, bromodifluoro-, Halon 1201	470
Dinitrogen monoxide N_2O	**296**	Methane, bromotrifluoro-, Halon 1301	6900
Methane CH_4	**21**	Methane, chlorodifluoro-, HCFC-22	1700
Sulfur hexafluoride SF_6	**22200**	Methane, chlorotrifluoro-, CFC-13	14000
		Methane, dichloro-, HCC-30	10
		Methane, dichlorodifluoro-, CFC-12	10600
Chloroform $CHCl_3$	30	Methane, dichlorofluoro-, HCFC-21	210
Methane, bromo-, Halon 1001	5	Methane, difluoro-, HFC-32	5500
Butane, perfluoro-	8600	Methane, fluoro-, HFC-41	97
Cyclobutane, octafluoro-	10000	Methane, monochloro-, R-40	16
Ethane, 1-chloro-1,1-difluoro-, HCFC-142	2400	Methane, iodotrifluoro-	1
Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b	700	Methane, tetrachloro-, CFC-10	1800
Ethane, 1,1-difluoro-, HFC-152a	120	Methane, tetrafluoro-, FC-14	5700
Ethane, 1,1,1-trichloro-, HCFC-140	140	Methane, trichlorofluoro-, CFC-11	4600
Ethane, 1,1,1-trifluoro-, HCFC-143a	4300	Methane, trifluoro-, HFC-23	12000
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	1300	Pentane, 2,3-dihydroperfluoro-, HFC-4310mee	1500
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	6000	Pentane, perfluoro-	8900
Ethane, 1,1,2-trifluoro-, HFC-143	330	Propane, 1,1,1,2,3,3,3-heptafluoro-, HFC-227ea	3500
Ethane, 1,1,2,2-tetrafluoro-, HFC-134	1100	Propane, 1,1,1,3,3,3-hexafluoro-, HCFC-236fa	9400
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	9800	Propane, 1,1,2,2,3-pentafluoro-, HFC-245ca	640
Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124	620	Propane, 1,3-dichloro-1,1,2,2,3-pentafluoro-, HCFC-225cb	620
Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123	120	Propane, 3,3-dichloro-1,1,1,2,2-pentafluoro-, HCFC-225ca	180
Ethane, chloropentafluoro-, CFC-115	7200	Propane, perfluoro-	8600
Ethane, hexafluoro-, HFC-116	11900		
Ethane, pentafluoro-, HFC-125	3400		
Hexane, perfluoro-	9000		

Table 8. GWP100 of fluorinated Greenhouse gases

PFC	**perfluorocarbon**	
CF_4	perfluoromethane	**6500**
C_2F_6	perfluoroethane (10% van CF_4)	**9200**
C_3F_8	perfluoropropane	**8600**
C_4F_8	perfluorocyclobutane	**10000**
C_4F_{10}	perfluorobutane	**8600**
C_5F_{12}	perfluoropentane	**8900**
C_6F_{14}	perfluorohexane	**9000**
CFC	**chlorofluorocarbon**	
CFC-10	tetrafluoromethane	**1800**
CFC-11	CFCl3 (trichlorofluoromethane)	**4600**
CFC-12	CF2Cl2 (dichlorodifluoromethane)	**10600**
CFC-13	CF3Cl (chlorotrifluoromethane)	**14000**
CFC-113	CF2ClCFCl2 (trichlorotrifluoroethane)	**6000**
CFC-114	CF2ClCF2Cl (dichlorotetrafluoroethane)	**9800**
CFC-115	CF3CF2Cl (chloropentafluoroethane)	**7200**
HFC	**hydrofluorocarbon**	
HFC-23	CHF_3	**12000**
HFC-32	CH_2F_2	**5500**
HFC-41	CH_3F	**97**
HFC-116	hexafluoroethane	**11900**
HFC-125	CHF_2CF_3	**3400**
HFC-134	CHF_2CHF_2	**1100**
HFC-134a	CF_3CH_2F	**1300**
HFC-143	$CH_2F\ CHF_2$	**330**
HFC-143a	CH_3CF_3	**4300**
HFC-152	CH_2FCH_2F	
HFC-152a	CH_3CHF_2	**120**
HFC-161	CH_3CH_2F	
HFC-227ea	CF_3CHFCF_3	**3500**
HFC-236cb	$CF_3CF_2CH_2F$	
HFC-236ea	$CF_3CHFCHF_2$	
HFC-236fa	$CF_3CH_2CF_3$	**9400**
HFC-245ca	$CH_2FCF_2CHF_2$	**640**
HFC-245ea	$CHF_2CHFCHF_2$	
HFC-245eb	CF_3CHFCH_2F	
HFC-245fa	$CHF_2CH_2CF_3$	
HFC-263fb	$CF_3CH_2CH_3$	
HFC-338pcc	$CHF_2CF_2CF_2CF_2H$	
HFC-356mcf	$CF_3CF_2CH_2CH_2F$	
HFC-356mff	$CF_3CH_2CH_2CF_3$	
HFC-365mfc	$CF_3CH_2CF_2CH_3$	
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	**1500**
HFC-458mfcf	$CF_3CH_2CF_2CH_2CF_3$	
HFC-55-10mcff	$CF_3CF_2CH_2CH_2CF_2CF_3$	
HCFC	**hydrochlorofluorocarbon**	
HCFC-21	$CHCl_2F$	
HCFC-22	CHF_2Cl	
HCFC-123	$C_2F_3HCl_2$	
HCFC-124	CF_3CHClF	
HCFC-141b	CH_3CFCl_2	**700**
HCFC-142b	CH_3CF_2Cl	**2400**
HCFC-225ca	$CF_3CF_2CHCl_2$	**180**
HCFC-225cb	$CClF_2CF_2CHClF$	**620**
HCFE-235da2	$CF_3CHClOCHF_2$	
Halons		
Halon 1001	bromomethane	**5**
Halon 1201	bromodifluoromethane	**470**
Halon 1211	bromochlorodifluoromethane	**1300**
Halon 1301	bromotrifluoromethane	**6900**

The greenhouse gases mentioned in Annex A of the Kyoto directive are

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs);
- Sulphur hexafluoride (SF6).

Anthropogenic (human origin) emissions of CO_2, CO, N2O and CH_4 occur mostly at combustion processes. CO_2 occurs also at cement production and in some chemical industry applications.

SF6, PFCs and HFCs are also known as “fluorinated greenhouse gases”, for which the European Commission is preparing a specific Regulation with abatement measures.[38] SF_6 typically occurs with magnesium casting as cover gas. The most well known PFCs are CF_4 and C_2F_6 that are emitted e.g. at the anodes of primary aluminium production. PFCs are also used in the semi-conductor industry and as cleaning solvents. HFCs are used as refrigerants, cleaning solvents and foam blowing agents.

HFCs and PFCs are groups of gases, each with their own specific weighting factor in GWP100 CO_2 equivalent. The tables 7 and 8 on the previous pages give the GWP100 by the IPPC 2001. These are weighting factors relating to the gas emissions only. To this the emissions of their production have to be added. This can be done by adding a specific percentage or by using production-specific emission-data. This will be discussed in the product-case on air conditioners.

For fuel-related CO_2 emissions the European Climate Change Program provides a host of data. Appendix IV, partially from the 2nd ECCP progress report Annex I and supplemented by VHK with data for industry and tertiary sector, shows baseline 1990 and scenarios for 2010 with and without additional measures.

3.7 Ozone Depletion Potential [Montreal]

The abatement of ozone depleting substances is regulated in the Montreal Protocol, which also provides the weighting factors. The ozone depleting substances that have been phased out according to REGULATION (EC) No 2037/2000[39], following the Montreal Protocol are:

(a) chlorofluorocarbons; (group I, CFC-11, 12, 113, 114, 115);
(b) other fully halogenated chlorofluorocarbons; (group II, CFC-13, 111, 112 and 211-217);
(c) halons; (III Halon-1211, 1301 and 2402);
(d) carbon tetrachloride; (IV, CCl_4);
(e) 1,1,1-trichloroethane; (V, $C_2H_3Cl_3$);

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[38] COM(2003)492 final, Proposal for a Regulation of the European Parliament and of the Council on certain fluorinated greenhouse gases, d.d. 11.8.2003

[39] REGULATION (EC) No 2037/2000 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 June 2000 on substances that deplete the ozone layer

(f) methyl bromide (VI, CH_3Br).

Production of these substances is prohibited in 2005, though some may still occur as involuntary emissions and there are some exceptions. Their ODP (in CFC-11 equivalent) is given in the above-mentioned regulation and the following table.

Table 9. Ozone Depletion Potential (ODP) in CFC-11 equivalent

Substance		ODP	Substance	ODP	Substance		ODP
Group I			**Group VII (c'td)**		**Group VIII**		
$CFCl_3$	(CFC-11)	**1**	$C_3H_4FBr_3$	**0.3**	$CHFCl_2$	(HCFC-21)	**0.04**
CF_2Cl_2	(CFC-12)	**1**	$C_3H_4F_2Br_2$	**1**	CHF_2Cl	(HCFC-22)	**0.055**
$C_2F_3Cl_3$	(CFC-113)	**0.8**	$C_3H_4F_3Br$	**0.8**	CH_2FCl	(HCFC-31)	**0.02**
$C_2F_4Cl_2$	(CFC-114)	**1**	$C_3H_5FBr_2$	**0.4**	C_2HFCl_4	(HCFC-121)	**0.04**
C_2F_5Cl	(CFC-115)	**0.6**	$C_3H_5F_2Br$	**0.8**	$C_2HF_2Cl_3$	(HCFC-122)	**0.08**
Group II			C_3H_6FBr	**0.7**			
CF_3Cl	(CFC-13)	**1**	CHFBr2	**1**	$C_2HF_3Cl_2$	(HCFC-123)	**0.02**
C_2FCl_5	(CFC-111)	**1**	CHF2Br	**0.74**	C_2HF_4Cl	(HCFC-124)	**0.022**
$C_2F_2Cl_4$	(CFC-112)	**1**	CH2FBr	**0.73**	$C_2H_2FCl_3$	(HCFC-131)	**0.05**
C_3FCl_7	(CFC-211)	**1**	C2HFBr4	**0.8**	$C_2H_2F_2Cl_2$	(HCFC-132)	**0.05**
$C_3F_2Cl_6$	(CFC-212)	**1**	C2HF2Br3	**1.8**	$C_2H_2F_3Cl$	(HCFC-133)	**0.06**
$C_3F_3Cl_5$	(CFC-213)	**1**	C2HF3Br2	**1.6**	$C_2H_3FCl_2$	(HCFC-141)	**0.07**
$C_3F_4Cl_4$	(CFC-214)	**1**	C2HF4Br	**1.2**	CH_3CFCl_2	(HCFC-141b)	**0.11**
$C_3F_5Cl_3$	(CFC-215)	**1**	C2H2FBr3	**1.1**	$C_2H_3F_2Cl$	(HCFC-142)	**0.07**
$C_3F_6Cl_2$	(CFC-216)	**1**	C2H2F2Br2	**1.5**	CH_3CF_2Cl	(HCFC-142b)	**0.065**
C_3F_7Cl	(CFC-217)	**1**	C2H2F3Br	**1.6**	C_2H_4FCl	(HCFC-151)	**0.005**
Group III			C2H3FBr2	**1.7**			
CF2BrCl	halon 1211	**3**	C2H3F2Br	**1.1**	C_3HFCl_6	(HCFC-221)	**0.07**
CF3Br	halon 1301	**10**	C2H4FBr	**0.1**	$C_3HF_2Cl_5$	(HCFC-222)	**0.09**
C2F4Br2	halon 2402	**6**	C3HFBr6	**1.5**	$C_3HF_3Cl_4$	(HCFC-223)	**0.08**
Group IV			C3HF2Br5	**1.9**			
CCl_4	carbon	**1.1**	C3HF3Br4	**1.8**	$C_3HF_4Cl_3$	(HCFC-224)	**0.09**
Group V			C3HF4Br3	**2.2**			
$C_2H_3Cl_3$	1,1,1-	**0.1**			$C_3HF_5Cl_2$	(HCFC-225)	**0.07**
Group VI phase out 2004							
CH_3Br	(methyl	**0.6**			$CF_3CF_2CHCl_2$	(HCFC-225ca)	**0.025**
Group VII phase out 2009							
$C_3HF_5Br_2$		**2**			C_3HF_6Cl	(HCFC-226)	**0.1**
C_3HF_6Br		**3.3**			$C_3H_2FCl_5$	(HCFC-231)	**0.09**
$C_3H_2FBr_5$		**1.9**			$C_3H_2F_2Cl_4$	(HCFC-232)	**0.1**
$C_3H_2F_2Br_4$		**2.1**			$C_3H_2F_3Cl_3$	(HCFC-233)	**0.23**
$C_3H_2F_3Br_3$		**5.6**			$C_3H_2F_2Cl_4$	(HCFC-232)	**0.1**
$C_3H_2F_4Br_2$		**7.5**			$C_3H_2F_3Cl_3$	(HCFC-233)	**0.23**
$C_3H_2F_5Br$		**1.4**			$C_3H_2F_4Cl_2$	(HCFC-234)	**0,280**
$C_3H_3FBr_4$		**1.9**			$C_3H_2F_5Cl$	(HCFC-235)	**0,520**
$C_3H_3F_2Br_3$		**3.1**			$C_3H_3FCl_4$	(HCFC-241)	**0,090**
$C_3H_3F_3Br_2$		**2.5**			$C_3H_3F_2Cl_3$	(HCFC-242)	**0,130**
$C_3H_3F_4Br$		**4.4**			$C_3H_3F_3Cl_2$	(HCFC-243)	**0,120**
					$C_3H_3F_4Cl$	(HCFC-244)	**0,140**
					$C_3H_4FCl_3$	(HCFC-251)	**0,010**
					$C_3H_4F_2Cl_2$	(HCFC-252)	**0,040**
					$C_3H_4F_3Cl$	(HCFC-253)	**0,030**
					$C_3H_5FCl_2$	(HCFC-261)	**0,020**
					$C_3H_5F_2Cl$	(HCFC-262)	**0,020**
					C_3H_6FCl	(HCFC-271)	**0,030**
					CF_2ClCF_2CHClF	(HCFC-225cb)	**0.033**

Ozone depleting substances, that are not yet phased out are hydrobromofluorocarbons (HBFCs, Group VII) and hydro chlorofluorocarbons (HCFCs, Group VIII).

In our data analysis we have set out to collect emission data for various ozone depleting substances from materials production, but it appeared that in all sources after 2000 there were very little of these substances left. Furthermore, the data collection on this issue from various sources seemed sketchy. As a result we ended up with a data-collection that would give an unfair and up to a degree incorrect comparison of the ODP of construction materials and we decided not to use these data in the methodology. For specific products where ozone-depleting substances may still be used (refrigerants, foaming agents, etc.) it is proposed to take this into account on an ad-hoc basis.

3.8 Acidification [Gothenburg]

The policy framework for acidification through air pollution consists of

- European Community legislation and strategies;
- The United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP).

The latter is also known as the Gothenburg protocol. A key element of EU legislation is the national emissions ceiling directive (NECD, European Community, 2001a), which sets emission ceilings for the acidifying agents sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3). Furthermore, but this is outside the scope of this impact category, the NECD sets emission ceilings for volatile organic compounds (VOCs). These have to be achieved through EU-wide and national policies and measures aimed at specific sectors. National emission ceilings for non-EU countries have been agreed under the CLRTAP Gothenburg protocol (UNECE, 1999). These ceilings represent cost-effective and simultaneous reductions of acidification, eutrophication and ground-level ozone. The EU NECD ceilings were developed using a similar approach. The Gothenburg protocol is signed by 31 countries, incl. the Russian Federation and the USA.[40]

In calculating the "acid equivalent" for emission reduction targets the Gothenburg protocol uses the following weighting factors: Sulphur dioxide * $^1/_{32}$, nitrogen oxide * $^1/_{46}$ and ammonia * $^1/_{17}$.

Recalculated to sulphur dioxide equivalent these factors are: Sulphur dioxide (SO_2) **1**, nitrogen oxide (NO_x) **0.7** and Ammonia (NH3) **1.88**.

[40] For status of ratification see http://www.unece.org/env/lrtap/status/99multi_st.htm

The table below gives the acidification reactions that are the basis for the Gothenburg weighting factors.

Table 10. Acid Rain Potential for a Number of Acidifying Chemicals

Compound	Reaction ARPI	α	MWI (mol/kg)	ηi, (mol H+/ kg "i")	weighting factors
SO_2	$SO_2 + H_2O + O_3 \rightarrow 2H^+ + SO_4{}^{2-} + O_2$	**2**	**0.064**	**31.25**	**1**
NO	$NO + O_3 + ½ H_2O \rightarrow H^+ + NO_3{}^- + ¾ O_2$	**1**	**0.03**	**33.33**	**1.07**
NO_2	$NO_2 + ½ H_2O + ¼ O_2 \rightarrow H^+ + NO_3{}^-$	**1**	**0.046**	**21.74**	**0.7**
NH_3	$NH_3 + 2 O_2 \rightarrow H^+ + NO_3 - + H_2O$	**1**	**0.017**	**58.82**	**1.88**
HCl	$HCl \rightarrow H^+ + Cl^-$	**1**	**0.0365**	**27.4**	**0.88**
HF	$HF \rightarrow H^+ + F^-$	**1**	**0.02**	**50**	**1.6**

source: Adapted from (Heijungs et al., 1992) in http://www.epa.gov/oppt/greenengineering/docs/module_3_master.pdf

Perhaps a simpler way of explaining how the factors are linked is through the atomic weight of N and S (at the same number of H+ ions). For instance ammonia NH_3 has atomic weight 17 with $^{14}/_{17}$ (82 ato wt. %) nitrogen and weighting factor 1.88. Therefore nitric oxide NO with $^{14}/_{30}$ (47 ato wt. %) nitrogen has a weighting factor of $^{47}/_{82}$ * 1.88 = 1.07.

These factors are also used in the Regional Air Pollution Information and Simulation (RAINS) model (Amann *et al.*, 1999b) developed at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. RAINS is also the model used in the revision of National Emissions Ceilings for 2015 and 2020 EU-values that will include particulate matter (PM, dust).

Table 11 shows that also the most authoritative LCA-databases conform to the Gothenburg weighting factors.

Table 11. Acidification multipliers misc. sources (source: SIMAPro 6)

	CML 1992	**CML 2 baseline 2000 V2.1**	Eco-indicator 95 V2.1	**Eco-indicator 99 V2.1 hierarchic**	**Eco-indicator 99 V2.1 hierarchic normalized**	**EcoPoints 97(CH)**	**EDIP/UMIP 96 V2.1 (Denmark)**	**EPS 2000 V2.1 (Sweden)**	**EPS 2000 V2.1 (Sweden)**
	kg AP / kg	**kg SO_2 eq / kg**	**kg SO_2 / kg**	**PDF*m² yr / kg**	**PDF*m² yr / kg (/1041)**	**g SO_2 eq. / g**	**g SO_2 / g**	**H+ eq. / kg**	**H+ eq. / kg**
Ammonia NH_3	1.88	1.6	1.88	15.57	0.015		1.88	1.47	0.94
Ammonium carbonate H_2CO_3 x NH_3	0.67		0.67				0.67	0.52	0.33
Ammonium nitrate NH_4NO_3	0.40		0.40				0.40	0.312	0.20
Dinitrogen monoxide N_2O	1.78		1.78				1.78	1.47	0.94
Hydrogen chloride HCl	0.88		0.88			0.88	0.88	1.39	0.89
Hydrogen fluoride HF	1.6		1.6			1.6	1.60	2.5	1.60
Hydrogen sulphide H_2S							1.88	2.32	1.49
Nitrate NO_3				5713	5.488				
Nitric acid HNO_3	0.51		0.51				0.51	0.8	0.51
Nitric oxide NO	1.07		1.07	8789	8.443		1.07	1.67	1.07
Nitrogen dioxide NO_2	0.7	0.5	0.7	5713	5.488		0.70	1.09	0.70
Nitrogen oxides NO_x	0.7	0.5	0.7	5713	5.488		0.70	1.09	0.70
Sulphate SO_4				1041	1.000		0.98		
Sulphur dioxide SO_2	1	1.2	1	1041	1.000	1	1	1.56	1.00
Sulphur oxides SO_x	1	1.2	1	1041	1.000	1	1	1.56	1.00
Sulphur trioxide SO_3	0.8		0.8	0.8323	0.001		0.80	1.25	0.80
Sulphuric acid H_2SO_4	0.65		0.65		0.000		0.65	1.02	0.65

The table shows that e.g. CML, EcoIndicator95 and EDIP conform to RAINS factors.

As mentioned, the table not only shows for the main agents SO2, NOx and NH3, but also for additional compounds that are precursors of these substances through oxidation or reduction. As explained above, the weighting factors for these compounds correlate to the original weighting factors through the atomic weitght of nitrogen (N, atomic weight 14) and sulphur (S, atomic weight 12). In other words, the additional compounds are complementary to the existing legislation and it is proposed to also take these into account.

Apart from —or rather within— the overarching Gothenburg emission ceilings, there are a number of EU directives controlling emissions from point sources like vehicles (EC 1998), large combustion plants (LCP directive, EC 2001), waste incineration and large industrial installations (IPPC, 1996). Furthermore, there is a daughter directive of the Ambient Air Quality directive (AAQD) dealing with SO_2, NO_x and other non-acidifying substances.[41] The AAQD directive does not refer to point sources but to local air quality measurements in a national grid of measurement points. These are the same measurement points that are used to assess conformity to the Gothenburg protocol.

The limit values in the above directives, especially the AAQD directive, mirror the weighting factors of the Gothenburg protocol, but mostly they are rounded. For instance, the AAQD daughter directive specifies an eco-toxicity limit value of 20 µg/m³ for SO_2 and 30 µg/m³ for NO_x. This reflects the weighting factor of 1 (SO_2) versus 0.7 (NO_x).

Table 12. Eco-Toxicity Limit Values for Sulphur Dioxide, Nitrogen Dioxide and Oxides of Nitrogen (source: Directive 1999/30/EC)

Averaging period		**Limit value**	**Margin of tolerance**	**Date by which limit value is to be met**
SO_2 Limit value for the protection of ecosystems	Calendar and winter year (October to March)	20 µg/m³	None	19 July 2001
NO_x Annual limit value for the protection of vegetation	Calendar year	30 µg/m³		19 July 2001

COUNCIL DIRECTIVE 1999/30/EC of 22 April 1999, relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air

[41] Lead, VOCs

The legislation for emissions from point sources is different and only partially related to acidification; human toxicity also plays a role. This explains for instance the much more stringent emission limit values (ELVs) of HCl and HF in the waste incineration directive than would be justified from the acidification perspective only.

Table 13. ELV of waste incineration (Dir. 2000/76/EC)

Emission incineration plant	Limit Value mg/m³
Total dust	10
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	10
Hydrogen chloride (HCl)	10
Hydrogen fluoride (HF)	1
Sulphur dioxide (SO_2)	50
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) capacity > 6 t/h for new incineration plants	200
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), capacity <6 t/h	400

Also the ELVs in e.g. the LCP directive 2001/80/EC do not reflect the acidification effect only, but e.g. the best available technology given the type of fuel involved.

As a conclusion the weighting factors from the Gothenburg protocol seem the most appropriate to weight the acidification impact, leading to the table below (most important substances in bold):

Table 14. MEEUP Weighting Factors for Emissions of Acidifying Agents to Air (VHK)

Acidifying agent	weighting factor g SO_2 eq./ g	Acidifying agent	weighting factor g SO_2 eq./ g
Ammonia NH3	**1.88**	Nitric oxide NO	**1.07**
Ammonium carbonate H_2CO_3 x NH_3	**0.67**	Nitrogen dioxide NO_2	**0.7**
Ammonium nitrate NH_4NO_3	**0.4**	**Nitrogen oxides NO_x**	**0.7**
Dinitrogen monoxide N_2O	**1.78**	Sulphate SO_4	**0.98**
Hydrogen chloride HCl	**0.88**	Sulphur dioxide SO_2	**1**
Hydrogen fluoride HF	**1.6**	**Sulphur oxides SO_x**	**1**
Hydrogen sulphide H_2S	**1.88**	Sulphur trioxide SO_3	**0.8**
Nitric acid HNO_3	**0.51**	Sulphuric acid H_2SO_4	**0.65**

3.9 Volatile Organic Compounds VOCs

Volatile Organic Compounds (VOC) are tracked by Corinair. Strictly also methane (CH_4) is part of VOCs, but because the effect on the environment is different it is excluded. For this reason VOCs are often called NMVOCs: Non-Methane VOCs.

VOCs appear in two EU directives and one monitoring activity:

- Dir. 2002/3/EC of 12 Feb. 2002 relating to (ground level) ozone in ambient air, where NO_x and VOCs should be monitored as precursors of ozone;
- Dir. 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations;
- IMPEL network monitoring the emissions of fugitive NMVOCs.

The first directive gives a list of VOCs. No explicit VOC weighting factors are supplied in any of the directives. Directive 2002/3/EC does supply emission limit values for human toxicity and eco-toxicity of ground level ozone, where VOCs are a contributing factor. These limit values, which are discussed with the values from other AAQD directives in the paragraph on heavy metals to air, at least give some idea of the relative weight of the impact. In the underlying study we will supply the data of VOC emissions from various sources "as is", i.e. in gram.

The Graph below shows the main sources of NMVOCs as background information.

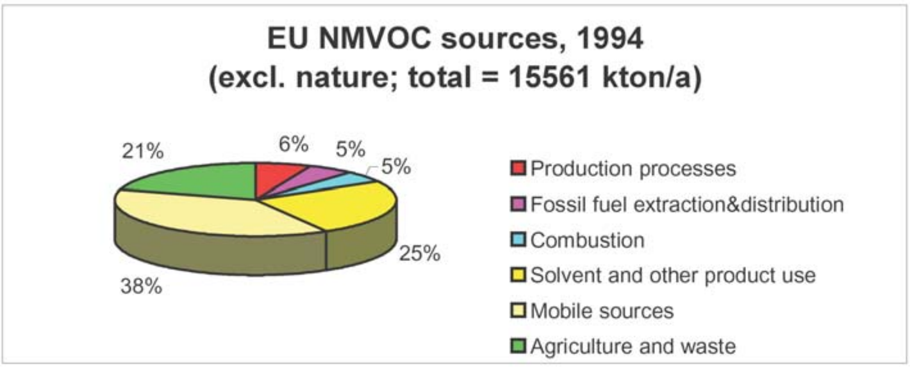

Figure 7. NMVOC emissions EU (Corinair 1994)

3.10 Persistent Organic Pollutants [Stockholm]

The POPs (Persistent Organic Pollutants) are defined under the Stockholm Convention[42] and include mainly pesticides (not relevant for EuP) and some other chemicals/emissions. The latter include PCBs, dioxins and furans. PCBs are relatively seldom with EuP, because they mainly occur with some specific products like large medium-voltage transformers. In some EU MS there are initiatives to phase out PCBs and in any case they are not part of the selected products we have to investigate in the underlying study. So, we propose to deal with PCBs on an ad-hoc basis for these very specific products. The same goes for bio-plastics and bio-fuels, where pesticides (and land-use) might come into the equation: They have a low market share and their application might occur only with very specific EuPs.

This leaves dioxins and furans, which typically occur at the (incomplete) combustion of solids. They are usually expressed as the total concentration equivalent (Teq) of Tetrachlorodibenzodioxin (TCCD). The table below gives the equivalence factors mentioned in Annex I of the Waste Incineration directive 2000/76/EC.

Table 15. Equivalence factors for dibenzo-p-dioxins and dibenzofurans

For the determination of the total concentration (TE) of dioxins and furans, the mass concentrations of the following dibenzo-p-dioxins and dibenzofurans shall be multiplied by the following equivalence factors before summing:

Dioxin	factor	Furan	factor
2,3,7,8 — Tetrachlorodibenzodioxin (TCDD)	**1**	2,3,7,8 — Tetrachlorodibenzofuran (TCDF)	**0,1**
1,2,3,7,8 — Pentachlorodibenzodioxin (PeCDD)	**0,5**	2,3,4,7,8 — Pentachlorodibenzofuran (PeCDF)	**0,5**
1,2,3,4,7,8 — Hexachlorodibenzodioxin (HxCDD)	**0,1**	1,2,3,7,8 — Pentachlorodibenzofuran (PeCDF)	**0,05**
1,2,3,6,7,8 — Hexachlorodibenzodioxin (HxCDD)	**0,1**	1,2,3,4,7,8 — Hexachlorodibenzofuran (HxCDF)	**0,1**
1,2,3,7,8,9 — Hexachlorodibenzodioxin (HxCDD)	**0,1**	1,2,3,6,7,8 — Hexachlorodibenzofuran (HxCDF)	**0,1**
1,2,3,4,6,7,8 — Heptachlorodibenzodioxin (HpCDD)	**0,01**	1,2,3,7,8,9 — Hexachlorodibenzofuran (HxCDF)	**0,1**
— Octachlorodibenzodioxin (OCDD)	**0,001**	2,3,4,6,7,8 — Hexachlorodibenzofuran (HxCDF)	**0,1**
		1,2,3,4,6,7,8 — Heptachlorodibenzofuran (HpCDF)	**0,01**
		1,2,3,4,7,8,9 — Heptachlorodibenzofuran (HpCDF)	**0,01**
		— Octachlorodibenzofuran (OCDF)	**0,001**

In the directive on Waste Incineration, there is an emission limit value of 0.1 ng/m³.

In some countries, like the UK, also PAHs (Polycyclic Aromatic Hydrocarbons) are included in the POP-category because of their persistent and damaging nature. But in the underlying study we conform to the Stockholm Convention and the 2004/107/EC directive[43], that includes PAHs with the Heavy Metals. Also, there has been a study by Sara Eklund[44], investigating whether PAHs could be included in the Stockholm Convention and she found several disadvantages in using this approach.

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[42] The Stockholm Convention is ratified in Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC

[43] DIRECTIVE 2004/107/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air

[44] Sara Eklund, PAH as a POP: possibilities, implications and appropriateness of regulating global emissions of poylcyclic aromatic hydrocarbons through the Stockholm Convention on Persistent Organic Pollutants, IIIEE, Lund, 2001

3.11 Heavy Metals To Air [Århus]

The policy framework for abatement of heavy metal emissions consists of

- European Community legislation and strategies;
- The United Nations Economic Commission for Europe (UNECE) Protocol.

UN-ECE adopted the Protocol on Heavy Metals on 24 June 1998 in Århus (Denmark). It targets three metals: cadmium, lead and mercury. According to one of the basic obligations, Parties will have to reduce their emissions for these three metals below their levels in 1990 (or an alternative year between 1985 and 1995). The Protocol aims to cut emissions from industrial sources (iron and steel industry, non-ferrous metal industry), combustion processes (power generation, road transport) and waste incineration. It lays down stringent limit values for emissions from stationary sources and suggests best available techniques (BAT) for these sources, such as special filters or scrubbers for combustion sources or mercury-free processes. The Protocol requires Parties to phase out leaded petrol. It also introduces measures to lower heavy metal emissions from other products, such as mercury in batteries, and proposes the introduction of management measures for other mercury-containing products, such as electrical components (thermostats, switches), measuring devices (thermometers, manometers, barometers), fluorescent lamps, dental amalgam, pesticides and paint.

The EU has approved Århus in 2002. In total there are 36 signatures to Århus, including countries in Central and Eastern Europe and the USA.[45] Unlike Gothenburg and Stockholm, Århus does not work with weighting factors.

The same goes for some EU-legislation in support of Århus, like the RoHS directive. The objective of RoHS is a mandatory ban (with exceptions) on the use in electric and electronic equipment of four metals —lead, mercury, hexavalent chromium and cadmium— and two groups of brominated flame retardants: PolyBrominated Biphenyls (PBB) and PolyBrominated Diphenyl Ethers (PBDE).

The only guidance in legislation as regards emission limit values and thereby weighting factors comes from directives on Ambient Air Quality[46] and specific emissions of point sources. As is the case with the Gothenburg convention, the Ambient Air Quality directives are the most “pure” in terms of expressing the environmental impact, whereas the legislation regarding point source emissions is “contaminated” with considerations regarding the feasibility with the specific technology.

Table 16 below gives the ELVs (emission limit values) of the AAQD daughter directives that are dealing with toxicity.

For directive 2004/107/EC these are "target values" for the total content in the PM10 fraction averaged over a calendar year. For directive 1999/30/EC these are 24-h "limit values" for human health. "Upper and lower assessment thresholds "in these directives are a percentage (e.g. 60-40%) of target/limit values mentioned and determine the extent of the monitoring effort by Member States.

Particulate Matter is a separate impact category/ indicator in our methodology.

[45] For status of ratification see http://www.unece.org/env/lrtap/status/98hm_st.htm

[46] COUNCIL DIRECTIVE 96/62/EC of 27 September 1996 on ambient air quality assessment and management

SO_2 and NO_2 are included in the separate category of acidifying agents with more or less the same relative weighting factor (1 vs. 0.7 for eco-toxicity, 1 vs. 0.62 here)

Ground-level ozone is not a direct anthropogenic emission but the result of a photochemical reaction that is more likely to occur in the presence of so-called precursors like nitrogen dioxides, oxides of nitrogen and volatile organic compounds (NO_2, NO_x, VOCs). In the proposed methodology VOCs are a separate category and NO_2/ NO_x are part of the acidifying agents (Gothenburg). Note that the limit value mentioned for ground-level ozone is the 8h-limit value for human health. The directive also mentions values that are relevant for eco-toxicity (vegetation, forests).

Table 16. Target/Limit values in EC Ambient Air Quality directives

Pollutant	Target/ limit values* in ng/m³	EC Air Quality directive
Benzo(a)pyrene (as a measure for polycyclic aromatics PAHs)	**1**	2004/107/EC
Cadmium (Cd)	**5**	2004/107/EC
Arsenic (As)	**6**	2004/107/EC
Nickel (Ni)	**20**	2004/107/EC
Lead (Pb)	**500**	1999/30/EC
Particulate Matter (PM10)**	**50,000**	1999/30/EC
Sulphur dioxide (SO_2)***	**125,000**	1999/30/EC
Nitrogen dioxide (NO_2)***	**200,000**	1999/30/EC
Ground-level ozone****	**120,000**	2002/3/EC
Benzene (aromatic HC, C_6H_6)	**5,000**	2000/69/EC
Carbon monoxide (CO)	**10,000,000**	2000/69/EC

sources:

DIRECTIVE 2004/107/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and poly-cyclic aromatic hydrocarbons in ambient air

DIRECTIVE 1999/30/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air

DIRECTIVE 2000/69/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air

DIRECTIVE 2002/3/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 February 2002 relating to ozone in ambient air

notes:

* =For directive 2004/107/EC these are "target values" for the total content in the PM10 fraction averaged over a calendar year. For directive 1999/30/EC these are 24-h "limit values" for human health.

** = Particulate Matter is a separate impact category/ indicator in our methodology

***= SO_2 and NO_2 are included in the separate category of acidifying agents with more or less the same relative weighting factor (1 vs. 0.7 for eco-toxicity, 1 vs. 0.62 here)

****= Ground-level ozone is not a direct anthropogenic emission but the result of a photochemical reaction (see text)

The target value for the protection of vegetation from the effect of ground-level ozone is not an emission limit value, but a derived parameter called AOT40. AOT40 (expressed in (µg/m³)·hours) means the sum of the difference between hourly concentrations greater than 80 µg/m³ (= 40 parts per billion) and 80 µg/m³ over a given period using only the 1-hour values measured between 8:00 and 20:00. Central European Time each day (1). These measurements have to take place over period May to July. In other words, the target value relate to the sum of around 1000 hourly samples. The target value for 2010 is 18 000 µg/m³·h (annual averaged over five years). If we average this out for 1000 hours this means 18 µg/m³ plus the base level of 80 µg/m³ results in 96 µg/m³ (96,000 ng/ m³). The long-term target is 6 000 µg/m³·h, resulting similarly in 86 µg/m³ annually.

These eco-toxicity values are not relevant here, but they at least provide some sort of indication of the relative importance of ground-level ozone versus the other Gothenburg substances and could be helpful in case of normalization exercise or similar at the end of the study. As mentioned in table 12, the annual eco-toxicity limit values in directive 1999/30/EC are 20 µg/m³ for SO_2 and 30 µg/m³ for NO_x.

The list of heavy metals in the above table is relatively short and we have turned to EU legislation on point sources to make the list more robust. As a weighting factor we primarily looked at the most generic (least technology-specific) point-source legislation, which in this case were the threshold values for reporting under EPER.

Table 17. EPER (European Pollutant Emission Register) Reporting Threshold Values

Pollutants / Substances	**Identification**	Thresholds Air in kg/yr	Thresholds water in kg/yr
Metals and compounds			
As and compounds	total, as As	20	5
Cd and compounds	total, as Cd	10	5
Cr and compounds	**total, as Cr**	100	50
Cu and compounds	**total, as Cu**	100	50
Hg and compounds	total, as Hg	10	1
Ni and compounds	total, as Ni	50	20
Pb and compounds	total, as Pb	200	20
Zn and compounds	**total, as Zn**	200	100

source: ANNEX A1 LIST OF POLLUTANTS TO BE REPORTED IF THRESHOLD VALUE IS EXCEEDED, Guidance Document for **EPER** implementation - Part III, European Commission, 2000

The table above suggests that Zinc (Zn) is in the same league as Lead (Pb). Chromium (Cr) and Copper (Cu) threshold values are half of that, suggesting that their impact is twice as serious as that of Pb/Zn, but half that of Nickel (Ni). Finally, Mercury (Hg) has the same threshold value as Cadmium (Cd). Using this outcome we constructed the MEEUP weighting factors shown in table 18 (first two columns). All values were normalized to index Nickel (Ni)= 1.

The way we handled the weighting of Heavy Metals has been the most debated issue by the reviewers and we would like to direct the reader to the MEEUP Project Report with the complete reviewer's comments and our answers.
To summarize: We do not pretend to have constructed an (eco) toxicity indicator. What we have is a set of weighting factors that is based on emission limit values (ELVs) in the various Ambient Air Quality directives and that allows us to summarize Heavy Metals and PAHs in a way that reflects the current view of the legislator. No more and no less.

The notion that this would not be in line with scientific methods is an over-simplification. The priorities **--**the ELVs in the legislation**--** were established ***also*** to a large extend on the basis of the scientific insights at the time of conception and scientific expert consultations. The Ambient Air Quality webpages give links to the position papers and other information to this effect (http://europa.eu.int/comm/environment/air/ambient.htm). However, what is also true, is that there were several scientific uncertainties where the respective Working Groups –with policy makers and scientists-- had to make choices. Furthermore, especially regarding consensus on the basic principle on how ecotoxicity should be modelled (fate modelling, etc.), progress has been made in recent years.

This does not mean that science can now provide a conclusive answer on (eco)toxicity rating of toxic substances. The scientific uncertainties have not disappeared. On the contrary, the Declaration of Apeldoorn (April 2004) by a group of foremost ecologists, toxicologists and other scientists concluded explicitly that there is currently no acceptable LCIA[47] method for ecotoxicity of non-ferrous metals. Following this, the UNEP/SETAC Life Cycle Initiative (see pages 144-145) and ICMM have started large research projects on the subject, that are planned to be completed in 2008. These projects are expected to constitute an important step forwards. And it is to be hoped that –despite large uncertainties that will remain-- they provide a practical and broadly acceptable way of using Fate Modelling, etc. that can be translated into appropriate legislation. Until such time –and given that our assignment requires us to supply aggregated data on Heavy Metals-- we can only be very cautious and adhere to substances where the legislator at the level of Council Directives has decided that emission limit values are appropriate in view of (eco)toxicity. As mentioned in paragraph 3.1, it is inconceivable that a Commission Directive, which would be the legal status of implementing measures under the Ecodesign of EuP Framework Directive, could decide on the (degree of) toxicity of an as yet unregulated substance. Such an issue has legal and economical effects far beyond its scope and should be part of democratic and scientific scrutiny at a different legal level.

Having said that, this did not keep us from comparing our weighting factors with the human toxicity and aquatic toxicity weighting factors currently proposed by CML from (Guinée, 2002), supplied by Huppes (see Annex II). All values were normalized to index Nickel (N).

Table 18. MEEUP weighting factors compared to human and eco-toxicity factors CML

MEEUP (VHK)		**CML(Guinée et al., 2002)**				
air pollutant ranked by factor from EU legislation	**weighting factor (calculated in Ni. Equivalent)**	**air pollutant ranked as MEEUP (all recalculated to Ni. Equivalent)**	**Human toxicity potential (HTP)**	**Eco- toxicity potential Fresh Water Aquatic (FAETP)**	**Eco- toxicity potential Fresh Water Sediment (FSETP)**	**Eco- toxicity potential Terrestrial (TETP)**
carbon monoxide	**0.000002**	carbon monoxide	**n.a.**	**n.a.**	**n.a.**	**n.a.**
benzene	**0.004**	benzene	**0.05**	**0.00**	**0.00**	**0.00**
zinc*	**0.04**	zinc*	**0.00**	**0.03**	**0.03**	**0.10**
lead	**0.04**	lead	**0.01**	**0.00**	**0.00**	**0.13**
chromium (III)*	**0.5**	chromium (III)*	**0.02**	**0.00**	**0.00**	**25.00**
copper*	**0.5**	copper*	**0.12**	**0.35**	**0.35**	**0.06**
nickel	**1**	nickel	**1.00**	**1.00**	**1.00**	**1.00**
arsenic	**3.33**	arsenic	**10.00**	**0.08**	**0.08**	**13.33**
cadmium	**5**	cadmium	**4.29**	**0.46**	**0.46**	**0.68**
mercury*	**5**	mercury*	**0.17**	**0.51**	**0.51**	**233.33**
Carc. PAHs	**20**	Carc. PAHs	**16.29**	**0.27**	**0.35**	**0.01**
chromium VI	**n.a.**	chromium VI	**97.14**	**0.01**	**0.01**	**25.00**
2,3,7,8-TCDD	**n.a.**	2,3,7,8-TCDD	**54285.71**	**3333.33**	**4250.00**	**100.00**

*= from EPER, rest AAQD; all values normalised to index Nickel=1

[47] Life Cycle Impact Assessment (weighting method for environmental impact)

Without going into detail, we conclude from this table that the proposed MEEUP weighting factors are not completely out of line when considering both the human toxicity and eco-toxicity factors proposed by CML 2002. Note that CML has specified Cr VI and Cr III. The first will be banned from EuP in 2006 and there are very little emissions of Cr VI if it is not actually used in a product. Therefore we are happy enough with the weighting factor for Cr, which will be essentially Cr III, as is. CML has also added the toxicity factors for the dioxin 2,3,7,8-TCDD, thereby providing the link with weighting factors in our separate POP category.

One suggestion by several reviewers (Pennington, Frischknecht and Quella et al.) is that of greater transparency. For this reason —still using the weighting factors (Ni eq.) given above— we have made a subdivision of organic toxins like carcinogenic PAHs, CO and benzene on the one hand and the real metals Cd, Hg, As, Cu, Cr, Pb and Zn on the other. The first category will be dominated by PAHs, given the weighting factors and the released quantities, and we give that the header "PAHs". The second category will be "Heavy Metals"("HM"). Because we keep the same accounting unit (Ni. Equivalent), these two subcategories could be compared. Finally, and this became clear from a first data analysis of the Unit Indicators, we have added an 'emergency' weighting factor for the category "Heavy Metals unspecified" with a weight (Ni eq.) of 2, being somewhere between Ni and Hg/Cd.

3.12 Particulate Matter

Particulate Matter PM or dust is an important indicator for smog Human Toxicity (respiratory problems). AAQ Directive 1999/30/EC [48] sets a 24h emission limit value of 50 µg/m³ PM_{10}, not to be exceeded more than 35 times a calendar year, starting 1 Jan. 2005. The annual average emission limit should not exceed 40 µg/m³. Starting 1 Jan. 2010 the latter annual average should not exceed 20 µg/m³.

Assessment of particulate matter mass from available LCA-data sources is straightforward. For a subdivision between PM10 and finer dust PM2.5 not enough data are available.

For the development of the thematic strategy on air pollution, including PM10 and PM2.5, and for the revision of the ceilings of the National Emission Ceiling directive to be achieved before end 2006, the Commission is using the RAINS model which is notably calculating emission of 5 pollutants for each MS and by grids of 50*50 km on the basis of energy/agri scenarios and "standardised" emission factors for each activity. For each grid and each country, total emissions by fuel and type of appliance is available as well as an estimate of the impact in terms of ozone, acid and N deposition. The database is accessible through the www.iiasa.ac.at website. As regards EuP, RAINS distinguishes amongst others stationary combustion installations with e.g. solid fuel boilers (biomass, coal) as important contributors for PM2.5. More information on this subject is available from technical reports by AEAT[49], EGTEI[50] and JRC-IPTS[51] and strategic documents on the Commission website[52].

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[48] COUNCIL DIRECTIVE 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air

[49] http://europa.eu.int/comm/environment/air/cafe/pdf/final_report_aeat.pdf

[50] - the "EGTEI" notes - EGTEI is a group of experts from the MS working under the UN Convention on air pollution. Their mandate is basicaly to review the database on cost/technologies used in RAINS: http://www.citepa.org/forums/egtei/egtei_index.htm They have produced 3 notes on solid fuel combustion in the smaller installations: http://www.citepa.org/forums/egtei/egtei_doc-Comb-non-Ind.htm

[51] http://europa.eu.int/comm/environment/air/cafe/activities/pdf/emerg_tech_final_report_05_02_11.pdf (see page 61 and onwards).

[52] http://europa.eu.int/comm/environment/air/cafe/pdf/strat_com_en.pdf (point 4.2.1.1)

3.13 Water emissions

Our assignment requires us to provide parameters on the impact of emissions of heavy metals, eutrophication and POPs to water. As with the air emissions, the emission of POPs is mainly relevant for agricultural production (pesticides, etc.) and much less for EuP. Furthermore, whereas for air emissions of dioxins still values can be found in LCA-databases this is not the case of water emissions of dioxins and furans. So, until further notice we must assume that emissions of POPs to water are negligible for EuP.

This leaves the categories of Heavy Metals (HM) and Eutrophication (EU), incl. substances that affect the oxygen balance. For water the situation is less clear than for air emissions.

There are international UN-ECE agreements on (pollution of) trans-boundary water flows like the 1992 Water Convention and the most recent Protocol on Water and Health in London, 1999 but they are generally less stringent than what the EU proposes in its legislation in terms of monitoring and they lack generally applicable quantitative emission targets. The reason may be, that we are dealing with different requirements for the different types of water compartments: drinking water, urban waste water treatment, groundwater pollution, bathing water quality, accidental marine pollution, etc. Furthermore, there is pollution from point sources but also it is recognized that diffuse sources may play a bigger role than was expected.

The Water Framework Directive (WFD,. 2000/60/EC) is the equivalent of the AAQD but only for water. It defines monitoring conditions for a number of so-called “List I” substances. Discussions eventually leading up to this directive have allegedly been very difficult and the discussions on Daughter Directives continue this trend. Annex VIII of the WFD gives the following indicative list of the main pollutants:

1. Organohalogen compounds and substances that may form such compounds in the aquatic environment;.
2. Organophosphorous compounds;
3. Organotin compounds;
4. Substances and preparations, or the breakdown products of such, which have been proved to possess carcinogenic or mutagenic properties or properties which may affect steroidogenic, thyroid, reproduction or other endocrine-related functions in or via the aquatic environment;
5. Persistent hydrocarbons and persistent and bio-accumulable organic toxic substances;
6. Cyanides;
7. Metals and their compounds;
8. Arsenic and its compounds;
9. Biocides and plant protection products;
10. Materials in suspension;
11. Substances which contribute to eutrophication (in particular, nitrates and phosphates);
12. Substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD, etc.).

The WFD indicates in Annex IX that the emission limit values from daughter directives of the 1976/464/EEC water quality directives apply:

- The Mercury Discharges Directive (82/176/EEC);
- The Cadmium Discharges Directive (83/513/EEC);
- The Mercury Directive (84/156/EEC);

- The Hexachlorocyclohexane Discharges Directive (84/491/EEC);
- The Dangerous Substance Discharges Directive (86/280/EEC).

However, these directives are of little help for determining weighting factors for EuP, because they relate to emissions from very specific industrial point sources, e.g. chlorine-alkali production, mercury battery production, etc. or they refer to emissions from pesticides like DDT and others. At best one can derive a weighting factor of 5 (Hg) versus 3 (Cd) from the fact that the concentration in territorial and internal coastal waters, other than estuary waters, must not exceed 0,3 (Hg, dir. 82/176/EEC) or 0,5 (Cd, dir. 83/513/ECC) mg/ litre respectively. But already the directive 84/156/EEC mentions much lower (equal or smaller than 0.1 mg/l) mercury emission limit values, so the only conclusion one can draw is that mercury should be weighted at least a factor 2 more polluting than cadmium.

When we look at existing and recently proposed Daughter Directives from the WFD, the priorities of the legislator become a bit clearer, at least for eutrophication. The directive 91/271/EEC on Urban waste water treatment[53] is quite explicit about a weighting of the eutrophication: the proportion between nitrogen (N, in Kjeldahl-nitrogen) and phosphorus (P) in terms of emission limit values is given as 15 mg/l versus 2 mg/l, which seems fairly exact in line with e.g. Eco-indicator95 values (0.42 vs. 3) which are based on WHO values. Also the directive gives clear emission values on BOD, COD and suspended solids.

Table 19. Emission Limit Values according to Council Directive 91/271/EEC of 29 May 1991 on Urban Waste Water Treatment

Parameters	Concentration
Biochemical oxygen demand (BOD)	**25 mg O_2/l**
Chemical oxygen demand (COD)	**125 mg O_2/l**
Total suspended solids	**35 mg/l**
Total phosphorus	**2 mg P/l**
Total nitrogen	**15 mg N/l**

Total nitrogen means: the sum of total Kjeldahl-nitrogen (organic N + NH_3), nitrate

The proposal on the directive on Bathing Water[54] is of little help for weighting factors as it either looks at micro-biological parameters (intestinal enterocossi, escherischia coli, algae growth) that are not in themselves an emission, but more a consequence/symptom of such emissions. It looks at oil residues but only through a visible inspection and finally it monitors the pH value, which again is a symptom and not a cause.

The proposal on the directive against Groundwater Pollution[55] might be a suitable candidate for weighting heavy metal emissions in the future, but at the moment it just proposes that the Member States themselves should establish emission limit values for List II metals. The only concrete values in the proposal are a general limit value of 50 mg/l for nitrates that shouldn't be exceeded and a limit value of 0.1 µg/l that is the maximum for traces of

53 Amended by COMMISSION DIRECTIVE 98/15/EC, but this does not alter the weighting factors in principle

[54] COM(2002) 581 final, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL concerning the quality of bathing water, Brussels, 24.10.2002

[55] COM(2003) 550 final, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the protection of groundwater against pollution, Brussels, 19.9.2003

persistent pesticides (POPs). This suggests a weighting factor of 1 to 500,000 for POPs versus nitrates, but —as mentioned— for EuP this isn't helping very much because POPs are negligible.

The only measure that gives an indication of weighting factors for heavy metal emissions is the reporting threshold values for EPER. These are given in table 17 in the section on air emissions of heavy metals.

Apart from legislation, we have particularly for water emissions looked at LCA-sources. Table 20 lists weighting factors from older sources, presumably more inspired by human toxicity (WHO).

Table 20. Weighting factors for water emissions proposed by misc. older LCA-sources (source: SIMAPro 6)

Eco-indicator 95 V 2.1

in kg Pb eq.	**To Water**
Antimony Sb	2
Arsenic, ion As	1
Barium Ba	0.014
Boron Bo	0.03
Cadmium (ion) Cd	3
Cadmium oxide Cd	
Chromium Cr	0.2
Copper, ion Cu	0.005
Lead Pb	1
Manganese Mn	0.02
Mercury Hg	10
Molybdenum Mo	0.14
Nickel, ion Ni	0.5
Metal(lic ions), unspecified	0.002223
Heavy metals, unspecified	

Source: Eco-indicator 95 V 2.1 (SIMAPRO 6)

Emissions to Water

CML 1992: eutrophication in kg NP	
Ammonia NH_3	0.33
Ammonium carbonate H_2CO_3 x NH_3	0.12
Ammonium nitrate NH_4NO_3	0.074
Ammonium, ion NH_4+	0.33
COD, Chemical Oxygen Demand	0.022
Dinitrogen monoxide N2O	0.13
Nitrate NO_3-	0.1
Nitric acid HNO_3	0.093
Nitric oxide NO	0.2
Nitrite	0.13
Nitrogen dioxide NO_2	0.13
Nitrogen oxides NO_x	0.13
Nitrogen, total N	0.42
Phosphate PO4	1
Phosphoric acid	0.97
Phosphorus P	3.06
Phosphorus pentoxide P_2O_5	1.34
Phosphorus, total P	3.06

Ecopoints 97 (CH) V2.1: Impact category COD in g/g	
COD, Chemical Oxygen Demand	1
DOC, Dissolved Organic Carbon	3
TOC, Total Organic Carbon	3

Table 20 shows that the values from CML1992 are in line with the values of the directive on Urban Waste Water Treatment, but —on atomic weight basis— a more complete list of N and P values is given. N and P are calculated on basis of share in atomic weight of the compound (see also par. 3.7).

Furthermore, Table 20 shows that the weighting factors of EcoIndicator95 are not identical but show more or less the same ranking as the EPER 2001 values. That means that human toxicity has played a major role. The most significant difference is for Copper (Cu), where EcoIndicator95 gives a much lower importance than EPER.

Table 21 gives the latest (2005) toxicity factors from CML, Leiden, that take fully into account eco-toxicity to the fresh water and marine compartment, apart from human toxicity. The CML accounting unit is kg 1,4-Dichloroethylene equivalent. The individual scores of MAETP, MSETP and TETP can be found in the MEEUP Project Report.

Table 21. Toxicity Emissions to Fresh Water and Sea Water (Guinée et al., CML, 2002)

		Human Toxicity Fresh Water	Eco-Toxicity Fresh Water			Eco-Toxicity Sea Water		
Water emission	CAS-nr	HTP	FAETP	FSETP	TETP	MAETP	MSETP	TETP
		kg 1,4-DCE eq./kg	kg 1,4-DCE eq./kg	kg 1,4-DCE eq./kg	kg 1,4-DCE eq./kg	kg 1,4-DCE eq./kg	kg 1,4-DCE eq./kg	kg 1,4-DCE eq./kg
2,3,7,8-TCDD	1746-01-6	**860000000**	**170000000**	**560000000**	**590**	**130000**	**430000**	**830**
arsenic	7440-38-2	**950**	**210**	**530**	0.00	0.00	0.00	0.00
benzene	71-43-2	**1800**	**0.091**	**0.07**	0.00	0.00	0.00	0.00
cadmium	22537-48-0	**23**	**1500**	**3900**	0.00	0.00	0.00	0.00
carc. PAHs		**280000**	**28000**	**89000**	0.00	**0.12**	**0.38**	0.0008
chromium III	16056-83-1	**2.1**	**6.9**	**18**	0.00	0.00	0.00	0.00
chromium VI	18540-29-9	**3.4**	**28**	**71**	0.00	0.00	0.00	0.00
copper	15158-11-9	**1.3**	**1200**	**2900**	0.00	0.00	0.00	0.00
lead	14280-50-3	**12**	**9.6**	**25**	0.00	0.00	0.00	0.00
mercury	14302-87-5	**1400**	**1700**	**4400**	**930**	**6.8**	**17**	**7600**
nickel	7440-02-0	**330**	**3200**	**8300**	0.00	0.00	0.00	0.00
zinc	23713-49-7	**0.58**	**92**	**240**	0.00	0.00	0.00	0.00

FAETP=Fresh water Aquatic Ecotoxicity Potential, FSETP= Fresh water Sediment Ecotoxicity Potential, TETP=Terrestrial Ecotoxicity Potential, MAETP and MSETP = FAETP and FSETP but Marine instead of Fresh water; HTP= Human Toxicity Potential

The information from the various sources on heavy metals is not conclusive. What has been said about the state-of-the-art in science in par. 3.11 also goes here. Therefore –taking the legislation as a basis but also looking at the CML data—we have to make an estimate. The table below shows the EPER values and all values are normalized to Ni (Nickel) Equivalent. Normalization on Nickel was chosen in analogy of the air emissions.

Table 22. EPER + MEEUP Weighting Trials

Water emission	EPER reporting weighting 2001	**MEEUP weighting factors Trial 1**	**MEEUP weighting factors Trial 2**
	Ni. Eq.	Ni. Eq.	Hg/20 equivalent
2,3,7,8-TCDD		**200000**	**2666666.7**
arsenic	4.00	**0.2**	**2.7**
benzene	2.00	**0.3**	**4.0**
cadmium	4.00	**0.5**	**6.7**
carc. PAHs	80.00	**50**	**666.7**
chromium III	0.40	**0**	**0.0**
chromium VI		**0.01**	**0.1**
copper	0.40	**0.4**	**5.3**
lead	1.00	**0.01**	**0.1**
mercury	20.00	**1.5**	**20.0**
nickel	1.00	**1**	**13.3**
zinc	0.20	**0.03**	**0.4**

Unfortunately it is exactly Nickel (and Lead/Copper) where the largest differences occur between CML and EPER. E.g. if the nickel: mercury ratio would be also 1:20 with CML, then —except for Cu, Pb and Ni— the EPER values and MEEUP weighting would be more or less in line, taking into account that EPER would round the values. This is shown in the last column, where the unit is not Nickel equivalent but Hg/20 equivalent (‘mercury divided by 20’).

This leaves the question of Cu, Pb and Ni. Without entering into a debate on modelling or ethics (eco- vs. human toxicity) we simply propose to use an approach of "minimizing the error", i.e. taking the average of the two given values.

This leaves the following table of rounded weighting factors for heavy metals

Table 23. MEEUP Weighting Factors for Emissions to Water (final)

Heavy Metals		**Eutrophication**	
Hg/20 eq.		PO4 eq.	
arsenic	3.00	**Nitrogen, total N**	**0.42**
cadmium	**7.00**	Ammonia NO3-	0.1
chromium	0.40	Ammonium, ion NH4+	0.34
copper	2.80	**Phosphorus P**	**3.06**
lead	0.50	Phosphate PO4	1
mercury	**20.00**	Phosphorus pentoxide P2O5	1.34
nickel	7.00	**Chemical Oxygen Demand COD**	**0.05**
zinc	0.20	**Biological Oxygen Demand BOD**	**0.25**
		Suspended Solids	**0.18**
		Dissolved Organic Carbon DOC	0.15
POPs	negligible	Total Organic Carbon TOC	0.15

Substances in bold font are part of legislation in the relative weight shown

3.14 Other

3.14.1 Hazardous Substances

The table in the tender document specifies a subdivision in waste from RoHS and non-RoHS substances. The RoHS substances and their maximum concentration thresholds are given in the table below.

Table 24. RoHS substances and their concentration thresholds

Substance	Concentration Threshold
Lead (Pb)	**0.10%**
Mercury (Hg)	**0.10%**
Hexavalent Chromium (Cr VI)	**0.10%**
PolyBrominated Biphenyls (PBB)	**0.10%**
PolyBrominated Diphenyl Ethers (PBDE)	**0.10%**
Cadmium (Cd) in homogeneous materials	**0.01%**

Source: COM(2004) 606 final, 23.9.2004, Proposal for a COUNCIL DECISION amending Directive 2002/95/EC of the European Parliament and of the Council for the purposes of establishing the maximum concentration values for certain hazardous substances in electrical and electronic equipment.

However, for the purpose of Ecodesign starting 2006 this subdivision in practice no longer exists as RoHS substances are prohibited and there is no information on the post-RoHS situation. The only product groups for which RoHS-substances still play a role, and where we propose to deal with them on an ad-hoc basis, are given in the Annex of the RoHS Directive 2002/95/EC (see box below).

Applications of lead, mercury, cadmium and hexavalent chromium, which are exempted from the requirements of Article 4(1)
1. Mercury in compact fluorescent lamps not exceeding 5 mg per lamp. 2. Mercury in straight fluorescent lamps for general purposes not exceeding: — halophosphate 10 mg — triphosphate with normal lifetime 5 mg — triphosphate with long lifetime 8 mg. 3. Mercury in straight fluorescent lamps for special purposes. 4. Mercury in other lamps not specifically mentioned in this Annex. 5. Lead in glass of cathode ray tubes, electronic components and fluorescent tubes. 6. Lead as an alloying element in steel containing up to 0,35 % lead by weight, aluminium containing up to 0,4 % lead by weight and as a copper alloy containing up to 4 % lead by weight. 7. — Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85 % lead), — lead in solders for servers, storage and storage array systems (exemption granted until 2010), — lead in solders for network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunication, — lead in electronic ceramic parts (e.g. piezo-electronic devices). 8. Cadmium plating except for applications banned under Directive 91/338/EEC (1) amending Directive 76/769/EEC (2) relating to restrictions on the marketing and use of certain dangerous substances and preparations. 9. Hexavalent chromium as an anti-corrosion of the carbon steel cooling system in absorption refrigerators. 10. Within the procedure referred to in Article 7(2), the Commission shall evaluate the applications for: — Deca BDE, — mercury in straight fluorescent lamps for special purposes, — lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunications (with a view to setting a specific time limit for this exemption), and — light bulbs
source: DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment

In this context it is relevant to mention that there are also Non-RoHS substances that in one way or another may have an influence on the environmental impact. For these substances the electronics industry is supplying reference lists that can be found in the ECMA Standard 341, 2nd ed., Dec. 2004, *Environmental design considerations for ICT & CE products (*www.ecma-international.org) and the EIA *Joint Industry Guide for Declaration of Materials Composition of Electronic Products* (www.eia.org).

As an example the ECMA 341, par. 6.7 and 6.8 list is given below (the EIA list is much longer):

6.7.1. General limitations

The product shall not contain (higher concentrations as specified in the sample references):

- Asbestos [EU 76/769/EEC (1999/77/EC)];
- Ozone Depleting Substances: Chlorofluorocarbons (CFC), hydrobromofluorocarbons (HBFC), hydrochlorofluorcarbons (HCFC), Halons, carbontetrachloride, 1,1,1-trichloroethane, bromochloromethane [EU : Regulation (EC) No. 2037/2000, 2038/2000, 2039/2000];
- PCB, PCT, monomethyltetrachlorodiphenylmethane (Ugilec 141), monomethyldichlorodiphenylmethane (Ugilec 121 or 21), monomethyldibromodiphenylmethane (DBBT) [EU 76/769/EEC];
- Mercury — with the exception of discharge lamps that require mercury for proper operation [Netherlands decree on Product Containing Mercury, 1998 Environmentally Hazardous Substances Act);
- PCN, TPT, TBT, TBTO [Japanese Law No.117 of Oct.16, Year-Showa-48 (1973) – Chemical Substance Control Law];
- DBB [EU 76/769/EEC];
- PentaBDE, OctaBDE [EU 76/769/EEC (2003/11/EC)];

From July 2006: Lead, cadmium, mercury, hexavalent chromium, PBB, PBDE as defined in Directive 2002/95/EC (commonly named RoHS directive) including a detailed list of exemptions. The latter will be updated by the EU commission and reviewed every 4 years

6.7.2 Limitations on plastic mechanical parts and housings

In addition to the limitation of 6.7.1, plastic parts shall not contain:

- Cadmium or cadmium compounds [EU 76/769/EEC (91/338/EEC)];

- Short chain chloroparaffins [Dutch decree 478 3.11.1999, Norwegian regulation relating to restrictions on the use of certain dangerous chemicals 20.12.2002];
- Lead or lead compounds [Danish Statutory Order No. 1012 of 13 November 2000 on Prohibition of Import and Marketing of Products Containing Lead].

6.7.3 Limitations on paints, coatings or colouring agents

Paints, coatings or colouring agents shall not contain:

- Cadmium or cadmium compounds [EU 76/769/EEC];
- Lead or lead compounds [Danish Statutory Order No. 1012 of 13 November 2000 on Prohibition of Import and Marketing of Products Containing Lead].

6.7.4 Others

- Regulations concerning textiles and leather with direct skin contact:
  - TRIS, TEPA [EU 76/769/EEC];
  - AZO colorants that split aromatic amines specified in [EU 76/769/EEC (2003/3/EC)];
  - Hexavalent chromium [German Food and Commodities Law (LMBG)].
- Regulations concerning wood:
  - Arsenic as a wood preservation treatment [EU 76/769/EEC (2003/2/EC)];
  - Mercury for preservation of wood [EU 76/769/EEC];
  - Pentachlorophenol and derivatives [EU 76/769/EEC].
- Benzene in toys [EU 76/769/EEC];
- Nickel for articles coming into direct and prolonged contact with skin [EU 76/769/EEC].

6.8 Product Packaging

Packaging material selection has an impact on the environment. When specifying materials, the designer should choose design alternatives that:

- reduce the variety of materials used;
- reduce the amount of material used and consequently the weight and size of the package;
- use materials that are considered to have lower environmental impact;
- use recycled materials;
- use renewable materials.

As a minimum requirement the designer shall ensure compliance to international, regional and national regulations, concerning:

a) restrictions on hazardous substances and preparations such as defined in the EU Directive 94/62/EEC (requiring that the sum of the concentrations of lead, cadmium, mercury, chromium-VI does not exceed 100 ppm by weight);

b) recyclability such as reuse, material recovery, energy recovery or organic recovery.

In addition the designer should ensure appropriate marking (material content) of packaging materials (e.g. according to ISO 11469).

NOTE For products placed on the market in the European Union, essential requirements of the 94/62/EC directive shall be applied (e.g. by applying standard EN 13427).

Similar lists exist in other industry sectors, see e.g. the Restricted Materials List 2004 from Electrolux as an example.

3.14.2 Land-use

Land Use for mining of metal ores is an important environmental parameter. However, it is not (yet) active part of EU policy. The main reason is of course that the EU hardly has mines in its territory. The non-hazardous solid waste quantity is a good indicator [col 7] as it includes both rock and ore waste. Land Use could also be an important parameter for bioplastics and biofuels. For relevant products, i.e. where this constitutes a significant quantity, this should be investigated on an ad-hoc basis.

3.14.3 Product specific emissions

As mentioned in the introduction the quantitative part of the methodology is looking at emissions and resources that occur over a wide range (more than one) of different product groups. This makes sense, because the methodology is supposed to discriminate between the environmental impact of different product groups. However, certain emissions are specific for just one product group, for instance ozone emissions of certain types of imaging equipment or radiation from certain types of televisions/monitors.

Furthermore, the aspect of noise is incorporated in EU legislation for only certain products/appliances. For practical reasons it is proposed to include those specific emissions, if there is a legislative basis, on an ad-hoc basis as a single design issue. Although in principle, according to the Ecodesign of EuP Directive these single design issues should be taken into account over the complete life-cycle, they will in practice mostly relate to the use phase.

3.15 Summary and Normalisation Options

The table below summarizes the weighting factors :

Table 25. Summary MEEUP weighting factors

GHG emissions (air)	CO_2	CO	N_2O	CH_4	CF_4	C_2F_6	SF_6	R134a	other
weighting → CO_2 eq. GWP-100	**1**	**1.57**	**296**	**21**	**6500**	**9200**	**22200**	**1300**	**IPCC**

Acidification emissions (air)	SO_X	NO_X	N_2O	NH_3	HF	HCl	H_2S	H_2SO_4
AP weighting → SO_2 equivalent	**1**	**0.7**	**1.78**	**1.88**	**1.6**	**0.88**	**1.88**	**0.65**

Heavy Metals (air)	Cd	Hg	As	HMU	Ni	Cr	Cu	Pb	Zn	MU
HM weighting -> Ni eq.	**5**	**5**	**3.33**	**2**	**1**	**0.5**	**0.5**	**0.04**	**0.04**	**0.01**

PAHs (air)	PAHs	C6H6	CO
HM weighting -> Ni eq.	**20**	**0.004**	**0.000002**

MU= Metals Unspecified
HMU= Heavy Metals Unspecified. *=preliminary factors

Heavy Metals (water)	Hg	Cd	Ni*	As	HMU	Cu*	Pb*	Cr	Zn
HM Weighting factor → Hg/20 eq.	**20**	**7**	**7**	**3**	**3**	**2.8**	**0.5**	**0.4**	**0.2**

Eutrophication (water)	P	P_2O_5	PO_4	N	NH_4+	NO_3-	BOD	Suspended Solids	DOC	TOC	COD
EP weighting → PO_4 equivalent	**3.07**	**1.34**	**1**	**0.42**	**0.33**	**0.1**	**0.11**	**0.08**	**0.066**	**0.066**	**0.05**

EC Directives and official EU references with threshold and conversion values from which the weighting factors are derived: *IPCC* (GWP), *EC 850/2004* (POP), *2001/81/EC* (SO_x, NO_x, NH_3, VOC), *1999/30/EC* (SO_2, NO_x, PM and Pb), *2000/69/EC* (aromatics, CO), *COM(2003)423* (As, Cd, Hg, Ni, PAHs), *1999/13/EC* & 2002/3/EC (VOC), *EC 2037/2000* (ODP), *91/271/EC & 98/15/EEC* (BOD, COD, P, N, susp. Solids to water), *76/464/EEC* (Metals etc. to water).

The equivalence factors are in relatively familiar units per category. They can only be used 'horizontally', i.e. to make comparisons between the environmental impact of products per category. As the categories are linked to EU environmental policy areas this would give the EU Commission —after proper consultation with the stakeholders and the Consultation Forum (Art. 14 of directive)— a good relative indication whether a product has a "significant environmental impact" (Art. 12 of directive) in a certain policy area. And this can be enough to make products eligible for measures in those policy areas, especially when it is measured against absolute benchmarks regarding e.g. the total amount of emissions in each category or the distance-to-target.

The equivalence factors cannot be used 'vertically', i.e. to sum between categories. In other words, they do not provide a quantification of the "overall" environmental impact. As mentioned, this is not needed to find a product eligible for measures under the directive and could also be solved in a more qualitative way, e.g. by assessing whether a product is within the top-ten of X categories[56].

Having said that, several reviewers from LCA-experts and industry have indicated (see MEEUP Project Report) that some guidance regarding the weighting or normalisation between categories would be very useful for Ecodesign in practice. Or even, even if the methodology would not provide this guidance, decision makers themselves would simply sum up the data 'as is' to arrive at an ad-hoc single value indicator of the environmental impact.

In that sense, although it is outside the strict scope of our assignment and our prime target audience of policy makers, we have provided some guidance and an illustration of how summing between the categories could be shaped. See MEEUP Project Report.

Please note that for the intent and purpose of the underlying study we are <u>not</u> proposing to use a single or double value evaluation, because it will necessarily contain a degree of subjectivity that goes beyond the more robust legal basis that we have chosen for the single categories. Should one want to go down this route, further study and consultation is recommended.

[56] Compare EIPRO study; compare also study by Te Riele 2004 that are both implying this type of evaluation.

4 ENVIRONMENTAL ANALYSIS: DATA RETRIEVAL

4.1 Introduction

This chapter makes an inventory of data required (par. 4.2), potentially available data sources (par. 4.3) and outlines methodological problems when retrieving and interpreting product-specific data for the use phase (par. 4.4). The non product-specific data –the so-called Unit Indicators—are not part of this chapter, but are discussed in Chapter 5.

4.2 Data Required

The Environmental Analysis in the context of this study requires the following data:

For the Selected Products (LCI design, EU average values):

1. Bill of Materials (BOM) and manufacturing processes for the Selected Products;
2. Performance (‘functional unit’, including product life), consumption (energy, water, paper, detergent) and emission (e.g. SO2, NOx, etc. from heating. ozone during copying, etc.) characteristics during the use phase of the Selected Products, preferably according to standardised test procedures and duty cycles;
3. Distribution characteristics (product volume/weight, avg. distance, transport mix);
4. End-of-Life (EoL) characteristics (fractions to landfill, incineration, recycling, etc.).

For relevant Unit Processes (LCI unit processes, EU average values):

5. Emission- and consumption data from extraction to the gate of the EuP-industry, per technical unit (kg, m^2 , tonne.km, m^3.km, etc.) per engineering material or manufacturing technology;
6. Emission- and consumption data for distribution per unit of product weight or volume, per kilometre and per means of transport (e.g. light truck m^3.km);
7. Emission- and consumption data of resources used during product life, e.g. per kWh electricity, kg of paper, per g detergent, etc.;
8. Emission- and consumption data of recycling and waste disposal processes, e.g. per tonne processed.

For weighting factors to arrive at ‘impact categories’ (LCIA information, EU average values):

9. Weighting factors to translate emissions of substances into the categories as specified by the Commission: greenhouse gases, acidifying agents, heavy metals, POPs, VOCs, etc.

For a yardstick to determine which Selected Products are ‘environmentally relevant’ (interpretation step):

10. Total EU emission and consumption data per category of emissions and consumption data for the most recent year. If e.g. a product contributes more than X % to the total of one or more ‘impact categories’ mentioned above, this could become an eligibility criterion. If available, total target EU emission and consumption data from EU legislation/ policy per category of emissions and consumption data for a target year. E.g. if the distance between target value and present value is high (‘distance-to-target’ approach), this could be a criterion to prioritize impact categories.

The weighting factors (nr. 9 above) were discussed in Chapter 3, as was the End-of-Life methodology. The Unit Processes (nr. 5 to 8) are discussed in Chapter 5. The total emission and consumption data (nr. 10 above) can only be established after the Market Analysis. Points 1, 2 and 4 are largely self-evident and will not be further explained; point 3 (use phase) raises some methodological questions, which will be addressed in paragraph 4.4.

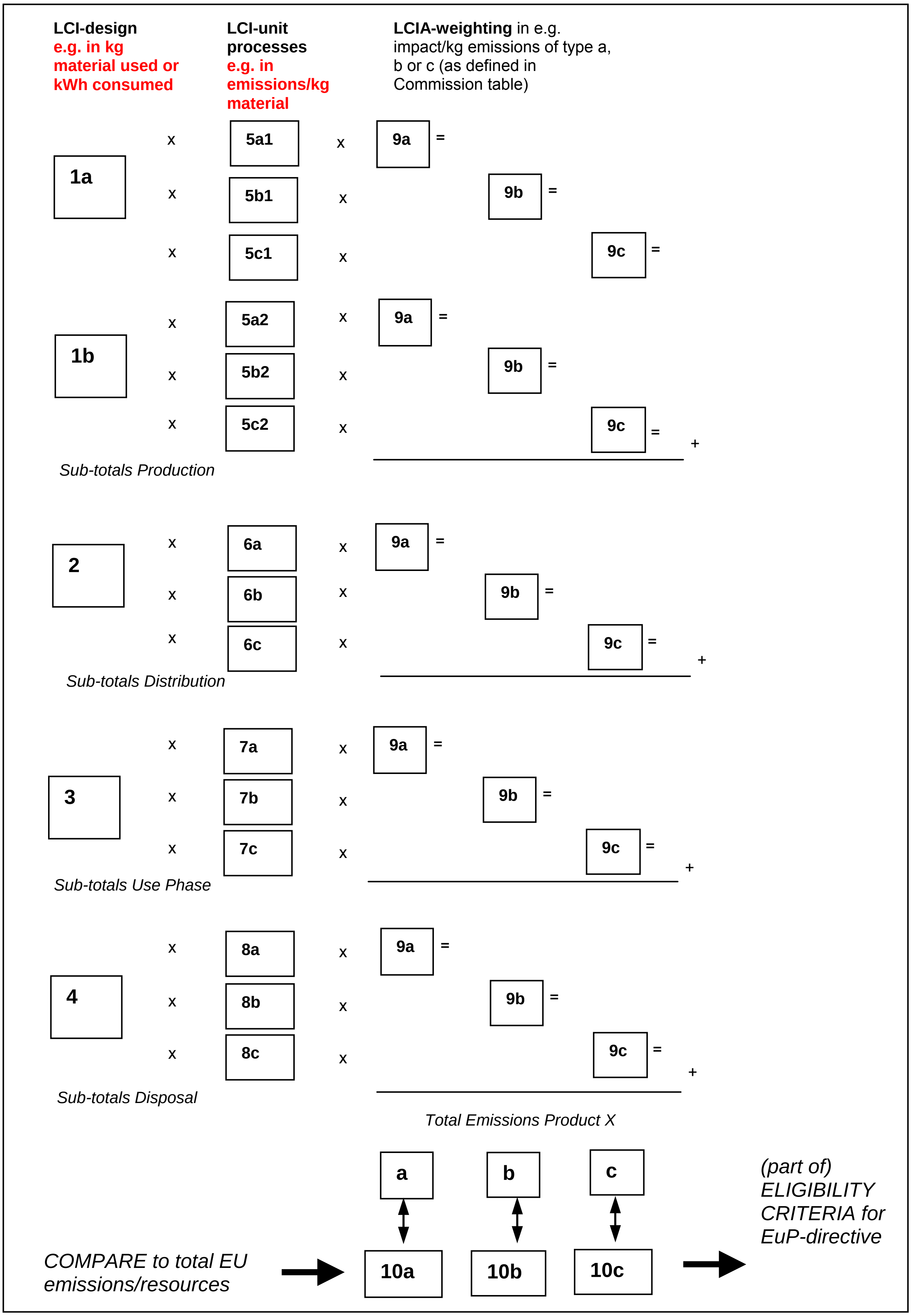


Figure 7. Environmental analysis data structure

4.3 Data Sources Available

For the Environmental Analysis of EuP a number of data sources can be distinguished:

- **Full LCA tools** (SimaPro 6, Gabi 4, etc.), databases (EcoInvent 2003, Idemat 2001, BUWAL-250, Gabi 4, etc.) and weighting methodologies (Eco-Indicator 99, CML 2000, EDIP '97, etc.);
- **Simplified LCA** tools, like Eco-It and EcoScan (single parameter design tools based on Eco-Indicator 99), KEPI (Key Environmental Performance Indicators), EIME, QFED and/or LIME (Japanese eco-design tool), etc.;
- **Legislation** and background reports from EU environmental and energy-related legislation. Especially the IPPC BREFs and SAVE studies preparing for Energy Labels are important primary data sources for emissions and consumption. Air- and Water Quality directives (incl. daughter directives), Waste directives, WEEE, ROHS, etc. and related documents give information on total EU emissions and threshold values, which can be used for weighting;
- **Industry associations** supplying emission and consumption data, like APME, IISI, EuroCopper, Eurelectric, etc. for production. EICTA, CECED, EHA, Eurelectric etc. for consumption;
- **Other literature sources**, preparatory studies for voluntary labelling (EU Ecolabel, Blue Angel and Nordic Swan), product-LCA studies, etc.;
- **Physical VHK product-analysis**, disassembling products to determine the 'BOM'(Bill-of-Materials);
- **Experts ,** both inside and outside the EuP stakeholder expert group.

Benefits and drawbacks of the sources are discussed hereafter.

4.3.1 Full LCA

Advantages of the Full LCA Tools are:

- Relatively easy handling of a large number of data;
- Enables comparison/choice LCIA methods and also sometimes of several LCI databases to work with;
- Large number of emission data (e.g. > 6000 unit processes);
- Complete set of potential in- and outputs (>700) per unit process;
- Given the two points above, suited in a policy context to study the impact and reach of new legislation regarding specific (as yet unregulated) substances. Also in a company context well suited in an integral environmental management and audit scheme to compare e.g. external LCI data with company-specific data;
- Transparent calculation from emissions to impact category and/or single environmental indicators;
- Attractive output in flow-diagrams and limited number of impact categories. Good interface with common data formats (CSV, XLS).

In short, there is nothing wrong with the software tools, but the problem lies more with the databases and LCIA weighting. Disadvantages for our purpose are:

- There is a wide discrepancy between emission data for one material or process between the various database sources. Several initiatives are underway to deal with this (e.g. SETAC/UNEP Life Cycle Initiative, European Platform on LCA by DG JRC-IES), but no homogenous average EU database exists.

As an example of the discrepancy, Table 26 gives an overview of available emission data for pig iron and liquid steel;

- Documentation regarding the origin of emission data and their validity (for which region? for which process? why are they different from the rest?) is often not clear from the tool alone and would require extensive additional research to explain the differences Also data on emission- and consumption-data that constitute an average for the EU or globally seem to be scarce. It would again require additional research to aggregate the data given into the required EU or global averages. In short, it is a specialist tool requiring an appropriate training and background that does not lead directly to single and conclusive EU figures on emissions and resources use;
- Public availability of data is limited. A few basic educational tools and databases are public[57], but practically all professional Full LCA tools are commercial products. Some vendors follow a more 'open' strategy in this respect and therefore some parts of their data can be found in policy studies[58], but for most vendors the data is a valuable asset and therefore not publicly available.
- Prices and training effort constitute a significant investment, especially for SMEs.[59]

All these factors make the use of Full LCA databases problematic in the underlying study, which is public domain and aiming at political transparency and consensus-building with stakeholders. This conclusion relates only to the underlying study and is no judgement on the usefulness of Full LCA tools for research purposes at company and institute level in general. In fact, VHK is a licensee of a full LCA tool that allows to compare LCI data from different sources, but this is primarily used indirectly, i.e. to check data from other sources.

The table below illustrates the discrepancies, comparing the average emissions to air per kg liquid steel (BREF & IISI data, in bold) or pig iron ("Fe") from various databases and the BREFs for the IPPC-directive.[60]

Table 26. Iron & steel, sel. emissions to air per kg liquid oxysteel/pig iron, misc. sources (source SIMAPro 6)

Substance	*unit per kg liquid product*	BREF IPPC, *St*	Ecoinvent converter steel	Ecoinvent (at plant), electric steel	ETH-ESU 96, Fe	Idemat, Fe	vd Bergh & Jurgens, Fe
Carbon dioxide	*kg*	**1.6**	1.001	1.046	1.81	1.07	0.96
Carbon monoxide	*g*	**32.37**	31.3	3.9	24.60	22.60	17.60
Chromium	*µg*	**240**	327	1489	274.00	65.00	3.37
Dioxins*	*mg/I-TEQ*	**3.09**	0.00680	0.00472	0.0046	1.3E-06	9.82E-07
NMVOC	*mg*	**90**	0.410	0.680	1330.00	11.80	14.20
Lead	*mg*	**4.66**	4.250	2.320	4.20	7.01	0.01
Nickel	*mg*	**0.03**	0.646	1.299	11.30	0.03	0.03
NO_x	*g*	**1.8**	2.507	3.360	2.92	6.93	2.45
PAH	*µg*	**250**	507	411	390.00	4.09	0.92
Dust (PM10)	*g*	**390**	4.279	0.838	12.40	0.06	9.41
Sulfur dioxide	*g*	**1.63**	2.813	3.517	4.97	6.21	3.25

**= measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin*

[57] E.g. part of Idemat 2001 and CML data-tools is on-line accessible, but there are several limitations to the use of these editions e.g. in an industrial context.

[58] E.g. policy studies by BIO extensively use SimaPro data.

[59] Prices are currently in the range of 3000 Euro and upwards. SMEs= Small and Medium-sized Enterprises.

[60] The BREF reference documents describe present and best available technologies for several installations. They are a mandatory input to national legislation on emission limit values for these installations. BREFs will be discussed in full later on in this report.

Similarly, the diagram below shows the range in emission values for HDPE, using Eco-indicator ’99 The table and figure show an extremely wide range of values from various authoritative and highly respected databases. Supposedly there are good reasons for the discrepancies, but it is outside the scope of this study to try to retrieve these reasons for each emission value and each material, especially if there is an alternative that takes more into account the policy context in which we have to develop the methodology (IPPC-BREFs, legislative and industry data).

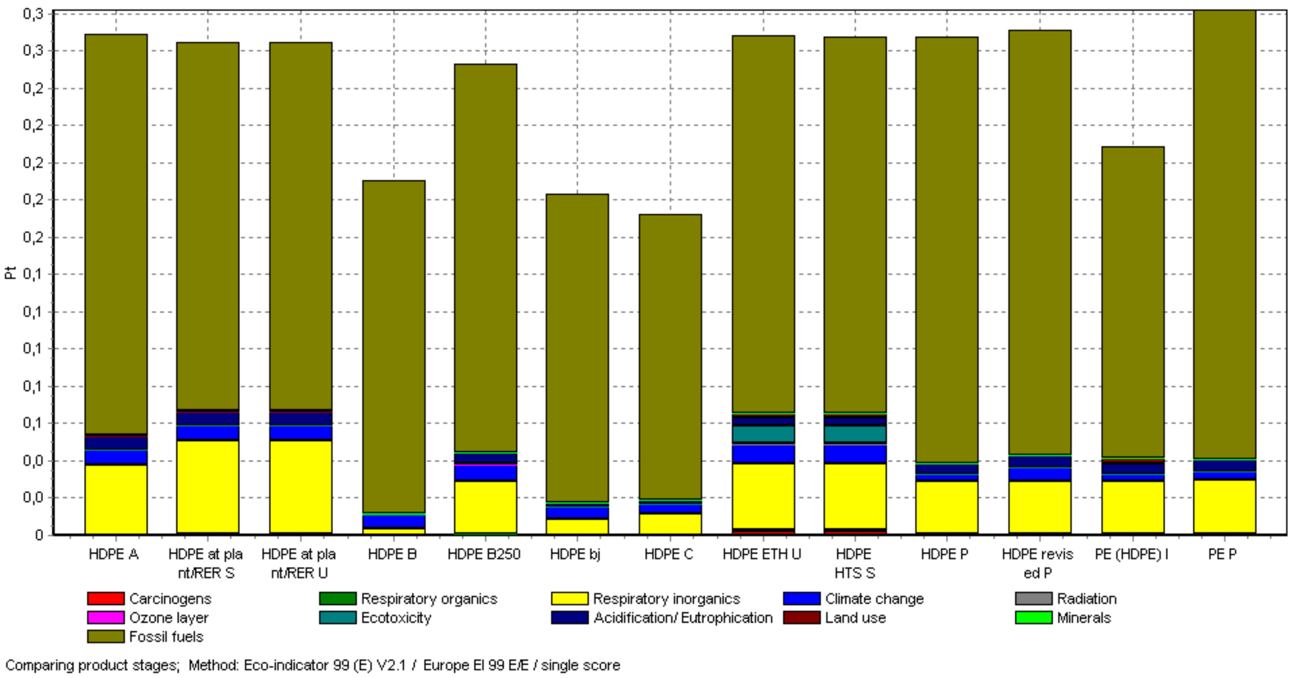


Figure 8. HDPE emission and consumption values compared of various sources using the Eco-indicator ’99 LCIA weighting factors.

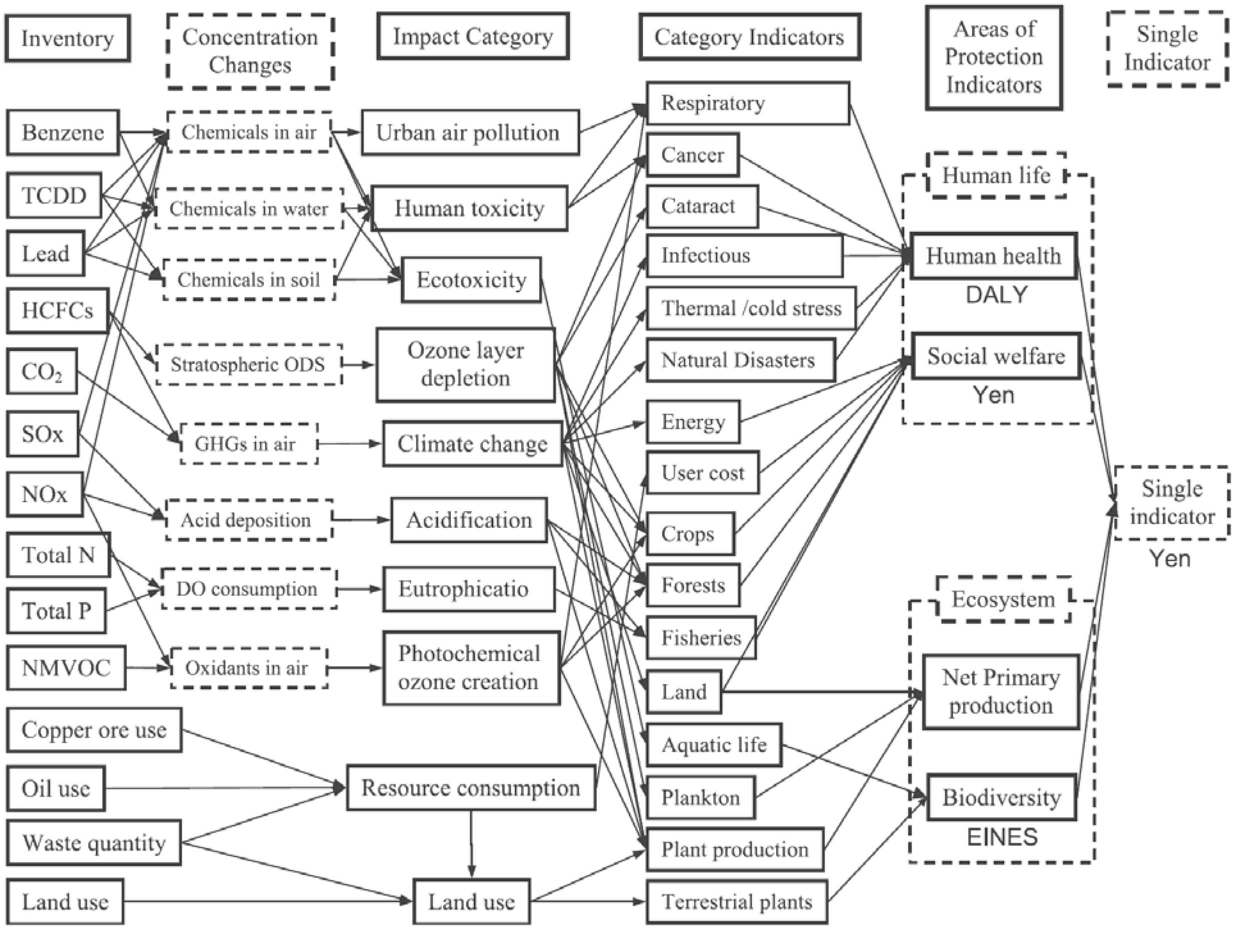
Please note that, while the total impact values range stays within a limited bandwidth of 60% (max. vs. min), the values of individual categories can vary a factor 10 or more.

The range of values found in the LCIA-weighing factors is narrower than with LCI Unit Process data discussed above. This is especially true for impact categories where there are already authoritative sources. Nevertheless, differences of up to a factor 10 or more for single emissions are not unusual. Again, a broad discussion of the merits and drawbacks of each of the LCIA-methods is outside the scope of this study. Therefore, we will not select any particular method, but will select the LCIA-values on the basis of what is used in the EU legislation, discussed in Chapter 3 and further on in this chapter.

4.3.2 Simplified LCA

In answer to specific drawbacks of the Full LCA-tools, simplified LCA-tools were developed with a limited dataset for input and one or only a few environmental indicators as output. Many of these are used by large EuP-manufacturers (e.g. Eco-Scan by Philips, EIME by Alcatel, etc.) , who also add proprietary data to the tool. These tools are clearly more geared towards the use by design engineers and prices/ training effort are more accessible, also for SMEs[61].

Figure 9. Pennington et al. 2004, based on Japanese national method 'LIME', Itsubo and Inaba, 2003.



Disadvantages are of course, that they are still commercial products and data is not publicly available. The origin of the emission data and the assumptions are even less clear than with a full LCA. And finally, in the whole process of attributing emissions to ultimately one single parameter, there are many choices on which there is no broad consensus (to say the least). The diagram above gives an example of the complexity and the sequence of weighing factors involved in arriving at a single, in this case monetary, parameter.

[61] Typically € 1000,- for the software and little training required.

4.3.3 Legislation

The background reports prepared for EU environmental and energy-related legislation as well as the legislation itself are very valuable sources of information and used in the underlying study as the preferred information source:

- Not only are these documents publicly available, but they are also based on a consultation and —mostly— consensus with the stakeholders (NGOs, industry, etc.). From a political viewpoint they are therefore the ideal source;
- The same goes for the legislative viewpoint: The use of quantitative material from existing legislation and background reports underpinning this legislation leads to a coherent and consistent framework;
- Most reports and legislation are very recent, e.g. issued in the 2000-2004 period, and more often than not the directives incorporate explicit measures to keep the information up-to-date;
- The quality of the research is usually very high. Working groups consist of 10 to 50 experts from industry, NGOs, universities and private researchers, working together over a period of 2 up to 4 years to produce extensive reports. This is particularly true of the adequately funded research for mandatory measures, like e.g. the BREFs[62] for the IPPC directive, the SAVE[63] reports for the mandatory Energy Label directive, Position Papers for the Ambient Air Quality and Water Directives, etc.

Having said that, there are also some disadvantages:

- The work does not completely cover the scope of the underlying study. For instance, the IPPC directive covers large installations in the EU; e.g. emissions and resources consumption outside the EU-territory, like mining activities, are not covered. The same goes for many manufacturing processes in the EuP industry, which have not been identified by the legislator as being very environmentally relevant. Also the SAVE studies do not cover the complete spectrum of products and will have to be supplemented by other sources e.g. on office equipment and consumer electronics;
- Much documentation describes emissions from processes. This implies that the data in the legislation and the underlying documents are often expressed in terms of emission limit values (ELV) per m³ of effluent gases or wastewater stream e.g. for a steel plant. This is an inappropriate format for Eco-design: For the environmental analysis of products, emission values need to be expressed e.g. per tonne steel output. This requires a mass-flow calculation, which —at least for some materials— is not always given.

The table below gives an overview of the relevant EU legislation that interfaces with the EuP directive and gives an indication of the type of quantitative data we expect to retrieve.

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[62] Best Available Technology (*BAT*) REFerence documents

[63] SAVE I and II were the predecessors of the Energy Intelligent Europe programme

Table 27. Sources for quantitative data from EU legislation & preparatory studies

EC 2037/2000 29.6.2000	REGULATION..on substances that **deplete the ozone layer** *[Montreal]*	HCFC to be phased out, rest is banned (ODP given as CFC11-equivalent)
EC 850/2004 850/2004	REGULATION..on **persistent organic pollutants** and amending Directive 79/119/EEC *[Stockholm]*	PCB, dioxin, furans, threshold values + totals
2001/81/EC (2001)	DIRECTIVE..on national emission ceilings for certain atmospheric pollutants *[**Gothenburg**/UNECE]*	NO_x, SO_2, VOC, NH_3 totals
96/62/EG (1996)	**Air Quality** framework directive, (draft) daughter directives are 1999/30/EC, 2000/69/EC, COM(2003)423, 2001/81/EG,	
1999/30/EC 22.4.1999	DIRECTIVE..relating to limit values for **sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead** in ambient air	thresholds SO_2, NO_x, PM10, Pb to Air
2000/69/EC 16.11.2000	DIRECTIVE..relating to limit values for **benzene and carbon monoxide** in ambient air	thresholds CO, benzene
2002/3/EC 12.2.2002	DIRECTIVE...relating to **ozone in ambient air**	identifying VOCs, NO, NO_x
COM(2003) 423 16.7.2003	proposed DIRECTIVE..relating to **arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons** in ambient air	thresholds As, Cd, Hg, Ni and PAHs
1999/13/EC 11.3.1999	DIRECTIVE..on the limitation of emissions of volatile organic compounds due to the use of **organic solvents** in certain activities and installations	VOCs in cleaning, wet coating; relevant in EuP manufacture (e.g. windings motor)
IMPEL	Status Report on fugitive emissions of **volatile organic compounds**	VOC (fugitive) emissions to air
96/61/EC 24.9.1996	DIRECTIVE concerning integrated pollution prevention and control (**IPPC**, including **EPER** database and BREFs)	BAT-reference docs (BREF) emissions on Iron & Steel, non-ferro metals, chemicals, polymers, surface treatment, waste incineration, etc.
2000/60/EC (2000)	**Water Quality** framework directive	threshold values
76/464/EEC 4 May 1976	framework DIRECTIVE. on pollution caused by certain **dangerous substances discharged into the aquatic environment** of the Community *[including 18 list I substances and 114 list II substances, including daughter directives on Cd, Hg, hexachlorocyclohexane, others]*	heavy metals, P, misc. pesticides, etc.
91/271/EC 21.5.1991	DIRECTIVE ..on **urban waste water treatment**	biochemical and chemical oxygen demand (BOD, COD), suspended solids, P, N in Water, threshold values
98/15/EEC 27.2.1998	COM.DIRECTIVE amending DIRECTIVE 91/271 on **urban waste water treatment**	thresholds P, N in Water (eutroph.)
2001/80/EC 23.10.2001	DIRECTIVE..on the limitation of emissions of certain pollutants into air from large combustion plants (**LCP**)	thresholds energy industry SO_2/ kWh_e, NO_x / kWh_e, etc
RRM	Renewable Raw Materials (from crops), policy in preparation by DG ENTR	bio plastics, bio fuels, etc.
ECCP (2001-'03)	Comm. Report on European Climate Change Programme (**ECCP**), 2nd report, Can we meet our Kyoto targets?, April 2003	total EU CO_2 emissions in EuP-use (incl. Studies)
COM(2002) 485 4.9.2002	proposal for REGULATION... on **detergents**	esp. surfactants
2000/55/EC 18.9.2000	DIRECTIVE ...on energy efficiency requirements for **ballasts** for fluorescent lighting	energy efficiency of ballasts
96/57/EC 3.9.1996	DIRECTIVE ... on energy efficiency requirements for household electric **refrigerators**, freezers and combinations thereof, (OJ, L 236 , 18/09/1996 P. 0036 - 0043)	minimum energy efficiency refrigerator (to be updated)
92/42/EEC 21.5.1992	DIRECTIVE... on efficiency requirements for new hot-water **boilers** fired with liquid or gaseous fuels (OJ, L 167 , 22/06/1992 P. 0017 - 0028)	minimum energy efficiency gas- and oil boilers (to be updated, preparatory SAVE studies 2001)
2001/77/EC 27.9.2001	DIRECTIVE ..on the promotion of electricity produced from renewable energy sources (**RES-E**) in the internal electricity market	influences emission values electricity
92/75/EEC 22.9.1992	DIRECTIVE…on the indication by **labelling** and standard product information of the consumption of energy and other resources by household appliances	framework directive for mandatory Energy Labelling (see Commission Directives below), of the product list only water heaters need to be implemented (CEN mandate underway, preparatory SAVE studies 2001)
2003/66/EC 3.7.2003	COMMISSION DIRECTIVE.. amending Directive 94/2/EC implementing Council Directive 92/75/EEC with regard to energy labelling of household electric **refrigerators**, freezers and their combinations (Official Journal L170 of 09.07.2003, p. 10-13)	energy classes refrigerators (incl. Preparatory SAVE studies)
2002/31/EC 22.3.2002	COMMISSION DIRECTIVE...with regard to energy labelling of household **air-conditioners**	energy classes Room Air Conditioners (incl. Preparatory SAVE study)
2002/40/EC 8.5.2002	COMMISSION DIRECTIVE... with regard to energy labelling of household **electric ovens**	energy classes ovens (incl. Preparatory SAVE study)

98/11/EC 27.1.1998	COMMISSION DIRECTIVE.. With regard to energy labelling of household **lamps** (Official Journal L 071 , 10/03/1998 p. 1-8	energy classes lamps (incl. Preparatory SAVE studies)
97/17/EC 16.4.1997	COMMISSION DIRECTIVE.. with regard to energy labelling of household **dishwashers** (Official Journal L 118 , 07/05/1997 p. 1-25)	energy classes dishwashers (incl. Preparatory SAVE studies)
96/60/EC 19.9.1996	COMMISSION DIRECTIVE.. with regard to energy labelling of household combined **washer-driers** (Official Journal L 266 , 18/10/1996 p. 1-27)	energy classes washer driers (incl. Preparatory SAVE studies)
95/13/EC 23.5.1995	COMMISSION DIRECTIVE.. with regard to energy labelling of household electric **tumble driers**, (Official Journal L 136 , 21/06/1995 p. 28-51)	energy classes tumble driers (incl. Preparatory SAVE studies)
95/12/EC 23.5.1995	COMMISSION DIRECTIVE...with regard to energy labelling of household **washing machines** (OJ L 136, 21.6.1995, p. 1)	energy classes of washing machines (incl. Preparatory SAVE studies)
2003/269/EC 8.4.2003	COUNCIL DECISION....concerning the conclusion on behalf of the Community of the Agreement between the Government of the United States of America and the European Community on the coordination of energy-efficient labelling programmes for office equipment (**Energy Star**)	energy efficiency office equipment (incl. Agreement text and past/present future criteria)
2004/8/EC	DIRECTIVE... on the promotion of **cogeneration** based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC (OJEU L 52 of 21. February 2004)	relevant for CH-boilers, micro-CHP (incl. Preparatory SAVE studies)
2002/91/EC 18.12.2002	Directive of the European Parliament and of the Council of 16th December 2002 on the energy performance of **buildings** (OJ L1, 4.1.2003, p. 65-70)	relevant for CH-boilers, ventilation, etc. (incl. Preparatory studies)
EC/1980/2000 17.7.2000	REGULATION (EC) on a revised Community **eco-label** award scheme	implementing COMMISSION DECISIONS on voluntary ecolabelling of certain EuP: fridge, washer, dishwasher, TV, PC, notebook. Also on printing paper and detergents (relevant for copier, resp. dishwasher)
COM(2003) 492 11.8.2003	proposed REGULATION…on certain **fluorinated greenhouse gases**	totals on HFC, PFC, SF6
COCs	Codes of Conduct on external power supplies, on digital TV services, etc. Motor Challenge	studies etc.
VA s	Voluntary agreements of industry on fridges, dishwashers (CECED), standby TV (EICTA), detergents (AISE COC)	energy efficiency and other resources use
2002/95/EC 2002	DIRECTIVE.. on restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS →Pb, Hg, Cd, Cr 6, PBB, PBDE)	ban Pb, Hg, Cd, Cr 6, PBB, PBDE + exceptions (lamps, CRT, etc.)
COM(2003)723 21.11.2003	proposed DIRECTIVE..on batteries and accumulators and spent batteries and accumulators	ban on Hg (button cells), min. recycling rates 65, 75, 55% resp. for Pb, Ni-Cd and other batteries
2004/12/EC 11.2.2004	DIRECTIVE..on packaging and packaging waste	50% recovery/25% recycled now (2008: 60%)
2000/76/EEC 4.12.2000	DIRECTIVE..on the incineration of waste	threshold values for ELVs of non-hazardous and hazardous waste incineration
2002/96/EC 27.1.2003	DIRECTIVE…on waste electrical and electronic equipment (WEEE)	minimum recycling and recovery rates for EEE
IPP	Green Paper and follow up studies (EIPRO, Nokia cell phone, BIO/O2, Institut Wallon, etc.)	LCA information

4.3.4 Industry associations

The eldest and most well-known example of industry associations publishing the environmental profile is the association of plastics manufacturers PlasticsEurope (former APME), which has hired Boustead to collect and process environmental data of plastics and their preceding products (monomers, chemicals, refineries, etc.). Although the profiles of some materials go some years back, they are well-documented and based of a representative sample of plants in the EU. Not surprisingly therefore, the IPPC BREFs for polymers and their preceding products in the chemical industry are based almost entirely on PlasticsEurope data as regards the present situation in the EU.

In recent years, also other industry associations, e.g. in the metals industry, have started to make environmental data of their materials public. Apart from the interest in self-promotion, the obligation of the sector to collaborate with the European Commission in producing BREFs for IPPC will have had something to do with this. In our quest for objective and un-biased data this industry consensus may also be a disadvantage. For that reason —in case data were used directly— we used the Full LCA databases and other sources to check for consistency and compatibility. The table below gives an overview of industry associations providing data:

Table 28. Indicative, nonexhaustive list of LCI data collected and published by industry associations [source: Rebitzer et al., 2004]

Database 'name' (if any) or designation	Geographical scope	Managed by	'Format'	Further information
Ecobalances of the European plastic industry	Europe	PlasticsEurope (former APME)	text format	(former http://www.apme.org) http://www.plasticseurope.org
Environmental profile report for the European aluminium industry	Europe	European Aluminium Association	hardcopy	http://www.aluminium.org
FEFCO European database for corrugated board—life cycle studies	Europe	FEFCO	hardcopy or 'Spold'	http://www.fefco.org
Life cycle assessment of nickel products	International	Nickel Development Institute	text format	http://www.nidi.org
LCA of the steel industry	International	IISI	hardcopy	http://www.worldsteel.org/env_lca.php

Apart from emission- and consumption data regarding production, the industry associations also supply data regarding products during product life. E.g. CECED and EICTA are reporting on the progress in energy efficiency of certain products for which there are voluntary agreements. Individual manufacturers are reporting using Environmental Product Declarations (e.g. refrigerators, copiers, CH pumps)

Finally, also in the field of LCIA weighting factors various industry associations and industries make a contribution. Several associations are proposing voluntary measures on a reduced use of non-ROHS 'substances of environmental concern', like the EIA list. A similar list is used by whitegoods-manufacturer Electrolux.

4.3.5 Other sources

Outside the EU legislation and the industry associations, there is a host of other literature sources in the public domain, revealing valuable LCA data. Although most product-LCAs are not public, there are still quite a few that are published because they were part of pilot projects in the field of eco-design. In the Netherlands, for instance, there have been pilot projects in the context of the NOH-programme, the Eco-design pilot, the PROMISE project, etc., that supply Bills-of-Materials and other valuable design-related LCA data. Likewise, in the context of eco-labelling (e.g. Blue Angel, EU Ecolabel) there have been studies revealing LCI-design parameters. In the underlying study, we are building on outcomes of Blue Angel for e.g. copiers and CH pumps as well as on the outcomes of EU Ecolabel studies on TVs and PCs.

The disadvantage of many of these product-LCAs is very often that it is not clear to what extent they are representative of an average EU product. In the context of the underlying study this aspect —which definitely very important in the context of the methodology— is not a high priority, but it would be helpful.

For that reason VHK is fully transparent regarding the Bills-of-Materials (BOM) that are being used, e.g. on the www.eupproject.org project website, and the BOMs obtained from stakeholder experts were published with the Product Cases so that they can be verified/updated/expanded in the preparatory studies that are to follow the underlying methodology study

4.3.6 Physical product analysis

In case no detailed BOM of a recent product was available, VHK has decided that it was more efficient to make a product analysis of some sample products to arrive at a BOM.[64] This was the case for dishwashers, copiers, room air conditioners and PCs. In those cases we disassembled the products into their main components, determined/estimated the type of material and it's the weight. Although here only the final results are given, the disassembly process and components are documented with pictures. As a reaction to these BOMs the stakeholder experts could then mostly deliver more updated BOMs of more representative products.

4.3.7 Stakeholder experts

Stakeholder experts (industry, NGOs) acted as a sounding board for the methodological development, but also have proven to be valuable suppliers of quantitative information. The information was retrieved through the stakeholder expert group (see Chapter 1) and personal interviews/ communication.

4.4 Data Retrieval Use Phase

As mentioned in the introduction, this paragraph only discusses some problems with product-specific parameters in the use phase, as e.g. Bill-of-Materials, product volume and weight (distribution phase) are largely self-explanatory. These latter parameters will be supplied by the manufacturers or can be derived from the product analysis. The same goes for the End-of-Life, where the industry sector has to indicate which fractions go to landfill, recycling or energy recovery.

The problems relating to the use phase of the product relate to

- Test standards;
- Consumer behaviour;
- System analysis and boundaries.

4.4.1 Harmonised Test Standards

In theory, the fact whether or not a harmonized EU test standard is in place to assess e.g. energy efficiency, water use and other environmentally relevant product performance parameters should not play a role in the eligibility of a product for an implementing directive. In practice, however, the lack of such a standard means that no reliable product information is available for these parameters and –with the EU's New Approach policy—it means a considerable delay of 3 years, but sometimes much more (up to 10 years)[65]. These are two factors that can severely slow down any legislative measures.

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[64] Please note that, apart from environmental- and energy research, the main VHK activity is product development of mass-produced consumer durables. And product analysis of (competing) products is a common procedure in the preparatory stages of the development process, in this case requiring 2 to 3 days per product.

[65] The issue is that in the present EU New Approach, as opposed to the older form of directives that merely contain a Technical Annex, the harmonised EN test standard is a necessary ingredient of the directive. If a standard needs to be made or adjusted, the normal procedure entails that the European Commission gives out a mandate to CEN/Cenelec. Follows an acceptance procedure, before the standard is elaborated in a new or existing Technical Committee and appropriate technical working group. This working group elaborates the text, very often also on the basis of test results from ring-tests to see whether the tests are accurate, repeatable, close to real-life, etc. Typically the working group consists of experts from industry and research institutes who perform this work more or less on a voluntary basis, i.e. based on vested interest in the matter at hand and with a

As with the “functional parameter” in paragraph 3.3.8, it is questionable whether “Test Standards” should be treated under the heading “Environmental Impact Analysis” or whether “Market Analysis” is more appropriate, because it is relevant for both. For “Market Analysis” it is obvious that without harmonized standards a reliable market segmentation according to environmentally relevant features (e.g. energy and water use) is very difficult. Yet, the most relevant would seem the Environmental Impact Analysis regarding the use phase, where assessments and comparisons are most difficult to make without appropriate harmonized test standards.

Data sources for harmonized test standards are the European normalization institutes CEN, Cenelec, ETSI and/or national members NEN (NL), DIN (D), etc. It is difficult to give a general rule as to when an appropriate test standard is lacking, but –being Energy using Products—there should be at least a basic test standard for the determination of energy consumption and performance[66].

With our Product Cases, the biggest problems arise from test standards for Consumer Electronics and ICT products, like televisions, personal computers and imaging equipment. These are relatively new and –in terms of product features—fairly dynamic product fields. Furthermore, as restrictive legislation is underway --inside and outside the EU—the industry is trying to minimize a possible impact of such legislation by proposing standards that are not so much linked to the functionality as to specific technologies. In that sense there are different test standards for e.g. various display and printing technologies. All these could be defined in terms of their output (size, pages-per-minute, resolution, etc.), but unfortunately are now often defined in terms of a specific throughput-technology. Here the policy makers have to strike a balance with what market parties want –and what therefore can be realized within a foreseeable future—and what would be methodologically correct. An important part of this ‘balance’ is also that policy makers take into account what technologies still have a sufficient improvement potential that can be addressed through appropriate measures.

To a lesser degree –because the products and markets are perhaps less subject to change—the standardization problems occur with (water) heating and cooling appliances. Here the standards are not only specific for the throughput-technology (e.g. storage-type vs. flow-through type for water heaters), but also for the inputs employed (gas, oil, electric, renewable sources, etc.). Also here, the policy makers have to make a choice between achieving short-term results and being methodologically fully correct. Because of their importance for implementing directives, a lot more could be said about harmonized test standards. But at this point it suffices to say that the lack of appropriate harmonized test standards can lead to serious distortions of market data, segmented by e.g. energy efficiency, water consumption, etc. Furthermore, no general methodology applies and it is proposed that the complex problems related to test standards should be solved on a case-by-case basis.

4.4.2 Use Phase: Consumer Behaviour

The main requirements of test standards are that they are accurate, repeatable and cost-effective. Furthermore, test standard should mimic as closely as possible the real-life situation. However, this latter demand is very often not (completely) met, because of the complexity of the real-life situation with a wide variation in user behaviour and ambient conditions on one hand and the testing costs that would be required to take this variation into account. For

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limited time budget. As a consequence, working groups meet two to three times per year and for certain standards progress depends significantly on the availability of (external) funding for the ring-tests. Sometimes this funding is part of the mandate, but also it has to come through industry associations.

[66] A harmonised performance standard is a necessary ingredient for energy efficiency: Efficiency=Energy use/ performance.

instance with cleaning devices the test standard only measures energy consumption and performance for one cycle, whereas in real-life consumers use a wide variety of cycles. In the SAVE studies for the EU Energy Label this has led to the definition of the energy use of two types of situations

- The test standard situation ("Standard BaseCase");
- the Real-life situation ("Real-Life BaseCase").

The former should –especially given the New Approach policy of the EU—of course be the basis for legislation, but the latter gives the policy makers a more accurate picture of the real energy use.

There is another aspect that is at least as important: The consumer behaviour is an important parameter for the energy use of most EuP and –up to a degree—any design measures that help to improve the consumer behaviour in that sense can constitute an important improvement potential (see task report there). Therefore it is important to assess the relevant parameters and to identify barriers and restrictions for design measures that would improve the situation. For instance, why are people still using high-temperature (90 °C) wash programmes while –with modern detergents-- it does not improve the wash performance? Why are people disabling the power management features of certain types of office equipment? Etc.

Appendix I, par. 3 gives the following parameters that relate to the environmental impact of consumer behaviour:

- Load efficiency (real load vs. nominal capacity);
- Temperature- and/or timer settings;
- Dosage, quality and consumption of auxiliary inputs (detergents, paper- and toner use, etc.);
- Frequency and characteristic of use;
- Identification of use of second hand auxiliary inputs during product life (e.g. toner, recycled paper);
- Power management enabling-rate and other user settings;
- Best Practice in sustainable product use, amongst others regarding the items above.

Data sources for these parameters are specific consumer surveys (questionnaires, diary-surveys, interviews) done by consumer's associations, industry and research institutes.

Consumer behaviour also plays an important role for product life (discussed in Chapter 3) and end-of-life. Should a broken EuP be repaired or thrown away? Will it be conscientiously recycled? Will the old device be handed down to the children or friends? Etc. Relevant parameters are:

- Economical product life (=actual time to disposal);
- Repair- and maintenance practice (frequency, spare parts, transportation and other impact parameters);
- Present fractions to recycling, re-use and disposal;
- Estimated second hand use, fraction of total and estimated second product life (in practice);
- Best Practice in sustainable product use, amongst others regarding the items above.

In real-life it is not only the consumer behaviour that is important, but also the local availability of resources and facilities. Relevant parameters (App. II, par. 3.3) are:

- Energy: reliability, availability and nature: e.g. storage tanks and distribution of solid and liquid fuels (incl. bio-mass), availability of gas-grid, state of chimneys, gaseous fuel (use of "hot-fill" dishwashers), special local tariffs influencing consumer behaviour (night-tariffs, progressive tariffs, etc.);
- Water (e.g. use of rain water, possibilities for "hot fill" dishwashers);

- Telecom (e.g. hot spots, WLAN, etc.);
- Installation, e.g. availability and level of know-how/training of installers;
- Physical environment, e.g. fraction of shared products, possibilities for shared laundry rooms, etc.

4.4.3 Use Phase: Product System Analysis

The previous sections have discussed the energy and resources consumption that can be measured at the product. But this is frequently not the only societal energy use that can be attributed to or influenced by the product during its use.

Almost every product has a clear interface with the surrounding system and often there are alternative routes to fulfil the same or a similar function. A CH boiler has an interface with the (heat load of the) house and the total heating system, the dishwasher has a manual alternative (hand-wash), PCs, TVs and mobile phones have overlapping functionality, refrigeration is only one way of food conservation and fridges interface with health/food waste/ packaging/shopping trips, etc. A system analysis should identify and describe the functional system to which the product in question belongs and identify and possibly quantify those product features that can reduce the environmental impact not only of the product but of the system as a whole. Please note that the scope of the system analysis is restricted only to issues that can be influenced by technical features of the product under investigation as defined in task 1. Furthermore, the system analysis serves primarily as an addition to the more traditional product-specific analysis, i.e. with the specific objective to design product-specific legislation (if any) in such a way that it would not make system-oriented innovations impossible.

An wide investigation of the system analysis for the Product Cases is out of the scope of our assignment, but should be included in more detailed studies.

5 ENVIRONMENTAL IMPACT: UNIT INDICATORS

Combining the methodology in Chapter 3 with the strategy for data retrieval in Chapter 4, the following table with so-called Unit Indicators was generated. The Unit Indicators constitute the non-product specific part of the EuP EcoReport that leads to the impact analysis as defined in the table of the tender document.

In the original version the layout of the table and explanatory notes fitted 6 pages, suitable for a folder. In this final report the layout was adapted to the rest of the report.

The Unit Indicator table covers over 90% of the relevant inputs needed for the environmental impact assessment in the Product Cases (MEEUP Product Cases Report) and they represent the best available data that could be retrieved within the underlying study. Their purpose is to provide a set of ‘default values’ for the methodology, demonstrating its feasibility and applicability on the short term. By no means they are intended to deter from activities aimed at improving the quality and scope of the data. On the contrary, it is hoped that the compact and easily accessible Unit Indicator dataset and the EuP EcoReport will contribute in making Ecodesign a practical reality, stimulating the materials industry and OEMs to bring more and better environmental (process) data into the public domain and stimulating public support for efforts by un-biased experts to elaborate these data into useful and consistent indicators for Ecodesign. Such improved process data are expected to be provided by the European Platform on Life Cycle Assessment, which is a project initiated by the European Commission.

5.1 Table Unit Indicator

The table below gives the Unit Indicators

Table 29. Unit Indicators

Version 5 VHK for European Commission - 25 Oct. 2005 | This document is subject to a legal notice (see p. 2 of table)

EuP EcoReport: MATERIALS & ENERGY UNIT INDICATORS

	Material	Re-cyc	Energy			Water		Waste		Emissions: To Air							To Water	
			prim/	electr/	fd	proc/	cool	haz/	non	GWP	AP	VOC	POP	HM/	PAH	PM	HM	EP
		%	MJ/	MJ	/ MJ	ltr/	ltr	g/	g	kg	g	g	ng	mg	/ mg	g	mg	mg
Plastics in kg																		
1	LDPE	0%	**78**/	13	/ 52	**3**/	45	**4**/	44	**1.90**	7	**0.49**	-	-/	0	1	**-**	27
2	HDPE	0%	**77**/	10	/ 54	**3**/	31	**5**/	38	**1.81**	6	**0.16**	-	-/	0	1	**-**	30
3	LLDPE	0%	**74**/	10	/ 47	**2**/	116	**3**/	31	**1.86**	6	**0.07**	-	-/	0	1	**-**	39
4	PP	0%	**73**/	7	/ 53	**5**/	40	**4**/	28	**1.97**	6	**0.02**	-	-/	0	1	**-**	165
5	PS	0%	**87**/	4	/ 48	**5**/	177	**1**	22	**2.79**	17	**0.00**	-	-/	121	2	**-**	55
6	EPS	0%	**84**/	3	/ 48	**6**/	176	**1**	38	**2.70**	18	**0.00**	-	-/	61	2	**-**	125
7	HI-PS	0%	**92**/	5	/ 49	**6**/	186	**1**	30	**2.90**	19	**0.00**	-	-/	61	2	**-**	60
8	PVC	0%	**57**/	11	/ 23	**11**/	62	**5**	67	**2.16**	15	**0.00**	-	-/	0	3	**3**	314
9	SAN	0%	**89**/	4	/ 47	**6**/	163	**4**/	32	**3.00**	14	**0.00**	-	-/	0	2	**-**	281
10	ABS	0%	**95**/	7	/ 46	**9**/	165	**10**	92	**3.32**	18	**0.00**	-	-/	2	3	**2**	630
11	PA 6	0%	**120**/	15	/ 39	**16**/	219	**19**/	176	**8.56**	39	**0.01**	-	-/	0	5	**49**	1872
12	PC	0%	**117**/	15	/ 38	**14**/	114	**10**/	177	**5.39**	25	**0.00**	-	-/	0	7	**-**	504
13	PMMA	0%	**110**/	13	/ 42	**10**/	26	**1**/	105	**6.00**	44	**0.00**	-	-/	0	5	**3**	2068
14	Epoxy	0%	**141**/	25	/ 43	**19**/	384	**19**/	407	**6.59**	44	**0.00**	-	-/	0	15	**-**	9650
15	Rigid PUR	0%	**104**/	17	/ 39	**60**/	301	**20**/	427	**4.17**	31	**0.00**	-	-/	20	7	**43**	3186
16	Flex PUR	0%	**104**/	19	/ 40	**70**/	298	**32**/	549	**4.48**	32	**0.00**	-	-/	20	8	**3**	5686
plastic fillers, reinforcement, additives																		
17	Talcum filler	0%	**10**/	-	/ 0	-/	-	-/	6	**0.61**	3	**-**	-	-/	1	-	**-**	-
18	E-glass fibre reinf	0%	**66**/	21	/ 11	**54**/	271	**7**/	311	**3.36**	29	**0.00**	-	-/	-	8	**47**	3151
19	Aramid fibre	0%	**257**/	82	/ 42	**212**/	1058	**28**/	1214	**13.09**	114	**0.02**	-	-/	-	32	**185**	12290
OEM Manufacturing																		
20	all plastic parts		**41**/	25	/ 1	-/	12	-/	128	**2.27**	10	**-**	-	-/	-	2	**-**	24
Metals in kg																		
21	St sheet galv.	5%	**34**/	2	/ -	-/	-	-/	1722	**2.83**	7	**0.14**	26	**4**/	-	3	**4**	65
22	St tube/profile	50%	**17**/	5	/ -	-/	-	-/	801	**1.38**	4	**0.12**	12	**3**/	-	1	**2**	38
23	Cast iron	85%	**10**/	-	/ -	**1**/	4	-/	315	**1.06**	3	**0.12**	6	**2**/	-	14	**1**	26
24	Ferrite	0%	**51**/	3	/ 0	**39**/	-	-/	2582	**4.24**	11	**0.20**	39	**36**	-	4	**2**	79
25	Stainless 18/8 coil	63%	**62**/	10	/ 4	**76**/	8	-/	1000	**6.21**	56	**0.14**	8	**148**/	-	8	**86**	2328
26	Al sheet/extrusion	11%	**193**/	-	/ 0	-/	-	-	360	**10.35**	67	**0.07**	5	**4**/	97	17	**35**	5
27	Al die-cast	85%	**55**/	-	/ 0	-/	-	-	150	**3.55**	16	**0.07**	33	**1**/	18	4	**6**	1
28	Cu winding wire	0%	**143**/	-	/ 0	-/	-	**1**	40	**7.37**	304	**0.03**	4	**57**/	6	3	**6**	158
29	Cu wire	0%	**117**/	-	/ 0	-/	-	-	12	**6.20**	292	**0.01**	4	**55**/	5	3	**94**	155
30	Cu tube/sheet	60%	**51**/	-	/ 0	-/	-	-	14	**2.73**	63	**0.00**	10	**33**/	5	1	**38**	62
31	CuZn38 cast	85%	**38**/	-	/ 0	-/	-	-	43	**1.81**	35	**0.01**	25	**57**/	3	1	**9**	15
32	ZnAl4 cast	85%	**28**/	-	/ 0	**2**/	-	**1**/	33	**1.10**	6	**0.01**	60	**2**/	1	1	**-**	1
33	MgZn5 cast	50%	**162**/	-	/ 0	**119**/	13	**6**/	286	**18.38**	45	**0.07**	27	**3**/	49	9	**18**	4
OEM Manufacturing																		
34	foundries Fe/Cu/Zn		**2**/	1	/ 0	-/	1	-/	7	**0.12**	1	**0.00**	-	-/	-	-	**-**	1
35	foundries Al		**7**/	4	/ 0	-/	2	-/	20	**0.36**	2	**0.00**	-	-/	-	-	**-**	4
36	sheetmetal plant		**15**/	9	/ 1	-/	4	-/	47	**0.84**	4	**0.00**	-	-/	-	1	**-**	6
37	sheetmetal scrap		**12**/	5	/ 0	-/	0	-/	180	**0.80**	4	**0.09**	11	**25**/	-	1	**-**	-
Coating/plating per kg coating (Au/Pt/Pd in g)																		
38	pre-coating coil	0%	**314**/	83	/ 43	**19**/	384	**19**/	407	**15.56**	59	**0.80**	-	**1**/	-	15	**-**	9652
39	powder coating	0%	**357**/	61	/ 43	**19**/	384	**21**/	492	**17.81**	63	**0.03**	-	**1**/	-	15	**1**	9652
40	Cu/Ni/Cr plating	0%	**2759**/	2584	/ 0	**187**/	1742	**58**/	20000	**124.68**	1676	**3.15**	397	**1935**/	5	53	**153**	95004
41	Au/Pt/Pd **per g**	25%	**225**/	203	/ 0	-/	-	**26**/	187500	**17.74**	344	**-**	-	**128**/	-	13	**-**	-
Electronics per kg (unless indicated otherwise)																		
42	LCD per m2 scrn		**3563**/	2270	/ 0	**45**/	670	**1**/	52	**184.3**	59	**0.42**	-	**1**/	-	-	**-**	-
43	CRT per m2 scrn		**3169**/	2131	/ 0	**290**/	-	**49**/	2468	**171**	1077	**801**	14	**933**/	-	2823	**14**	630
44	big caps & coils		**383**/	0	/ 0	**35**/	55	**20**/	601	**21.67**	142	**0.12**	2	**8**/	205	36	**74**	7
45	slots / ext. ports		**187**/	59	/ 0	**75**/	255	**17**/	308	**10.03**	184	**0.01**	1	**38**/	2	13	**32**	6470
46	ICs large, per kg !		**8022**/	7951	/ 0	-/	-	**237**	8789	**505.41**	2787	**69.01**	49	**447**/	15	73	**374**	21481
47	ICs SMD, per kg !		**1787**/	1744	/ 0	-/	-	**67**/	1807	**115.11**	816	**13.80**	10	**185**/	3	24	**10**	4296
48	SMD/ LED's avg.		**2969**/	2886	/ 0	**925**/	-	**131**	2831	**167.00**	1620	**7.48**	15	**422**/	5	51	**15**	2195
49	PWB 1/2 lay 3.75kg/m2		**281**/	151	/ 9	**170**/	77	**1733**	2625	**11.22**	214	**2.33**	3	**36**/	4	5	**15**	3686
50	PWB 6 lay 4.5 kg/m2		**367**/	146	/ 9	**485**/	77	**1892**	4073	**15.69**	396	**1.03**	5	**70**/	7	37	**125**	2443
51	PWB 6 lay 2 kg/m2		**488**/	333	/ 12	**403**/	104	**4256**	2335	**20.21**	219	**0.07**	3	**33**/	3	6	**326**	2845
52	Solder SnAg4Cu0.5		**234**/	194	/ 0	**70**/	-	**5**	228	**11.60**	65	**0.07**	1	**3**/	2	1	**-**	6

Material/ Process c'td	Re-cyc %	Energy prim/ electr/ fd MJ/ MJ / MJ	Water proc/ cool ltr/ ltr	Waste haz/ non g/ g	Emissions: To Air GWP kg	AP g	VOC g	POP ng	HM / PAH mg / mg	PM g	To Water HM mg	EP mg
Electronics OEM Manufacturing												
53 PWB assembly		**128** 3 5	**12** 36	**4** 107	**8.52**	49	**2.13**	-	**1** / 3	15	**-**	709
Miscellaneous												
54 Glass for lamps	0%	**16**/ 13 / 0	**8** / -	- / 14	**0.83**	3	**-**	-	**-** / -	-	**-**	-
55 Bitumen	0%	**48**/ - / -	**6** / -	- / -	**0.51**	3	**7.98**	-	**9** / -	259	**4**	292
56 Cardboard	90%	**28**/ 2 / 16	**-** / -	- / 52	**0.70**	1	**-**	-	**-** / -	-	**-**	86
57 Office paper	0%	**40**/ 6 / 27	**-** / -	- / 68	**0.58**	5	**0.20**	-	**-** / -	2	**-**	5288
58 Concrete	-	**1**/ - / 0	**-** / -	- -	**0.19**	1	**-**	-	**-** / -	-	**-**	-
Final Assembly, Offices, Transport to Wholesale/Large Retail per m³ packaged final product												
59 per m³ CE&ICT		**2962** 3 28	**-** / -	**26** / 1318	**231.39**	811	**39.30**	7	**67** / 43	904	**2**	35
60 per m³ appliances		**700** 3 0	**-** / -	**6** / 277	**46.67**	150	**15.73**	2	**14** / 36	3204	**-**	7
61 per product		**52** - 0	**-** / -	**1** / 51	**4.52**	12	**0.05**	-	**3** / 3	-	**-**	1
Distribution & retail per m³ packaged final product												
62 per m³ retail product		**500** - 0	**-** / -	**6** 322	**29.31**	84	**5.03**	2	**16** / 9	215	**1**	9
63 per m³ installed product		**312** - 0	**-** / -	**4** 177	**18.60**	50	**4.91**	1	**9** / 8	214	**-**	5
64 per retail product		**59** - 0	**-** / -	**1** 55	**4.03**	13	**0.04**	-	**3** / -	-	**-**	1
Use: Energy per MWh electric or GJ heat out CH boiler, (unless indicated otherwise)												
65 Electricity per MWh		**10500**/ 0 / 0	**700** / 28000	**242**/ 12174	**458.21**	2704	**3.95**	69	**180** / 21	58	**68**	323
66 Electric, η 96%, per GJ		**3045**/ 0 / 0	**203** / 8120	**70**/ 3531	**132.88**	784	**1.15**	20	**52** / 6	17	**20**	94
67 Elec. GSHP, η 288%, GJ		**1015**/ 0 / 0	**68** / 2707	**23**/ 1177	**44.29**	261	**0.38**	7	**17** / 2	6	**7**	31
68 Gas, η 86%, atmospheric		**1163**/ 0 / 0	**0** / 0	**0**/ 0	**64.29**	19	**0.85**	0	**0** / 0	0	**0**	0
69 Gas, η 90%, atmosph.		**1111**/ 0 / 0	**0** / 0	**0** 0	**61.43**	18	**0.81**	0	**0** / 0	0	**0**	0
70 Gas, η 101%, condens.		**990**/ 0 / 0	**-14** / 0	**0** 0	**54.74**	16	**0.72**	0	**0** / 0	0	**0**	0
71 Gas, η 103%, condens.		**971**/ 0 / 0	**-20** / 0	**0** 0	**53.68**	16	**0.71**	0	**0** / 0	0	**0**	0
72 Oil, η 85%, atmosph.		**1176**/ 0 / 0	**0** / 0	**0** 0	**87.76**	110	**1.52**	0	**0** / 0	2	**0**	0
73 Oil, η 95%, condens.		**1053**/ 0 / 0	**-14** / 0	**0** 0	**78.52**	98	**1.36**	0	**0** / 0	2	**0**	0
74 Wood pellets, η 85%.		**1176**/ 0 / 0	**0** / 0	**0**/ 383	**0.66**	105	**19.41**	1	**0** / 28	20	**0**	0
75 Wood pellets, η 88%.		**1136**/ 0 / 0	**0** / 0	**0**/ 370	**0.34**	86	**9.37**	1	**0** / 27	19	**0**	0
76 Wood logs, η 67%.		**1493**/ 0 / 0	**0** / 0	**0** 434	**3.27**	105	**93.22**	2	**0** / 34	23	**0**	0
77 Wood logs, η 74%.		**1333**/ 0 / 0	**0** / 0	**0**/ 435	**9.66**	106	**313.04**	2	**0** / 43	77	**0**	0
78 Extra for fossil fuel extraction & transport: Gas +7% (row 68-73) , Oil +10% (row 72-73), for Wood pellets and logs add 5% of row 72												
Use: Consumables per kg (unless indicated otherwise)												
79 Toner		**50**/ 2 / 25	**4** / 81	**2** 158	**2.00**	8	**0.05**	3	**13**/ -	7	**1**	100
80 Detergent dishw.		**32**/ - / 0	**-** / -	**1** 37	**1.40**	8	**0.01**	-	**1**/ -	-	**-**	53601
81 Rinsing agent dish		**20**/ - / 0	**-** / -	**-** 23	**0.87**	5	**0.01**	-	**-**/ -	-	**-**	1
82 Regen. Salt dishw		**2**/ - / 0	**-** / -	**-** 2	**0.07**	0	**-**	-	**-**/ -	-	**-**	-
83 Water per m³		**0.008**/ - / 0	**1000** / -	**-** -	**0.000**	0.002	**0.000**	0.000	**0.00**/ 0.00	-	**-**	-
84 Vacuum cl. bags	50%	**17**/ 1 / -	**-** / -	**0**/ 39	**0.98**	3	**-**	-	**-**/ -	-	**-**	324
85 Void												
Use: Maintenance, Repairs												
86 Mini-van diesel		**2**/ - / -	**-** / -	**-**/ -	**0.19**	0.19	**0.04**	-	**1**/ 1	9	**-**	-
87 Repair parts		1% of total impact for production and distribution of the product										
Disposal: Env. costs per kg final product (unless indicated otherwise)												
88 Landfill		**68**/ - / -	**-** / -	**-**/ 226	**5.10**	10	**0.28**	8	**20**/ -	89	**6**	325
89 Dumped Hg		**-**/ - / -	**-** / -	**-**/ -	**-**	-	**-**	-	**5000**/ -	-	**-**	-
90 HFC refrigerants & R744		GWP values: R134a=1300, R404a=3260, R410a=1730, R152a=140, R744= CO_2=1										
91 Incinerated		**67**/ - / -	**-** / -	**-**/ -	**5.02**	10	**0.14**	-	**18**/ -	85	**5.7**	325
92 Plastics, re-use, recyc.		**7**/ - / -	**-** / -	**-**/ 3	**0.44**	2	**0.13**	-	**1**/ -	30	**-**	-

Disposal: Env. Benefits of Re-use, Recycling, Heat Recovery (HR), credits per kg materials

93 Metals, WEEE recycling credits already incorporated in production (e.g. 85% recycling rate instead of 60-65% for cast metal products)
94 Plastics, Thermal recycling: credit is 75% of feedstock energy & GWP of plastics used (displaces oil)
95 Plastics, Re-use/ closed loop recycling: credit is 75% of all production impact of plastics used
96 Plastics, Recycling: credit is 27 MJ (displaces wood) + 50% of feedstock energy & GWP of plastics (less chance heat recovery)
97 Electronics: if designed for easy separate shredding credit is 20% of production impact components and materials

Legend: - = not available . 0= explicitly indicated as zero (rounded) by the source

5.1.1 Scope

The main table gives environmental indicators of almost 100 materials and unit processes relevant to the Eco-design of Energy-using Products (EuP). Each row in the table represents a material or energy conversion process, characterized by numerical Environmental Indicators (EI). The EIs are aggregated data derived from emissions and resources-use of the processes involved. Weighting factors for some EIs are given in Chapter 3. Following the principles laid down also in Chapter 3, emissions and resources were traced back to the 2nd or 3rd level. Indicators are given per unit (kg, GJ, etc.) of materials and process-outputs and allow the conversion of product-specific data from the production (Bill-of-Materials, BOM), distribution, use and disposal into environmental impacts.

The totals of the different EIs per product will be called the Product Environmental Indicators (PEIs). Together with the Functional Unit (FU) - the reference unit for the assessment - the PEIs make up the Eco-design Product-indicator (PI = PEI * FU). The PI is the starting point for assessing the environmental improvement potential. An improvement can be quantified in % reduction of PI new versus PI old (per EI).

For policy purposes the PEIs - multiplied by product-specific EU market data - can also be used to assess the total environmental impact (per EI) of the product category in the EU. This allows to prioritize one product category versus another (per EI) or to compare the product impact with EU targets (per EI). A prioritization between different EIs (e.g. Global Warming versus Acidification) is outside the scope of the underlying Methodology.

DATA

These refer to the average EU/ global technology 2005/ 2006. Great care was taken to create a robust data-set, yet the figures will be subject to change as more and better data become available and the underlying technologies change. Important selection criteria for source material were horizontal quality, i.e. finding the most informed, recent and transparent public source per material or process, and vertical consistency, i.e. allowing a fair comparison on every aspect between potentially ‘competing’ materials and processes.

5.1.2 Sources

Sources for emission data are amongst others: APME (plastics), AKZO (aramid fibres), IISI, Eurofer (St), IPAI, Aluminium Institute (Al), ETH-1996 (preliminary data on Cu pending Eurocopper input), The Nickel Institute (Ni), IPPC BREF on VOCs (Cu filaments, pre-coat, powder coat), The European Dioxin Inventory (secondary metals, solids combustion), Frauenhofer Institute and SemaTech 2002 (ICs), IPPC BREFs on Paper, Glass (misc.), NTM (transport), ANEC, Öko-institut GEMIS 4.2 (Fossil fuel heat), EPER 2001, Eurelectric (electricity), IPPC BREF on Waste Incineration (disposal), Ecolabel-studies (dishwasher detergents, paper/cardboard, CRT), USGS and US DoE EER (mining), US EPA (some Hg emissions), SAVE studies (Heating & hot water appliances), Lithuanian Cleaner Production programme (plating) and individual manufacturer’s environmental reports, like AT&S (PWBs). We are especially grateful for the personal contributions/reviews by AMD (ICs), Sharp Corp. Japan (LCD Factory) and Philips (CRT). Data were checked against public VHK studies in the past (downloads from www.vhk.nl), LCI-databases such as EcoInvent in SIMAPRO 6 and a host of other literature. The largest part of the emission data refers to 2000-2005. For the electronics sector, primarily more recent (2003-2004) information was used, because of the sector-dynamics in pollution abatement.

5.2 Notes per Policy Area

The columns in the table refer to the following POLICY AREAs:

- **Energy**: The total Gross Energy Requirement GER ***[column 1]*** and – as a part of the GER **-** the energy requirement (in MJ primary) of electricity ***[col. 2]*** and the net calorific value of feedstock ***[col. 3].*** Please note that electricity and feedstock are auxiliary parameters and not as such indicators of environmental impact. Apart from being an indicator of energy resources depletion, the GER allegedly are covering 90% of the **Materials Depletion** aspect. See paragraph 3.3 for more information.

- **Water**: Process water ***[col. 4]*** and cooling water volume ***[col. 5]***. The water data of metals should be treated with caution because they may be incomplete. Cooling water is not always considered by all sources; process water use, especially for mining/ benefication is often underestimated. See paragraph 3.4 for more information.

- **Waste**, subdivided in hazardous ***[col. 6]*** and not hazardous ***[col. 7]***. LCA sources on metals tend to underestimate the waste from mining operations. The non-hazardous waste quantities for metals production from the various sources were therefore replaced by an independent set of waste data that allows a fairer comparison. See paragraph 3.5 for more information.

- **Global Warming Potential GWP *[col. 8]*** includes the weighted emissions of greenhouse gases (GHG's), including fluorinated GHG's, with GWP-100 factors given by the Intergovernmental Panel for Climate Change (IPCC), in order to attain the CO2 equivalent. See paragraph 3.6 for more information.

- **Acidification Potential AD *[col. 9]* in SO2** weighting factors for acidifying agents, derived from EU legislation, are given in Table 1 below. See paragraph 3.8 for more information.

- **Volatile Organic Compounds VOC *[col. 10]*** are indicators (precursors) for smog and ground-level ozone. NOx (part of AD) is another important parameter. Furthermore VOCs, esp. in higher concentrations can cause neurological health problems (Human Toxicity indicator). See paragraph 3.9 for more information.

- **Persistent Organic Compounds POP *[col. 11]* :** Mainly dioxins and furans into air are relevant to EuP's, expressed in ng I-TEQ (2,3,7,8-TCCD equivalent). Conversion factors are part of EU-legislation, values taken from the European Dioxin Inventory. PCBs in medium/high voltage transformers should be treated on an ad-hoc basis and are not included in the table. There are no POP emissions to water with EuP. See paragraph 3.10 for more information.

- **Heavy Metals *[col. 12]*** relates to emissions of regulated heavy metals, weighted according to their emission limit values as specified in current legislation under the Ambient Air Quality Framework Directive. See paragraph 3.11 for more information

- **Polycyclic Aromatic Hydrocarbons PAH *[col. 13]*** relates to emissions of regulated organic compounds (incl. CO and benzene) of which PAHs are the most prominent, weighted according to their emission limit values as specified in current legislation under the Ambient Air Quality Framework Directive. Original accounting unit in legislation is ng/m3 Benzo(a)pyrene equivalent (for PAHs), CO and benzene, but it was converted to Nickel-equivalent (1 ng/m3 Benzo(a)pyrene equals 20 ng/m3 Nickel as in directive 2004/107/EC) to keep the link with the previous column on Heavy Metals. See paragraph 3.11 for more information.

- **Particulate Matter PM *[col. 13]*** or dust is an important indicator (precursors) for smog and ground-level ozone. Furthermore PM are indicators for Human Toxicity (respiratory problems). For a subdivision between PM10 and PM2.5 not enough data were available. See paragraph 3.12 for more information.

❖ **Heavy Metals (Water)** ***[col. 14]*** relates to emissions of regulated heavy metals, weighted according to their emission limit values as specified in current legislation under the Water Quality Framework Directive. See paragraph 3.13 for more information.

❖ **Eutrophication** ***[col. 15]*** refers to substances that influence the oxygen balance of the water. Individual emissions are weighted according to threshold values in the Water Quality directive to attain the aggregated EI value. See paragraph 3.13 for more information.

Please note that

On **Ozone Depletion Potential (ODP)** data was gathered, but generally quantities were negligible and did not differentiate between competing options. ODP may still play a role for a few specific products, e.g. using certain refrigerants and blowing agents, but should be dealt with on an ad-hoc basis. Weighting factors for CFC11 equivalent of substances with an ODP that are still permitted, can be found in EU legislation. See paragraph 3.2 for more information.

Noise is incorporated in EU legislation for appliances. Can be dealt with as a single design issue for the use phase.

Land Use for mining of metal ores is an important environmental parameter. However, it is not (yet) active part of EU policy. The main reason is of course that the EU hardly has mines in its territory. The non-hazardous solid waste quantity is a good indicator [col 7] as it includes both rock and ore waste.

Hazardous substances are dealt with in the disposal phase (see there).

Please note that no (eco)toxicity category is distinguished. Categories of impacts that relate to the current concept of (eco)toxicity include most emissions to water and air: POP, PAH, Heavy Metals to Air and Water, Acidification, Eutrophication, Particulate Matter PM and VOC. The figures for these categories are either results from straight mass-additions (PM, VOC) or from weighted mass-additions on the basis of equivalence factors and/or emission limit/target values in legislation (see Chapter 3, par. 3.7 to par. 3.11).

5.3 Notes per Unit Indicator

5.3.1 *Plastics*

[row. 1-16] Lists most commonly used polymers. Technical polymers that are not in the list can be estimated from the eco-profiles of the ones that are listed, possibly calibrated with GER data from the Table 30 below.

Table 30. GER of some technical plastics not listed, in MJ/kg

PIB	PA 6.6	POM	PBTP	UP	PF	PF+wood
95	as PA6	115	108	78	82	50

[row 17-19] The fraction of fillers and reinforcement is usually expressed as volume %. In order to calculate the corresponding weight fractions, use the following indicative density table:

Table 31. Densities of plastics and fillers/reinforcements in g/ml

LDPE	HDPE	PP	PMMA	PVC	PA6	PC
91.3	**0.96**	**0.9**	**1.28**	**1.38**	**1.12**	**1.2**
EP	PUR rigid	PS/ABS/SAN		Talc	E-glass	Aramid
1.08	**ca. 1.2**	**1.05**		**1**	**2.54**	**1.58**

Talcum data: VHK estimate based on similarity with chalk + extra purification and grinding. Glass fibre data include intermediate coatings and chemical binders.

No emission data was found (yet) on additives. Interesting additives could be PVC plasticizers, which can be 20-30% of the materials fraction in compounds for electric wires, and TBBA, which is (still) the most popular flame retardant in PWBs. Concentration is typically 0.5%.

5.3.2 *Metals*

[row 20] The EIs of OEMs (Original Equipment Manufacturers) only relate for 20-25% to electric process energy of high-pressure die-casting, extrusion, blow-moulding, etc. Space heating, lighting and transport of raw material (granulate) take a bigger part and these show a wide spread in consumption data. Differentiation between OEMs on the basis of a specific process technology is therefore not useful.

[row 21] Cold rolled steel coil or sheet, hot-dip galvanized, with good surface quality (suitable for coating) is the typical steel-product for EuP housing and some structural components. Galvanisation stands for any type of basic corrosion protection at the steel plant. Production-route is 100% blast furnace. The low recycling rate (5%) is typical of the surface quality required. For recycling see also Sensitivity Analysis, par. 7.8.3.

[row 22] Steel profiles are used sometimes for structural components (frames), tubes are used in heating appliances. Production-route is 50% blast furnace and 50% electric arc furnace. Values are given for low carbon steel (<0.3%). For high-C alloyed engineering steel add ca. 15%.

[row 23] Common grey (GG20) cast iron. The high recycling percentage of 85% already anticipates the estimated effect of the WEEE directive. The 2005 recycling percentage, excluding run-around scrap is estimated to be around 65%. The same goes for other die-/sand-casts metals in the list, i.e. Al, CuZn38, MgZn5, ZnAl4

[row 24] High-purity ferrite for application in transformers, electric motors, etc. , preliminary VHK estimate.

[row 25] Austenitic Stainless Steel (FeCr18Ni8), type 304,Surface quality 2B, on coil.

[row 26] Differences between extruded and cold rolled Al sheet are small enough to fall within a 5% range, which is smaller than the overall error margin. Therefore they fall under the same indicators. High PAHs because of carbon anode. High GHG because of fluorinated GHG.

[row 27]Aluminium die-casts, e.g. AlSi1 and AlMg5. High dioxins due to secondary Aluminium smelters.

[row 28] Winding wires e.g. for el. Motors, coated (IPPC BREF VOCs 2004)

[row 29] Based on ETH 1996 data for virgin Cu. Typical of el. wire.

[row 30] Cu tube (heating/ hot water appliances) and sheet (hot water tanks).

[row 31] Cu with 38% Zn, general purpose brass, die-cast. High dioxins because of secondary Cu smelting, as with al cast-products; also ZnAl4 and MgZn5.

[row 32] Zn with 4% Al, general purpose “Zamac”, die-cast.

[row 33] Magnesium with 5% Zn. High GWP is due to SF6 as cover gas.

[row 34-35] For Fe/Zn/Cu the process energy was already included in the material. Only comprises space heating, lighting, transport, etc. As space requirements depend mostly on volume and not weight Fe/Zn/Cu (ca. 8-9 kg/l) and Al/Mg (ca. 2-3 kg/l) are distinguished in terms of impact.

[row 36-37] For sheet-metal and similar OEMs, there is an impact for the space heating, lighting, process energy, raw material transport, etc., expressed per kg final component/ product. And there is a second UI, which takes into account the waste and recycling of primary scrap. As a default, if no specific values are used, one can assume25-30% cutting losses for average deep-drawing, cutting and stamping. For folded sheet in e.g. fridge housings, losses are much less (default 10%).

5.3.3 Coating/plating

[row 38] Pre-coated Steel or Al sheet with a 55 µm layer of epoxy or PUR is one of the few wet-paint process left in EuP. High VOCs.

[row 39] Powder coating with epoxy. Default layer thickness 35 µm/side.

[row 40] There are differences between Cu (GER 101 MJ/kg virgin), Ni (240 MJ/kg) and Cr (>400 MJ/kg) but the differences fall within the margins of error with electroplating. Default layer thickness for thin-layer Cu 12 µm (under-layer for Ni), Ni 20 µm, decorative Cr (on Ni) 2 µm. [sources: Clean Production projects Lithuania and manufacturer reports]. High N to water from Ni beneficiation to be discussed (225 g N/kg Ni ?)

[row 41] Typical impact and recycling rate for decorative plating with Au. For high purity “Five-Nine” (99.999%) applications in electronics the EI values should be increased by 25%. Default layer thickness for Pt (HDD application) and Pd (capacitors) is 1 µm. For gold plating default is 3 µm on Cu-Ni (8+8 µm) under-layer.

5.3.4 Electronics

[row 42] An LCD is mainly a semi-conductor (8-9 layers, 4-5 masks) on glass substrate (0.7mm), covered by another glass 0.7 mm panel with colour filters. The energy consumption data relate to state-of-the-art 6G plant 2005 (source Sharp Corp., Japan), using a cogeneration power plant and extensive recycling (100% water and waste recycling) and scrubbing facilities. As a consequence Sharp Corp. data for GWP from PFCs are a fraction of what was previously indicated for 4G and 5G fabs in 2003 and should be robust for the immediate future. The data are including glass production (IPPC BREF source) and include an indicative figure (0.12 GJ oil, emissions and resources according to row 72) for extraction & transportation of fuels for the cogeneration plant. Data are in m² viewable screen size. Conversion with density 2.76 g/ml (BSi glass) → 1 m² = 3.86 kg.

[row 43] Data in m² nominal screen size. Conversion 1 m² = 120 kg for CRTs >13" diagonal. Data refer to glass and Pb fractions (source IPPC, BREF) plus manufacturing based on US EPA 2001 minus 30% improvement.

[row 44] Refers to large capacitors (Al) and coils (Cu, Fe) components on a PWB. No doped silicon, no precious metals. Components are typical for power conversion functions. VHK estimate based on materials composition.

[row 45] PWB-mounted slots for RAM-chips, PCI cards + external ports. VHK estimate based on materials fractions. Per 1000 g: Cu alloy pins 330 g+5 g Cu/Ni plated + 635 g polymer+0.15 g Au.

[row 46 & 47] Based on Si wafer 200 mm diameter, 20 layer complexity. Following ESIA-indications (European Semi-conductor Industry Ass.) we used SemaTech 2002 data of 499 kWh electricity use per wafer and a yield of 44 g of core material per wafer (→ 11.34 kWh/g). At 5% core material per IC this results in 567 kWh per kg of IC. Back-end production is adding 25%, leading to 709 kWh electricity per kg of IC. To this a gold content of 0.2 % is added (avg. for larger IC, incl. memory), see row 41 +25%. For small SMD-type ICs we assume 1 wt. % core material and 0.1 wt. % gold content. For non-electricity related emissions sustainability reports of individual manufacturers were used. More in general, the two indicated data-sets for 1% and 5% core-material (=actual die, silicon, without lid) roughly represent extremes of the current range of ICs.

[row 48] SMD (Surface Mounted Devices) 50 g/m² PWB in a desktop PC main-board (1.2% of standard PWB weight, 3% of microvia PWB), est. 15 wt. % capacitors (of which estimated one third Pd based, rest Ta and ceramic). E.g. Pd= 300 layers of 1 um x 2 x 3 mm Pd → 20 mg Pd/50 mg capacitor → overall 3% Pd (at 225000 MJ/kg).

Diodes, thyristors, RF, etc. (estimated 35 wt. % of total) are treated as ICs with oversized packaging (0.5% doped silicon instead of 5%) without gold. The ecoprofile of resistors (estimated 50% of total) will be close to Cu/Ni plating+glass. In terms of energy there is not much difference with diodes etc., therefore no distinction is made.

[row 49] Standard FR4 (density 1.9) board with 1 or 2 Cu foils 35 µm thick. Overall board thickness 1.5 mm, assumed density 2.5 g/ml. 1 m² = 3.75 kg. Manufacturing energy 440 MJ + materials energy 490 MJ = 930 MJ/m² . → 248 MJ/kg. Typical PWB for appliances and motor controllers.[data: AT&S + standard Unit Indicator values for Cu, E-glass, epoxy, etc. for materials inputs].

[row 50] Multilayer standard FR4 (density 1.9) board resin (EP 30%-GF, 125 MJ/kg) with 2 external Cu foils 35 µg thick and 4 internal Cu layers of 18 µg. Overall board thickness 1.5 mm and assumed density 3 g/ml. 1 m² = 4.5 kg. Manufacturing energy 540 MJ/m² + materials energy 4.5*130=585 MJ/m² . Total 1125 MJ/m² → 250 MJ/kg. Typical PWB (also in 3-4 layer version) for PC Desktop mainboards, TVs, etc. [source as row 49]

[row 51] Multilayer board with microvias, resin (141 MJ/kg, 1.1 MJ/kg) aramid filled (<1 mm thick, estimated 30 vol% non-woven aramid at 250 MJ/kg, 1.6 g/ml). Assumed overall thickness 0.9 mm. Cu (143 MJ/kg) foils 9 um per layer internal (assumed 6 layer= total 60 um). Ni finish. Density excl. Cu 1.4 g/ml; Density incl. Cu 2 g/ml → 2 kg/m². Manufacturing 375 MJ/m² + materials ca. 300 MJ/m² . Total 675 MJ/m² → 337 MJ/kg. Typical PWB for mobile products (laptop, cell phone). [source as row 49]

[row 52] Lead-free tin solder with 4% Ag and 0.5% Cu. VHK estimate of impacts based on materials composition.

5.3.5 Miscellaneous

[row 53] Includes total costs of outsourced assembly: packaging of components (packaging/component weight ratio may vary from >200% for overseas delivered ICs to <10% for locally delivered raw PWBs. Assumed 30%: 0.24 kg cardboard + 0.06 kg PUR/kg component), transport of components (30% air-freight 10.000 km, 100% trucking avg. 500 km), warehousing/plant heating & lighting (10 MJ gas/kg, 1 kWh_e/kg), assembly/soldering (5MJ/kg electric, soldering emissions not available; etching already included in PWB data), packaging (as for components) and shipping of PWB to final assembly (30% air-freight 10.000 km, 100% truck 500 km). Airplane emissions based on NTM data. Trucking emissions based on large (>20 t) Euro5 truck, highway, mix of GEMIS 4.2/Volvo data with Class 1, low-S (legal limit=10 ppm, assumed real= 5 ppm S) diesel. Transport is calculated on a volume basis at 270 kg/m³, whereas real density is half → on a weight basis (unit: t.km) 1 kg product/component counts for 2 kg transported.

[row 54] Glass as used in fluorescents and incandescents (excl. P).

[row 55] Bitumen used as sound dampening material

[row 56] Cardboard for packaging, 90% from recycled material.

[row 57] Office paper 80 g/m²for printing, copier, fax.

1 m² = ca. 16 pages A4. 1 kg is ca. 200 pages A4.

[row 58] Concrete used as counter-weight in dishwasher.

5.3.6 Final Assembly

[row 59] Final stage of ICT & CE manufacturing *per m³ packaged final product*. This includes final assembly, delivery to EU distribution centre(s) and warehouses (heating and lighting as row 53) either by intra-EU trucking/rail (50%), sea-freight + EU trucking/rail (45%) or air-freight + EU trucking/rail (5%). Trucking-rail ratio for ICT&CE products assumed 90:10. Distances: 1000 km intra-EU trucking/rail, 12,000 km sea-freight, 10,000 km air-freight. Final delivery to whole-seller or central retail warehouse: 500 km in medium-sized truck. Transport is again calculated on a volume basis as in row 54. Final packaging product is not included, but should be calculated from the actual packaging of the final product. [Assume 5 kg cardboard + 1 kg EPS + 1.5 kg paper manual per m³ packaged product if packaging is unknown].

[row 60] Final stage of heating/domestic appliance manufacturing *per m³* . Differences with row 59: Only 10% imports (instead of 50%) and no air-freight (→ sea-freight). EU trucking/rail ratio 70:30. Packaging not included [Assume 1 kg LDPE + 0.5 kg EPS + 1 kg paper manual per m³ (straps counted as EPS) if packaging unknown].

[row 61] Space heating and lighting of offices, executive travels, etc. are independent of the size or weight of the product. It cannot be influenced by product-design but is added to complete the picture.

5.3.7 Distribution & Retail

[row 62] Shop heating and lighting (0.5 GJ gas+90 kWh_e per m² shop) is calculated from NL data (source ECN/EIM), assuming 20 units sold per m² and >3.5 m ceiling height. Half of this is assumed to be fixed (counter+traffic space), half linked to the size of the product. Heating and electricity of the wholesale/central retail warehouse is ~60% of shop. Goods are transported from the retailer's central warehouse to the shop by medium-sized truck 200 km (Euro 5). From the shop, products go to the customer's home either by delivery van or customer's car 20 km (Euro 5, diesel, city-traffic). The part of shop heating and lighting that is depending on the size of the product is attributed here. The rest is taken into account under row 64.

[row 63] Wholesale & transport; no shop stock assumed.

[row 64] Fixed part of space heating and lighting requirements of EuP-retailer and wholesaler (also see row 62) per product. Overall, data in rows 54 and 59-64 are rough estimates for the sole purpose of giving the eco-designer an idea of the impact of product-size and weight on the general logistics effort.

5.3.8 Energy use during product life

[row 65] Electricity from public grid 230V AC. See table below.

Emissions based on EPER 2001 for LCP in EU-15 + corrected for coal based electricity emissions in new EU-10 electricity (see tables to right). For fossil fuel extraction and winning 10% was added [CO_2 corr. factor from GEMIS] + extra mercury emissions from coal mining (source US EPA 1999 NEI). Electricity distribution losses add 5% extra + extra SF6 emissions (source CIGRE) . Credit for waste heat use (CHP/DH) 10%. →Total correction +5% +Hg +SF6. Waste and water data based on Eurelectric env. statistics 2002 (companies reporting are ca. 50% of total EU-15). Energy figures are rounded data from Eurelectric for EU-15 plus corrections for new EU +5% (table far right, last row).

Table 32. Main Emissions Power Generation

Air emissions(uncorr.)	EU-15	nw EU10	EU-25*
CO_2 kg/kWh	**0.40**	0.58	**0.43**
SO_2 g/kWh	**1.24**	5.14	**1.91**
NO_x g/kWh	**0.66**	2.35	**0.95**
PM g/kWh	**0.024**	0.202	**0.055**
Hg (at mine)mg/kWh	**0.007**	0.015	**0.010**
SF6(transm) mg/kWh	**0.1**	0.1	**0.1**

*= Final figures for CO_2, SO_2, NO_x, PM are 5% higher

Fuel mix	EU-15	nw EU10	EU-25
Solids(Coal)	**25%**	65%	**31%**
Gas & Oil	**25%**		**22%**
Non-fossil	**50%**	35%	**47%**
Electricity TWh	**240**	550	**2950**
% of EU-25 el.	**81%**	19%	**100%**
Energy MJ/kg	**9.7**	10.5	**10****

**= rounded, actual corr. figure is ~10.5 MJ/kg

Data on cooling water use and process water consumption from various statistical, LCA and technical sources (e.g. IPPC BREF) show a very wide spread. The rounded figures in the table come from UCTE 2000 and should be seen as preliminary.

[row 66] Heat from electric resistance CH boiler 96% efficiency. 1 GJ electric CH heat = 290 kWh. Electric water storage CH boilers are not listed because they are rare and data is lacking. Emissions are expected to be higher because of standby losses.

[row 67] Electric Ground Source Heat Pump (GSHP) with an assumed COP (Coefficient Of Performance) of 300% and 4% heat losses.

[rows 68-77] Data from GEMIS 4.2 for fossil fuel powered 10 kW Central heating (CH) boilers in GJ heat produced at the boiler exit in the form of hot CH water. Intermediate emission values can be extrapolated from the ones given. Efficiency values relate to net calorific value (lower heating value) of the fuel. Electricity (pump, fan, control) is not included. Please note, that direct CO_2 emissions from wood log and wood pellet boilers are zero by political default (renewable fuel). Dioxin emissions (POP) are taken from EU Dioxin Inventory. Operating time is 1600h during 15 years. The table below gives some more details on specific operating conditions of the boilers.

Table 33. Details of boiler operation

	Gas CH				Oil CH		Wood CH			
Row nr.	68	69	70	71	72	73	74	75	76	77
% O2	3%				3%		13%			
% CO_2 in flue	9.96%				13.11%		7.69%			
Nm³/h flue	11.7	11.2	10.0	9.8	12.2	10.9	27.9	27.0	32.3	36.2

[row 78] For the sake of transparency, emissions from fossil fuel powered CH boilers in rows 64-75 are only direct emissions and energy. To take into account fuel extraction and refining add 7% for gas (pipeline, North Sea, compressors, gas-grid), 10% for oil (refinery, transport), 15% for coal (mining, sea-freight, etc.) and 5% of oil emissions (incl. CO_2) for wood logs and wood pellets (collection, transport, treatment).

5.3.9 Consumables during product life

[rows 79-85] Emissions and resources for the production of a number of consumables during product life. Office paper [row 54] is also part of this (for copiers, printers, etc.). Note that emissions that are not part of EU legislation (yet) are not mentioned, e.g. ozone-emissions from copiers, electro-magnetic radiation, etc. Noise should be dealt with on an ad-hoc basis if EU legislation exists.

[row 79] Toner based on 48% SAN, 45% iron oxide, 4% PP, 3% silica.

[row 80-82] Dishwasher detergent, rinsing agent and salt based on EU Ecolabel studies (avg. EU phosphate) and CECED data (energy). Phosphate emissions are considered after Urban Waste Water Treatment (80% removal efficiency).

[row 83] Emissions and resources consumed per m³/1000 kg water. include distribution (pumps, Cu) and energy of waste water treatment.

[row 84] Vacuum cleaner bags, high quality thick paper, 50% recycled.

5.3.10 Maintenance, Repairs

[row 86] Given is a Euro5 mini-van/diesel car in city traffic per km.

[row 87] VHK estimate (based on wall-hung CH boiler).

5.3.11 Disposal: Environmental costs

[row 88] Emissions from landfill. In post-WEEE directive era for EuP this is assumed to be 50% illegal dumping and 50% inert fractions. For illegal dumping emissions based on the equivalent of 1 MJ (Euro 5, city traffic combusted) diesel for transport, cleaning+ landfill emissions (no data available, assume impact as the equivalent of all galvanic protection leaching to groundwater before site is cleaned: 20 mg Zn equivalent per kg product at

0.1 weighting factor= PAH & HM +2) + normal landfill emissions (ecl. CH_4) according to EPER 2001 (counting 115,000 kt municipal waste to landfill in EU-15) before eventually it will have to be treated anyway as most EuP-fractions are not biodegradable (assume equivalent of full incineration and no credits for recycling of metals because of cleaning effort).

[row 89] Per kg Hg in Hg-containing products that are still permitted in the RoHS directive (mainly discharge lamps and button-type batteries). Roughly 80% of these products is assumed to be collected and treated. If no other data are available assume 20% of Hg in the product to be dumped.

[row 90] GWP-100 (in CO_2-equivalent) per kg of not recovered refrigerants. To be calculated per product, depending on fraction illegal dumping and fugitive emissions during use phase. Not recovered fraction ranges from 1-2% for pre-sealed fridges and pre-sealed RACs up to 50% for certain types of commercial refrigeration. Values given are direct GWP impacts according to IPCC. Data on GWP and other emissions of refrigerant production are relatively minor with respect of direct impact, vary widely between sources and are therefore not taken into account. Just as an example of the wide disparity of production impact data, find the GWP-table below.

Table 34. GWP of manufacturing of refrigerants (kg CO2 eq.)

REFRIGERANT	source [1]	source[2]	REFRIGERANT	source [1]	source[2]
R12	1229	-	R404A	136	30
R22	393	-	R407C	142	13
R32	190	12	R410A	173	23
R124	72	-	R170	1,2	-
R125	160	33	R290	0,95	0,5
R134a	87	9	R600a	1,5	-
R143a	120	30	R717	2,53	-
R152a	14	-	R744 (CO2)	1,62	0
R227ea	120	-	R1270	1,3	-

DeLonghi, pers. Comm.. from miscellanious literature 1995-2003, 2005

Proceedings Earth Techn Forum 2004, Japan (courtesy Daikin)

[row 91] Emissions from hazardous incineration from EPER 2001 for ca. 40,000 kt municipal waste incinerated in EU-15 + 17% added to exclude the energy contribution from the plastics. The latter will be added if the plastics are not taken out from the waste stream to be recycled, through the credits for thermal recycling (row 94). Note that Frischknecht (Appendix II) thinks our estimates of the energy requirement (and linked emissions) of hazardous waste is too high; this needs to be investigated.

[row 92] Environmental ‘costs’ of the logistics and treatment of re-use, recycling and heat-recovery is assumed to be similar to distribution and assembly [rows 56-57], but substituting air-freight with sea-freight (with ICT).

5.3.12 Disposal: Environmental Benefit

[rows 93-97] Environmental benefits from re-use, recycling and heat-recovery. Please note that this relates to (a prediction for) the situation after 2010-2015, when presently designed EuP will be first disposed off under WEEE and other Waste directive requirements. Table 5 (Chapter 3) is given as a rough guideline for EuP as a whole, but can be adjusted for individual products if data is available.

No recycling or energy recovery is assumed to be possible where halogenated compounds and/or substances mentioned in ECMA-standard 341 are still found in the final product. Energy recovery credits ***[row 94]*** typically apply when no halogenated compounds and/or substances mentioned in the ECMA-341 standard, Chapter 6.7 are found, but the design-focus was on dematerialisation through increased use of (re-enforced) plastics and composite materials. The latter makes disassembly and recycling difficult but shredding plus waste heat recovery from plastics and PWBs the next best option (displacing fossil fuels). In order to receive the credit for the recycling of electronics ***[row 97]***, Printed Wiring Boards (PWBs) should be easily disassembled from the rest of the device[67], so that —in a shredder-based recycling scenario— the electronics parts can be shredded separately.

Credits for recycling of plastics apply ***[row 94]*** when the product is designed for disassembly and consequent re-use and recycling, following design rules in ECMA-341, Chapter 6.6. Documentation of materials fractions following EIA list of materials (incl. 'Materials of Interest') should be available. Credits for re-use and closed-loop recycling apply ***[row 95]*** when a stakeholder sets up a distribution and collection system for a specific product.

Note that Frischknecht (Project Report) thinks our estimate of the credits of energy recovery from plastics incineration is too high ***[row 94]***. Allegedly in Switzerland only 25-30% of the combustion value is recuperated usefully; this needs to be further investigated.

[67] Following DeWulf: Handling and disassembly in less than 60 seconds (EGG 2004 proceedings)

5.4 EuP EcoReport

In order to facilitate the environmental impact analysis an MS Excel form was designed by VHK. The form called "*EuP EcoReport*" uses the Bill-of-Materials, Energy and other resources use during product life, as well as key parameters for manufacturing, distribution and end-of-life as input parameters and —using the Unit Indicators— generates the environmental impacts for the indicators required by the tender document for the 4 stages of product-life. These impacts are summarized on the "Output" worksheet. Furthermore, for analysts, the outputs per single input item are given on the "Raw" worksheet. On the next pages "EuP EcoReport version 5" of 25.10.2005 is illustrated.. Both the Output and Raw worksheets allow the production and printing of any type of graphs available in MS Excel from the given data. In parallel to the calculation of environmental impacts, the Input and Output worksheets of the latest versions of the EuP EcoReport also include sections to facilitate the calculation of average Life Cycle Costs per product and the calculation of the total expenditure of EU consumers in the most recent year. Please note that the total expenditure relates to the production and distribution of new products plus the emissions and resources of the stock in that year. The total expenditure is given in direct costs to the end users in one year; running costs are not discounted and –despite that in the report it is often placed in the same table in the Product Cases Report—it is not a summation of individual Life Cycle Costs.

Illustrations of the use of EuP EcoReport can be found in the Product Cases Report.

5.4.1 Input worksheet EuP EcoReport

The Input Worksheet starts with a section of 200 lines reserved for the Bill-of-Materials. Descriptions of the components can be filled in manually or pasted from e.g. standard CAD-files. Product weights have to be filled in manually. For the selection of a Process of Material first a category has to be selected; both from drop-down menu's. In the BOM-section the weight per component is multiplied with the environmental Unit Indicators from Table 29. In the RAW Worksheet this can be seen. Also the product weights are summed per Category (Ferro, Non-Ferro, Bulk Plastics, etc.) and summed parameters are prepared for the manufacturing, distribution and en-of-life phases.

Table 35. Input EuP EcoReport

Version 5 VHK for European Commission 28 Nov 2005 — Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS — EuP EcoReport: INPUTS
Assessment of Environmental Impact

Nr	me		Date	Author
Pos nr	**MATERIALS Extraction & Production Description of component**	**Weight in g**	**Category** Click &select	**Material or Process** select Category first !
1				
2				
3				
4				

Pos nr	Description			
5				
6				
7				
8				
9				
.				
198				
199				
200				
	TOTAL	0		

The following section describes the (OEM) manufacturing of metals and plastics components. Most of this section uses fixed impacts on a weight basis (see explanations of rows 25, 34-37 of Table 29). Specific weights per process are calculated automatically from the BOM section. The only variable that can be edited is the percentage of sheetmetal scrap, i.e. the default 25% value can be changed.

Pos nr	MANUFACTURING Description	Weight in g	Percentage Adjust	Category index (fixed)
201	OEM Plastics Manufacturing (fixed)	0		20
202	Foundries Fe/Cu/Zn (fixed)	0		34
203	Foundries Al/Mg (fixed)	0		35
204	Sheetmetal Manufacturing (fixed)	0		36
205	PWB Manufacturing (fixed)	0		53
206	Other materials (Manufacturing already included)	0		
207	Sheetmetal Scrap (Please adjust percentage only)	0	25%	37

The section on Final Assembly and Distribution covers all activities from OEM components to the final customer (rows 59-64 of Table 29). The only design variable is volume of the final (packaged) product, but the impact also depends on what type of product is concerned. The latter is characterized by two Boolean (yes/no) variables.

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)	
208	Is it an ICT or Consumer Electronics product <15 kg ?		YES	59	1
209	Is it an installed appliance (e.g. boiler)?		NO	60	0
				62	1
210	Volume of packaged final product in m³	in m³		63	0
				64	1

For the Use Phase, the average Product Life in years has to be filled in. After that, the 'Electricity' subsection gives the option to fill in the electricity use split-up in 3 modes (on/standby/off mode). These modes can be used, but they don't have to be used; it is also possible to simply specify an aggregated annual energy use (in kWh) in the on-mode and fill in '1' in the next line. The thing to remember is that the energy use is given per year. The spreadsheet programme just sums the electricity use over the 3 modes and multiplies with the Product Life (in years).

The "Heat" consumption applies to stationary combustion installations using fossil fuels and more specifically for our product case of central heating boilers. It requires that the average heat output is filled in (in kW) as well as the number of hours the installation is supplying this heat output (or equivalent, if it is in part load). Under the heading 'Type and Efficiency' a number of standard heat generators with different efficiencies are presented. Starting with the EuP EcoReport version 3 and on request of the boiler manufacturers, the standard efficiency numbers can be varied within a pre-determined narrow bandwidth.

After the Heat subsection, the user can fill in the annual consumption in kg of other consumables like water, detergent, toner, paper, etc. Apart from water, the consumables can select up to 3 different consumable types per product from a drop-down list.

The last subsection deals with the travelling distance of maintenance and repair services, where the number of km over Product Life needs to be estimated. The following line –which cannot be edited—specifies the number of spare parts, presumably 1% of the impact of the BOM.

The Use Phase section uses the Unit Indicators from rows 57 (paper), 65-78 (electricity and heat), 79-84 (consumables), 86-87 (maintenance, repairs).

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	0	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.		kWh	0
213	On-mode: No. Of hours, cycles, settings, etc. / year		#	
214	Standby-mode: Consumption per hour		kWh	0
215	Standby-mode: No. Of hours / year		#	
216	Off-mode: Consumption per hour		kWh	0
217	Off-mode: No. Of hours / year		#	
	TOTAL over Product Life	0	MWh (=000 kWh)	65
	Heat			
218	Avg. Heat Power Output		kW	
219	No. Of hours / year		hrs.	
220	Type and efficiency (Click & select)	→	85-not applicable	
	TOTAL over Product Life	0.00	GJ	
	Consumables (excl. spare parts)			material
221	Water		m³/year	83-Water per m³
222	Auxiliary material 1 (Click & select)	0	kg/ year	85-None
223	Auxiliary material 2 (Click & select)	0	kg/ year	85-None
224	Auxiliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	0	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	0	g	

The last part of the environmental impact assessment deals with aspects of the end-of-life and some special cases where e.g. the product leaks refrigerants (fugitive & illegally dumped) or where the product uses mercury that is not captured completely during and after the product life. The refrigerants can be selected from a drop-down list.

The subsection on environmental disposal costs has only one editable variable, namely the waste going to landfill. The assumed default value of non-recovered products in a post-WEEE scenario is 5% (see Chapter 3), but this can be changed. The other two parameters cannot be altered. The weight fraction of plastics and printed wiring boards incinerated as hazardous is derived from what remains if they are not re-used, recycled or there is effective thermal heat recovery. The cost-side of plastics re-use/recycling (collection, logistics) relates to the weight fraction in the next subsection.

This next subsection asks the split-up of the weight fractions of plastics in re-use, materials recycling and heat recovery. Default values relate to one of the post-WEEE scenarios in Chapter 3, but they can be changed. The next question relates to the easy disassembly of printed wiring boards from the rest of the product so they can follow a different –shredder based—route for materials recovery. And finally the last line indicates that the standard recycling rate for metals and TV glass is set at 95%. But this can be changed indirectly by altering the percentage that goes to landfill.

Pos nr	DISPOSAL & RECYCLING Description		unit	Subtotals
	Substances released during Product Life and Landfill			
227	Refrigerant in the product (Click & select)		g	1-none
228	Percentage of fugitive & dumped refrigerant	0%		
229	Mercury (Hg) in the product		g Hg	
230	Percentage of fugitive & dumped mercury	0%		
	Disposal: Environmental Costs per kg final product			
231	Landfill (fraction products not recovered) in g en %	0	5%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	0	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	0	g	92-fixed
			% of plastics fraction	
	Re-use, Recycling Benefit	in g		
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	0	1%	4
235	Plastics: Materials Recycling (please edit% only)	0	9%	4
236	Plastics: Thermal Recycling (please edit% only)	0	90%	72
237	Electronics: PWB Easy to Disassemble ? (Click & select)	0	YES	47
238	Metals & TV Glass & Misc. (95% Recycling)	0.0		fixed

After the inputs for calculating the environmental impacts, there is a small section that allows the calculation of EU totals and of the Life Cycle Costs. The Product Life (in years) is derived from the environmental section. Next the total annual EU sales and the installed EU stock, both in million units have to be given. Follows a section that asks the average price and –if applicable—the installation and maintenance costs of the product to the consumer (incl. taxes). For energy and water some default rates are given. Prices for other consumables can be filled in (see par. 6.8 of this report and the individual Product Cases). All these prices and rates can be adjusted. The same goes for the discount rate. What cannot be changed directly is the Present Worth Factor (in years). This is calculated from the discount rate and the product life (see Chapter 6).

Finally, the last input in the LCC calculation is a rough indicator of the ratio between the energy consumption of the average new product and the energy consumption of the average product installed ('stock'). Approximately, if there has been no revolutionary growth or decrease in sales, the average product installed should equal the average new product a number of years ago, where the number of years equals half the product life. For instance, for whitegoods (refrigerators, dishwashers with a product life of ca. 15 years) this would be the average new product 7 to 8 years ago.

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	1	years
B	Annual sales		mln. Units/year
C	EU Stock		mln. Units
D	Product price		Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate		Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs		Euro/ unit
M	Discount rate (interest minus inflation)	5.0%	%
N	Present Worth Factor (PWF) (calculated automatically)	0.95	(years)
O	Overall Improvement Ratio STOCK vs. NEW, Use Phase	1.00	

5.4.2 Output Worksheet EuP EcoReport

The Output Worksheet immediately reflects the changes in the Input Worksheet. The most important table in the output worksheet is the first one, which indicates the environmental impacts per product over its life-cycle, subdivided in production, distribution, use and end-of-life. This table is also exactly the table that is required by our assignment for each of the Base Cases (see Chapter 1).

Table 36. Output EuP EcoReport

Version 5 VHK for European Commission 28 Nov. 2005 Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: RESULTS
Assessment of Environmental Impact

Nr	Product name								Date		Author
	Life Cycle phases →		**PRODUCTION**			**DISTRI-**	**USE**	**END-OF-LIFE***			**TOTAL**
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**0**			0	0	**0**	**0**
2	TecPlastics	g			**0**			0	0	**0**	**0**
3	Ferro	g			**0**			0	0	**0**	**0**
4	Non-ferro	g			**0**			0	0	**0**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**0**			0	0	**0**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**0**			0	0	**0**	**0**
									see note!		
	Other Resources & Waste							debit	credit		
8	Total Energy (GER)	MJ	0	0	**0**	**0**	**0**	0	0	**0**	**0**
9	of which, electricity (in primary MJ)	MJ	0	0	**0**	**0**	**0**	0	0	**0**	**0**
10	Water (process)	ltr	0	0	**0**	**0**	**0**	0	0	**0**	**0**
11	Water (cooling)	ltr	0	0	0	0	0	0	0	0	0
12	Waste, non-haz./ landfill	g	0	0	**0**	**0**	**0**	0	0	**0**	**0**
13	Waste, hazardous/ incinerated	g	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO_2 eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
15	Ozone Depletion, emissions	g R-11 eq.				negligible					
16	Acidification, emissions	g SO_2 eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
17	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	ng i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	mg Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	mg Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	g	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	mg				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

From this table and the inputs for LCC and EU Totals we can now calculate the total environmental impact of all products sold in the most recent years, over the coming years (up till and including the end-of-life). This is not shown here, because the table looks the same as above, only the accounting units are different and of course the data are different. Basically what has happened is that all figures in the table above are multiplied by the EU sales (in mln. units). For policy makers this is the impact that they can hope to improve through measures.

The third table is also derived from the two above. It copies the production, distribution and end-of-life figures from the second table to indicate the EU environmental impact in the current year. But the use phase data are not copied directly, but first multiplied with the 'Overall Improvement Ratio' to indicate the difference between the new sales and the current stock. Policy makers largely cannot influence this, because on average most of the impact was caused already half a product lifetime ago. But it tells them how the product fits in the current statistics and –together with the previous table—it tells them how much progress (or not) the sector is already making.

The last table of the Output worksheet calculates two parameters, that both relate to economic expenditure, but that are otherwise completely different. The first parameter is the Life Cycle Costs of one product to an end-user, i.e. a (potential) buyer that calculates the economic rationale of his or her investment decision today and that looks into the future in terms of discounted running costs. This is important for the Base Case and the evaluation of an appropriate target (see Chapter 7). The second parameter calculates the EU Total of all expenditure to end-users in the most recent year, i.e. the running costs are not discounted and for the running costs in the use phase the calculation starts from the installed stock..

The Input and Output worksheets of the EuP EcoReport can be used to calculate the average EU product –the so-called Base Case—but it can also be used to calculate the Base Case including one or more design options. With each design option the environmental and the economic profile of the product will change. When opening several instances of the EuP EcoReport in MS Excel and summarizing the outcomes in a new spreadsheet it is possible to experiment with the ranking of design options.

5.4.3 Worksheet RAW EuP EcoReport

Finally, as mentioned before, the RAW worksheet gives the calculated results per line of the BOM and the lines of e.g. the Use Phase. Thereby it allows manual checking and –as the case may be—manual correction of business specific parameters. Also the RAW worksheet contains an exact spreadsheet copy of the Unit Indicator table that is used, also for easy checking. Please note that the RAW worksheet works only one way: It shows the results at the most detailed level, but the cells are filled in by calculations on the Input worksheet.

Table 37. Worksheet RAW EuP EcoReport

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: RAW OUTPUTS
Assessment of Environmental Impact

Nr:	**0**	**Product:**	**0**	**Date:**	**0**	**Author:**	0

MATERIALS EXTRACTION & PRODUCTION

	Product				Energy			Water		Waste		Emissions to Air							to Water	
nr	component	weight	cat.	material	GER	electr	feedst	water (proces)	water (cool)	haz. Waste	non-haz. Waste	GWP	AD	VOC	POP	HM	PAH	PM	Metal	EUP
		in g			MJ	MJ	MJ	ltr.	ltr.	g	g	kg CO_2 eq	g SO_2 eq	g	ng i-Teq	mg / mg Ni. Eq.		g	mg Hg / 20 eq	mg PO4 eq
1	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
2	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
3	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
4	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
5	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
6	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
7	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
8	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
9	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
10	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
11	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
12	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
13	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
14	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00
15	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0/0.0		0.00	0.00	0.00

6 MARKET ANALYSIS

6.1 Introduction

The role of the market analysis is defined first of all by the directive itself, as is indicated in Article 12, sub 1a: *"..the EuP shall represent a significant volume of sales and trade.."* . Second, market and economic data are important inputs for the environmental impact analysis and the assessment of the improvement potential. But perhaps the most important contribution of the market analysis is in identifying barriers to trade in general.

The Ecodesign of EuP Directive is based on Article 95 of the Treaty establishing the European Community. In other words, as the first and third consideration of the directive stipulate:

(1) The disparities between the laws or administrative measures adopted by the Member States as regards the eco-design of energy using products can create barriers to trade and distort competition in the Community and may thus have a direct impact on the establishment and functioning of the internal market. The harmonisation of national laws is the only means to prevent such barriers to trade and unfair competition.

(3) A coherent framework for the application of Community eco-design requirements for EuPs should be established with the aim of ensuring the free movement of those products which comply and of improving their overall environmental impact. Such Community requirements should respect the principles of international trade.

As a consequence, the first paragraph of Article 1 of the Directive says:

(Article 1, Subject matter and scope)

1. This Directive establishes a framework for the integration of environmental aspects in product design and development to ensure the free movement of energy-using products within the internal market.

The tool used in the Directive is CE conformity marking, with all its consequences as laid down in Articles 3 to 11. In order for CE conformity marking to work, the first prerequisite is to make a clear, comprehensive and legislatively univocal **definition** of the products to which Community eco-design requirements apply. The subject of Product Definition is treated in par. *6.2*.

Following the principles of subsidiarity and proportionality, a large part of the consequences of Articles 3 and 11 are directed towards the Member States. Furthermore, the Directive is a so-called New Approach directive, seeking to simplify legislation by referring to **harmonised EU test standards**. In this context it is relevant to know which standards exist. This is discussed in par. *6.3*.

Being designed to alleviate trade barriers and '*respect the principles of international trade*', it is very relevant to make an inventory of the **existing product-specific legislation**, both within the EU Member States and globally. This is discussed in par. *6.4*.

Implementing measures under the Directive also constitute an administrative effort not only by the stakeholders but also by the Member States. For that reason -also following the principles of proportionality- the eligible products or product groups should not be products of which only a few "one-offs" or a small client-specific product series are made. This is covered in Article 12, par. 2, sub a. (see Chapter 1): *"EuP shall represent a significant volume of sales and trade, indicatively more than 200 000 units a year within the Community according to most recently available figures"*.

Under the heading "**generic economic data**" paragraph 6.5 will propose a methodology to assess general consumption and trade figures, using easily accessible and comprehensible data sources. Furthermore, it will indicate which product group classifications –like Eurostat's PRODCOM-- are available from these data sources that can help to underpin the product definition. This is then illustrated with some outcomes of the Product Cases.

In a second instance, the function of the market analysis is to supply commercial and economic inputs to the environmental impact analysis, the improvement potential and the definition of the average EU product (the so-called "Base-Case").

EU sales data are an important complement to the environmental impact analysis per product, as explained in the previous chapter. They allow the assessment of the total environmental impact –over their product life-- of the products sold/designed in the EU in a particular year. E.g. for 10 mln. products sold/designed in 2005 it sums the projected impact of the production, use and end-of-life it sums the total impact. This is discussed in paragraph 6.6.

If the average product-life of these products is 10 years, this would span a projection period 2005-2015. Furthermore, the market analysis should provide the sales data not only in the most recent year, but preferably there should be a time series of sales data that allows to make a stock model. An assessment of the **stock of products already installed and used** in the market allows the assessment of the total environmental impact of a product group in one particular year. This is discussed in paragraph 6.7.

The difference between the environmental impacts mentioned in paragraph 6.6 and 6.7 require some explanation, especially because for saturated markets with mainly replacement sales it is almost identical. In paragraph 6.6 one looks at products made and sold e.g. in 2005 and –using the product life and consumer behaviour as an input— projects their resources use over a product-life up to e.g. 2015. Around that year they will be discarded and/or recycled in a way that is not known today, but where one has to use an assumption or a future-oriented scenario. Effectively, this is the parameter that implementing measures aim to influence. But policy makers that are trying to position the environmental impact of a product group in a particular year, say 2005, will be more interested in the second parameter, which does not look in the future but describes mainly the effect of the products designed in the past (say 1995-2005) on the resources and emissions today. As mentioned, in a steady market the outcome of the two parameters will be similar, but in markets with e.g. a strong growth rate they can be very different.

Figure 13 illustrates the difference graphically (and simplified). The sum of the top row is the first parameter as discussed in paragraph 6.6: This sums the impact of all products sold in 2005 over their product life. The sum of the first column is the second parameter discussed in paragraph 6.7: It looks at the environmental impact of the production of products sold in 2005 –which is an overlap with the first parameter—but then sums the impact of the use phase and End-of-Life of these products in the same year 2005. Assuming a product life of 10 years, this means that we are actually looking at the past, i.e. products that were sold in the 1995-2005 period.

EU market and stock data are a very relevant input for the assessment of the improvement potential and specifically the impact analysis of certain possible implementing measures. As mentioned in Chapter 2, the EuP distinguish themselves from e.g. packaging and foodstuffs in terms of a significantly longer product-life, e.g. ranging from 3-5 years for small appliances up to 25 years for central heating devices. For policy makers trying to incorporate the effect of Ecodesign in policy objectives it is very important to recognize this characteristic of EuP. Furthermore, in the event of a major progress in environmental improvement regarding product-life, they may even contemplate using additional measures to temporarily speed up the replacement process.[68]

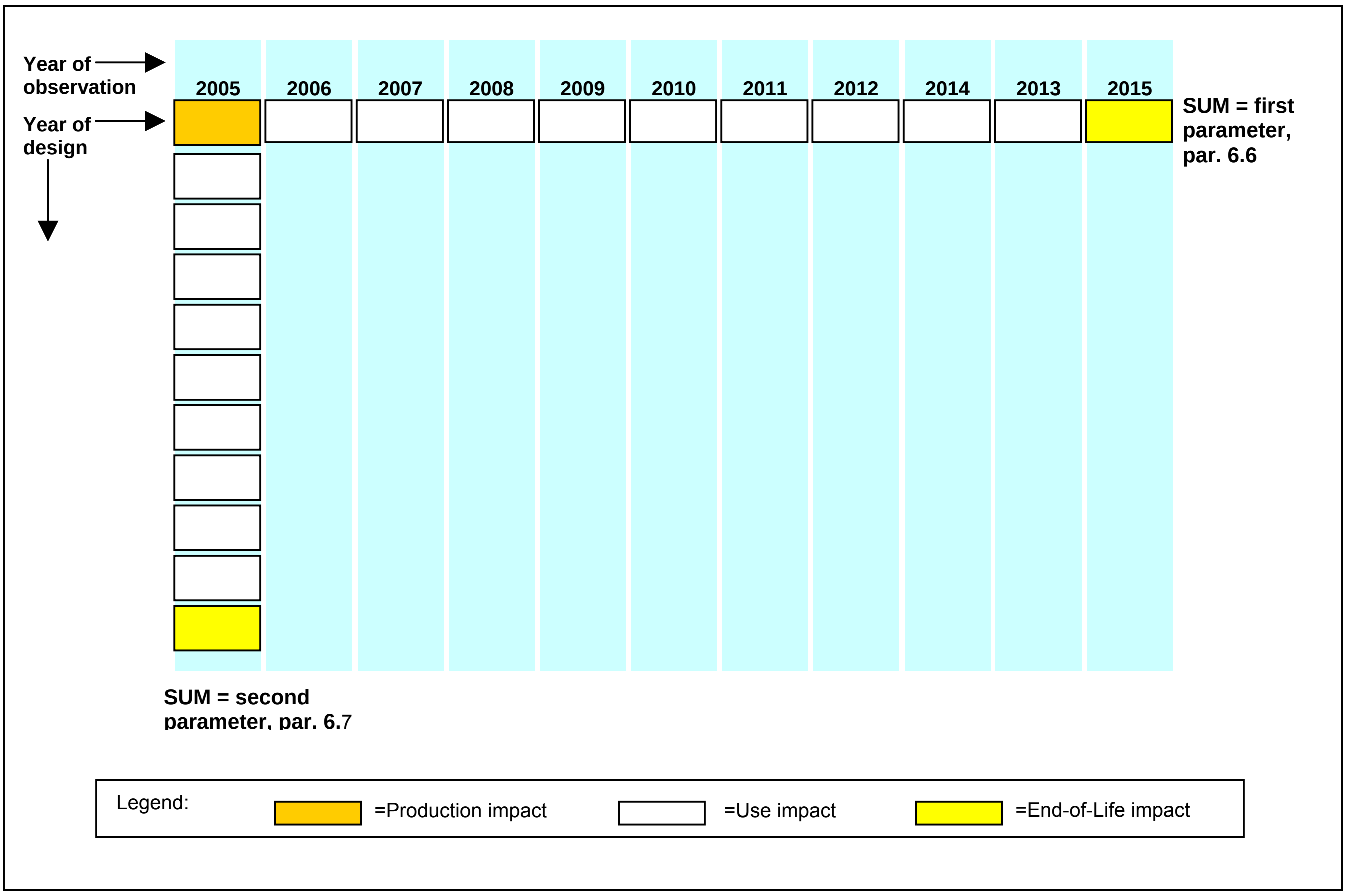

Figure 9. Difference between first and second parameter. The first sums the impact of X products over 10 years. The second sums the impact of 10X products in 1 year. (10=avg. product life, X=volume produced in 1 year)

General market trends, e.g. changes in design features and functionality, are another relevant input for the impact analysis. At least a part of the commercial impact of implementing directives --for the industry and the retail sector—will be measured against whether the directive would be in line with current market and design trends or whether it is opposed to what consumers appear to desire. This is discussed in paragraph 6.8.

[68] Compare similar measures with cars.

Finally, the “market analysis” is a source of **inputs for defining the Base-Case**, i.e. the average EU machine. It provides the price of the product, the rates of the resources used, etc. This is discussed in paragraph 6.9.

All in all, the methodology for the market analysis should provide the answers to a checklist of questions that are vital for any implementing directive under the Ecodesign of EuP Directive:

- ✓ Is there clear, comprehensive and legislatively univocal product-definition?
- ✓ Are there harmonised test standards to assess the most important environmental impact?
- ✓ What is the already existing product-specific legislation –and thereby potential trade barriers between Member States and globally-- relating to the most important environmental impacts?
- ✓ Does the EuP represent a significant volume of sales and trade(indicatively more than 200 000 units a year)?
- ✓ Are there sales and stock data that are reliable enough to assess the impact of measures?
- ✓ Is there enough insight in general market trends to predict, together with the sales and stock data, a reference “Business-as-Usual” scenario?
- ✓ Do we have accurate economic data (prices, rates, etc.) to build a sufficiently reliable Base-Case (EU average product) to be used as a basis for improvements?

6.2 Product Definition and Classification

6.2.1 General considerations

The Product Definition serves to determine whether or not the CE-marking of a product is subject to an implementing measure under the Ecodesign of EuP Directive, therefore it is a necessary technical ingredient. What we argue here is that it also is a relevant factor to determine whether a product is eligible for implementing measures: The extend of the definition of a product group is determining the significance of its economical, commercial and environmental impact. If we define a product group too wide –e.g. “Motors” or “Heating devices”- the statistics will show it to have an enormous impact. If we define a product group too narrow –e.g. “Electric motors, 1-15 kW, for use in industrial pumps of hypochloric acid”— not only the total impact will seem negligible but –more importantly- the improvement potential will seem negligible.

What we are looking for is a product group that is functionally similar. And as a consequence a similar group of design options would apply to improve its environmental performance. As mentioned in paragraph 3.3.8 (*functional parameter*), the assessment of the product function(s) is not as easy as it seems: In practice many products are distinguished on the basis of their specific technology[69] and the fact that the Ecodesign of EuP Directive also includes not only *final products* but also *components* doesn’t make it any easier. Like in par. 3.3.8 we do not expect that a general methodology will solve all problems related to the product definition and specific

[69] E.g. CRT vs. LCD TV, inkjet vs. electrostatic imaging equipment.

ad-hoc discussions will be needed. The Product Cases Report provides some guidance in how to solve these problems on an ad-hoc basis.

Having said that, a methodology can supply a general starting point of the discussion. In that sense we have looked for product definitions and a classifications already in use in the EU, e.g. in

- EU statistics;
- technical standards (EN, ISO);
- product-labelling.

Each of these sources –when available-- is discussed with our Product Cases. As a general rule, the technical EN/ISO standards and the product labels supply the most detailed description of the product definition they are dealing with. However, standards and labels are usually developed on an ad-hoc basis; there is no wider classification scheme that would allow a generally applicable methodology on this.

For classifications used in statistics this is different. Systematic product classification is a vital subject for trade and production world-wide. The US uses its SIC[70] , Europe the NACE[71] /PRODCOM[72] classification and the UN statistics office UNSTAT uses the less detailed ISIC[73], to name just a few. There is a continuous global harmonisation effort[74] and an established practice of translating product-codes between countries/regions.

For our purpose, the most appropriate source is the PRODCOM classification, as it is one of the most detailed classifications for product statistics available in the EU, containing some5000 product-codes. Furthermore, it is in line with the harmonised CPA (Classification of Products by Activity)[75]. Although –as mentioned above—in the final version of implementing directives the product definition has to be dealt with in more detail, this PRODCOM classification can be helpful in product classification at the level of product eligibility. This will be illustrated in the following paragraphs.

6.2.2 PRODCOM

The PRODCOM classification has an 8-digit product code. The first two digits specify sectors of the economy at the ISIC/NACE top-level. This top-level used to consist of 17 sections (A-Q) but in PRODCOM is indicated by its sub-section level, indicated by a 2-digit code running from 01 (Agriculture) to 99 (International Bodies). For EuP the most relevant section is “D” (*Manufacturing*), especially the sub-sections

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[70] SIC= (US) Standard Industrial Classification.

[71] The acronym "NACE" derives from the French title: Nomenclature générale des activités économiques dans les. Communautés Européennes.

[72] PRODCOM=PRODucts of the European COMmunity. The 8-digit PRODCOM code is a more detailed extension of the 4-digit NACE product classes.

[73] ISIC=International Standard Industrial Classification of All Economic Activities, used by UNSTAT. See http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=17&Lg=1

[74] For instance NACE Rev.1 is harmonised with ISIC Rev. 3.1.

[75] See http://europa.eu.int/comm/eurostat/ramon/other_documents/intro_cpa1996/en.cfm

28 - Manufacture of fabricated metal products, except machinery and equipment
29 - Manufacture of machinery and equipment n.e.c.
30 - Manufacture of office, accounting and computing machinery
31 - Manufacture of electrical machinery and apparatus n.e.c.
32 - Manufacture of radio, television and communication equipment and apparatus
33 - Manufacture of medical, precision and optical instruments, watches and clocks

At the 4-digit level, the EU and UN and US product classifications are no longer identical, but there is an "international concordance" on for instance the coverage of US SIC classes and the EU NACE classes. NACE descriptions for sub-sections 28-33 are given in the following table. Product groups that are most likely to contain eligible products are highlighted in a bold font.

Table 38. NACE product groups at 4-digit level in sub-sections 28 to 33 (source Eurostat).

28.11	metal structures and parts of structures	30.01	office machinery
28.12	builders' carpentry and joinery of metal	30.02	computers and other information processing equipment
28.21	tanks, reservoirs and containers of metal		
28.22	central heating radiators and boilers		
28.30	steam generators, except central heating hot water boilers*		
28.40	Forging, pressing, stamping and roll forming of metal; powder metallurgy		
28.51	Treatment and coating of metals		
28.52	General mechanical engineering	31.10	electric motors, generators and transformers
28.61	cutlery	31.20	electricity distribution and control apparatus
28.62	tools	31.30	insulated wire and cable
28.63	locks and hinges	31.40	accumulators, primary cells and primary batteries
28.71	steel drums and similar containers	31.50	lighting equipment and electric lamps
28.72	light metal packaging	31.61	electrical equipment for engines and vehicles n.e.c.
28.73	wire products	31.62	other electrical equipment n.e.c.
28.74	fasteners, screw machine products, chain and springs		
28.75	other fabricated metal products n.e.c.		
		32.10	electronic valves and tubes and other electronic components
29.11	engines and turbines, except aircraft, vehicle/cycle engines		
29.12	pumps and compressors	32.20	television and radio transmitters and apparatus for line telephony and line telegraphy
29.13	taps and valves		
29.14	bearings, gears, gearing and driving elements	32.30	television and radio receivers, sound or video recording or reproducing apparatus and associated goods
29.21	furnaces and furnace burners		
29.22	lifting and handling equipment		
29.23	non-domestic cooling and ventilation equipment		
29.24	other general purpose machinery n.e.c.		
29.31	agricultural tractors		
29.32	other agricultural and forestry machinery	33.10	medical and surgical equipment and orthopaedic appliances
29.41	portable hand held power tools	33.20	instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
29.42	other metalworking machine tools		
29.43	other machine tools n.e.c.		
29.51	machinery for metallurgy	33.30	industrial process control equipment
29.52	machinery for mining, quarrying and construction	33.40	optical instruments and photographic equipment
29.53	machinery for food, beverage and tobacco processing	33.50	watches and clocks
29.54	machinery for textile, apparel and leather production		
29.55	machinery for paper and paperboard production		
29.56	other special purpose machinery n.e.c.		Bold font= most likely to contain eligible EuP
29.60	weapons and ammunition		
29.71	electric domestic appliances		
29.72	non-electric domestic appliances		

There are over 200 NACE "product groups" defined at 4-digit level. Sub-sections 28 to 33 contain 54 product groups of which 16 are likely to contain eligible EuP. As can be seen from the descriptions, the NACE classes are generally too big and heterogeneous to be addressed by a single implementing measure.

At the 6-digit level, the PRODCOM classification distinguishes a bit more than 1300 product classes in sub-sections 1 to 40. In the sub-sections 28 to 33, where most of the EuP are classified, there are approximately 400 product classes. As also can be seen from table 39, this 6-digit level would seem appropriate for many products. There we find, e.g. for our Product Cases, the following descriptions:

Table 39. Some examples of PRODCOM definitions at 6-digit level (source: Eurostat)

28.22.12	**Central heating boilers**
29.12.24	**Centrifugal and roto-dynamic pumps**
29.23.12	**Air conditioning machines**
29.71.11	**Refrigerators and freezers (domestic)**
29.71.12	**Household dishwashing machines**
29.71.21	**Small domestic electro-mechanical cleaning devices (vacuum cleaners, floor polishers, grinders, etc.)**
30.01.21	**Photocopiers**
30.02.12	**Laptops and palmtop organizers**
30.02.13	**Desktop PCs**
31.50.15	**Discharge lamps**
32.30.20	**Televisions, monitors and related equipment (decoders, tuners, etc.)**

The 6-digit product classes are therefore a good starting point for eligibility-scan, but with reservations. For refrigerators & freezers (29.71.11), as well as dishwashers (29.71.12) the 6-digit level is about right. CH boilers (28.22.12) and copiers (30.01.21) need to be trimmed at 8-digit level to exclude some low-volume products. Our product case "Personal Computers" needs even two 6-digit classes (30.02.12 and 30.02.13), but the 6-digit level is still appropriate. Only for our product cases "circulators", that are in the same category as large multi-stage centrifugal pumps, and "vacuum cleaners", that are in the same category as floor polishers and kitchen grinders, the 6-digit level is clearly too wide.

At the 8-digit level, the PRODCOM classification features almost 6,800 products. In the sub-sections 28 to 32, where most of the EuP are classified, there are approximately 1500-2000 products. This product level will be too detailed for policy makers, unless –as is the case with the circulators and vacuum cleaners—we are talking of consumer products and components with a very high volume production. Only in those specific cases, the 8-digit level or a small group of products at the 8-digit level will be appropriate. Examples of descriptions

PRODCOM 29.12.24.17 Glandless impeller pumps for heating systems and warm water supply
PRODCOM 29.71.21.13 Domestic vacuum cleaners with a self-contained electric motor for a voltage >= 110 V

The complete PRODCOM list can be downloaded from the EU-server.[76]

[76] http://europa.eu.int/comm/eurostat/ramon/other_documents/index.cfm?TargetUrl=DSP_OTHER_DOC_DTL

Summarizing, the PRODCOM 6-digit level seems to be the most appropriate starting point for a product definition/classification with exceptions at the 8-digit level for mass-produced consumer goods and components.[77]

6.3 Existing product-specific legislation

As the Directive is designed –amongst others-- to alleviate trade barriers in the internal EU market, the (imminent) existence of product-specific legislation in Member States is an important eligibility criterion. For the Product Cases we investigated this is only the case for installed appliances, i.e. Heating, Ventilation and Air Conditioning devices (HVAC) linked to the building construction as well as Water Heaters. In some countries also Lighting Fixtures are regulated. For these products trade and production is not regulated directly, but often Building Regulations and similar legislation is regulating the application of certain types in buildings. Examples are Germany, where the Energie Einspar Verordnung (ENEV) is in effect hindering the installation of low-efficiency Central Heating Boilers in newly built and part of the replacement market, and the United Kingdom, where this year (2005) only condensing CH boilers would be allowed. This fact alone would make HVAC appliances, as well as Water Heaters and Lighting Fixtures priority subjects for implementing directives aimed at harmonizing the EU internal market. Furthermore, they are products subject to other EU legislation such as the Energy Performance of Buildings directive.

A second eligibility criterion is, whether product-specific environmental legislation exists outside the EU. First of all, for reasons of promoting the EU-export there is an interest to bring EU-legislation in line with global standards. Second, if the EU has no or very lenient legislation there is a risk that it can become an "international dumping ground" for products that are prohibited in other countries.

The tables on the following pages, composed by the Australian NACEEE, give an overview of the global product-specific Minimum Energy Efficiency Performance Standards (MEEPS) and the global labelling activities.

[77] E.g. small motors

Table 40. Summary of MEPS Worldwide ([78])

Product subject to Minimum Efficiency Performance Standard (MEPS)	Australia	Canada	Chile	China	Colombia	Costa Rica	EU-25	Ghana	India	Iran	Israel	Japan	Korea	Malaysia	Mexico	New Zealand	Peru	Philippines	Russia	Saudi Arabia	Singapore	Chinese Taipei	Tunisia	U.S.A.
Air Conditioner - Central	M	M	-	-	-	-	-	-	-	-	-	-	-	-	M	M	-	-	-	-	-	-	-	M
Air Conditioner - Room	M	M	?	M	M	M	V	M	V	-	M	T	M	-	M	M	-	M	M	?	M	M	P	M
Air Conditioner - Large HP & condenser	M	M	-	-	-	-	-	-	-	-	-	-	-	-		M	-	-	-	-	-	-	P	M
Air Conditioner - Packaged terminal & HP	M	M	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	M
Air ond., Single-p central/ HP	M	M	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	M
Air Conditioner - Split System central & HP	M	M	-	-	-	-	-	-	-	-	-	-	-	-	M	M	-	M	M	V	-	-	-	M
Audio Equipment	S	-	-	M	-	-	S	-	-	-	-	-	S	-	-	-	-	-	M	-	-	-	-	S
Ballasts	M	M	-	M	M	M	M	-	-	-	-	T	M	M	-	M	-	M	-	-	-	-	-	M
Boilers	-	M	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-	M
Clothes Dryers	S	M	?	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	M
Clothes Washer Dryers Int.	S	M	?	M	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M
Clothes Washers	S	M	-	-	-	-	-	-	-	-	M	-	S	-	M	-	-	-	-	-	-	-	-	M
Computers	P	-	-	-	-	-	-	-	-	-	-	T	S	-	-	p	-	-	M	-	-	-	-	S
Copiers	S	-	-	-	-	-	-	-	-	-	-	T	-	-	-	-	-	-	-	-	-	-	-	S
Dehumidifiers	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dishwashers	S	M	?	-	-	-	V	-	-	-	M	-	M	-	-	-	-	-	M	-	-	-	-	M
Fans	-	-	-	M	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	M	-	-
Fax Machines	S	-	-	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	-	-	-	-	-	S
Freezers	M	M	?	-	M	M	M	-	-	-	M	T	-	-	-	M	-	-	M	V	-	O	-	M
Furnaces	-	M	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	M
Hard-disk Drives	-							-	-	-	-	T	-	-			-				-			
Heat Pumps	P	M	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-	M
Icemakers	P	M	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-
Irons	-		-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lamps	M	M	-	M	M	M	-	-	-	-	M	T	M	-	M	M	M?	M	-	-	-	M	-	M
Monitors	P	-	-	-	-	-	-	-	-	-	-	-	S	-	-	P	-	-	M	-	-	-	-	S
Motors	M	M	M	M	M	M	V	-	-	-	-	-	-	V	M	M	M?	-	-	-	-	M	-	M
Power supplies (low V, int/ext.)	P	-	-	P	-	-	V	-	-	-	-	-	S	-		P	-	-	-	-	-	-	-	-
Printers	S	-	-	-	-	-	-	-	-	-	-	-	S	-	-	-	-	-	M	-	-	-	-	S
Pumps	-	-	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	-
Ranges/Ovens	-	M	-	-	-	-	-	-	-	-	M	T	-	-	-	-	-	-	M	-	-	M	-	-
Refrigerators	M	M	M	M	M	M	M	-	V	M	M	T	M	-	M	M	M?	M	M	V	-	M	M	M
Rice Cookers	-	-	-	M	-	-	-	-	-	-	-	-	M	-	-	-	-	-	-	-	-	M	-	-
Scanners	-	-	-	-	-	-	-	-	-	-	-	-	M	-	-	-	-	-	M	-	-	-	-	-
Set-Top Boxes	P	-	-	-	-	-	V	-	-	-	-	-	S	-	-	P	-	-	-	-	-	-	-	-
Solar Water Heating	-	-	-	-	M	M	-	-	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heaters	M	M	-	-	-	-	-	-	-	-	M	T	M	-	-	-	-	-	-	-	-	-	-	M
Televisions	P	-	-	M	-	-	S	-	-	-	-	T	S	-	-	P	-	-	M	-	-	-	-	S
Transformers	M	M	-	-	-	-	-	-	-	-	-	T	-	-	M	M	-	-	-	-	-	-	-	-
VCRs and/or DVDs	S	-	-	-	-	-	S	-	-	-	-	T	S	-	-	-	-	-	-	-	-	-	-	S
Water Chillers (large buildings)	P	M	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	M	-	-
Water Dispensers	P	-	-	-	-	-	-	-	-	-	-	-	M	-	-	P	-	-	-	-	-	-	-	-
Water Heaters	M	M	M	-	M	M	V	-	-	-	M	T	-	-	M	M	M?	-	M	-	-	M	-	M

M= Mandatory, V= Voluntary, S= Standby Target, P=Proposed Mandatory Program

[78] VHK from source: Harrington, L., Damnics, M., Labelling and Standards Programs throughout The World, NAEEEC, AU, 2004

Table 41. Part 1: Summary of Labelling Programs Worldwide 2004 ([79]).

Product	Argentina		Australia		Brazil		Canada		Chile		China		Colombia		Costa Rica		Croatia		EU-25		Hong Kong		India		Indonesia		Iran		Israel	
Type of Label	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E
Air Conditioner - Central	-	-	V	-	-	-	V	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Conditioner - Room	-	-	M	V	V	M	M	V	-	-	P	V	M	-	M	-	-	-	M	-	V	-	P	-	-	-	M	-	M	-
Air Conditioner - Split System	-	-	M	V	-	-	V	-	-	-	-	-	-	-	-	-	-	-	M	-	V	-	-	-	-	-	-	-	-	-
Air cond., Single-p central/ HP	-	-	V	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Compressor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Audio Equipment	-	-	-	V	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-
Ballasts	-	-	O	-	-	M		V	-	-	-	V	M	-	M	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-
Boilers	-	-	M	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clothes Dryers	-	-	M	V	-	-	-	-	-	-	-	-	-	-	-	-	M	-	M	-	V	-	-	-	-	-	-	-	-	-
Clothes Washer Dryers Int.	-	-	M	V	-	-	M	-	-	-	-	-	-	-	-	-	M	-	M	-	-	-	-	-	-	-	-	-	-	-
Clothes Washers	-	-	-	V	-	M	M	-	-	-	-	-	-	-	-	-	M	-	M	V	V	-	-	-	-	-	-	-	M	-
Computers	-	-	-	V	-	-	M	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-
Copiers	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	V	-	-	-	-	-	-	-	-	-
Dehumidifiers	-	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-
Dishwashers	-	-	-	V	-	-	M	-	-	-	-	-	-	-	-	-	M	-	M	V	-	-	-	-	-	-	-	-	M	-
Fans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-
Fax Machines	M	-	M	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-
Freezers	-	-	-	V	V	M	M	-	-	-	-	V	M	-	M	-	M	-	M	V	-	-	-	-	-	-	-	-	M	-
Furnaces	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Pumps	-	-	M	V	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heaters-Space	-	-	M	V	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
Heaters -Gas Fireplaces	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heaters- Gas Central	-	-	M	V	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lamps	-	-	V	-	-	M	-	-	-	-	-	V	M	-	M	-	M	-	M	V	-	V	-	V	-	-	-	-	V	-
Microwave Oven	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monitors	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	V	-	-	-	-	-	-	-	-	-
Motors	-	-	O	-	-	-	-	-	-	-	-	V	M	-	M	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-
Multi-Funct. Device (MFD)	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	V	-	-	-	-	-	-	-	-	-
Printers	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	V	-	-	-	-	-	-	-	-	-
Pumps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranges/Ovens	-		-	-	-	-	M	-	-	-	-	-	-	-	M	-	M	-	M	-	-	-	-	V	-	-	-	-	M	-
Refrigerators	M	-	M	V	V	M	M	V	?	?	P	V	M	-	M	-	M	-	M	V	V	-	P	V	V	-	M	-	M	-
Rice Cookers	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-
Scanners	-	-	-	V	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-
Solar Water Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M	-
Televisions	-	-	P	V	-	-	-	V	-	-	-	V	-	-	-	-	-	-	-	V	-	V	-	V	-	-	-	-	-	-
Transformers	-	-	O	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VCRs and/or DVDs	-	-	-	V	-	-	-	V	-	-	-	V	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-
Water Dispensers	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Heaters	-	-	V	V	-	-	-	V	-	-	-	V	M	-	M	-	-	-	-	-	V	-	-	V	-	-	-	-	M	-

C= Comparative label, E= Endorsement label, M= Mandatory, V= Voluntary, ?= Label Status Unknown, P=Proposed Program O=Other efficiency marking system

[79] VHK from source: Harrington, L., Damnics, M., Labelling and Standards Programs throughout The World, NAEEEC, AU, 2004

Table 42. Part 2: Summary of Labelling Programs Worldwide 2004 ([80]).

Product	Jamaica		Japan		Korea		Mexico		New Zealand		Norway		Philippines		Russia		Singapore		Sri Lanka		South Africa		Chinese Taipei		Thailand		Tunisia		U.S.A.	
Type of Label-->	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E
Air Conditioner - Central	-	-	-	-	**M**	-	**M**	-	**V**	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	**M**	V
Air Conditioner - Room	-	-	**V**	-	**M**	-	**M**	V	**M**	-	**M**	-	**M**	-	-	-	**V**	V	-	-	**P**	-	**O**	V	**V**	V	**P**	-	**M**	V
Air Conditioner - Split System	-	-	**V**	-	**M**	-	**M**	V	**M**	-	**M**	-	**M**	-	-	-	**V**	V	-	-	**P**	-	**O**	V	**V**	V	**P**	-	**M**	-
Air cond., Single-p central/ HP	-	-	-	-	**M**	-	**M**	-	**V**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**M**	V
Air Compressor	-	-	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Audio Equipment	-	-	-	V	-	-	-	-	-	V	-	V	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
Ballasts	-	-	-	-	**M**	-	**M**	-	**O**	-	-	-	**V**	-	-	-	-	-	**V**	-	-	-	-	-	-	V	-	-	-	V
Boilers	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**M**	V
Clothes Dryers	-	-	-	-	-	-	-	-	**M**	-	**M**	-	-	-	-	-	-	-	-	-	**P**	-	**V**	-	-	-	-	-	-	V
Clothes Washer Dryers Int.	-	-	-	-	-	-	-	-	**M**	-	**M**	-	-	-	-	-	-	-	-	-	**P**	-	-	-	-	-	-	-	-	-
Clothes Washers	-	-	-	-	**M**	-	**M**	V	**M**	-	**M**	V	-	-	-	-	-	V	-	-	**P**	-	**O**	V	-	V	-	-	**M**	V
Computers	-	-	**V**	V	-	V	-	-	-	V	-	-	-	-	-	-	-	V	-	-	-	-	-	V	-	V	-	-	-	V
Copiers	-	-	**V**	V	-	V	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	V	-	-	-	V
Dehumidifiers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
Dishwashers	-	-	-	-	**M**	-	-	-	**M**	-	**M**	V	-	-	-	-	-	-	-	-	**P**	-	-	V	-	-	-	-	**M**	V
Fans	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V
Fax Machines	-	-	-	V	-	V	-	-	-	V	-	V	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
Freezers	**M**	-	**V**	-	**M**	-	**M**	V	**M**	-	**M**	V	**M**	-	-	-	**V**	V	-	-	**P**	-	**O**	V	-	-	-	-	**M**	V
Furnaces	-	-	-	-	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**M**	V
Heat Pumps	-	-	-	-	**M**	-	-	-	**M**	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**M**	V
Heaters-Space	-	-	**V**	-	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**M**	V
Heaters -Gas Fireplaces	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heaters- Gas Central	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**M**	V
Lamps	-	-	**V**	-	**M**	V	**M**	V	**V**	-	**M**	-	**M**	-	-	-	-	V	**V**	-	**P**	-	-	V	-	V	-	-	**M**	V
Microwave Oven	-	-	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monitors	-	-	-	V	-	V	-	-	-	V	-	V	-	-	-	-	-	V	-	-	-	-	-	V	-	-	-	-	-	V
Motors	-	-	-	-	-	V	-	V	**O**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-
Multi-Funct. Device (MFD)	-	-	-	V	-	V	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
Printers	-	-	-	V	-	V	-	-	-	V	-	V	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
Pumps	-	-	-	-	-	V	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranges/Ovens	-	-	**V**	-	-	-	-	-	-	-	**M**	-	-	-	-	-	-	-	-	-	**P**	-	-	V	-	-	-	-	-	V
Refrigerators	**M**	-	**V**	-	**M**	-	**M**	V	**M**	-	**M**	V	**M**	-	**V**	-	**V**	V	-	-	**P**	-	**O**	V	**V**	V	**M**	-	**M**	V
Rice Cookers	-	-	-	-	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scanners	-	-	-	V	-	V	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
Solar Water Heating	-	-	-	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	-
Televisions	-	-	**V**	V	-	V	-	V	**P**	V	-	V	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
Transformers	-	-	**V**	-	-	V	-	-	**O**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
VCRs and/or DVDs	-	-	-	V	-	V	-	-	-	V	-	V	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	-	V
Water Dispensers	-	-	-	-	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Heaters	-	-	**V**	-	-	-	**M**	-	**V**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	-	-	-	-	**M**	-

C= Comparative label, E= Endorsement label, M= Mandatory, V= Voluntary, ?= Label Status Unknown, P=Proposed Program O=Other efficiency marking system

[80] VHK from source: Harrington, L., Damnics, M., Labelling and Standards Programs throughout The World, NAEEEC, AU, 2004

6.4 Generic economic data

To establish whether a product group represents a significant volume of sales and trade it makes sense to start from Eurostat's product-specific statistics. For trade and production these are the so-called PRODCOM statistics, combining the production statistics from national statistics offices in Member States with EU custom's statistics.

Advantages of using this source are:

- It is an official EU-source that is also used and referenced in other EU policy documents regarding trade and economic policy, guaranteeing EU consistency;
- It provides the necessary data, both in physical and monetary units: Intra- and extra-EU trade figures are provided directly. The volume of sales can be derived from the "apparent consumption" (= production + imports – exports), for which it provides all ingredients;
- It provides a consistent and coherent product classification with appropriate product definitions, based on an 8-digit code;
- It is complete in a sense that this one source is covering all product categories;
- It is a free and public source and can be consulted on-line.[81]

In short, it is the easiest way to check for a broad range of products whether they meet the eligibility criterion of Art. 12, par. 2, sub a.

For each of the Product Cases VHK has retrieved:

- The relevant PRODCOM categories (par. 1.1, Product Category, of each case report);
- The trade volume in the PRODCOM statistics, subdivided in intra-EU and extra-EU imports and exports (case reports, par. 2.1, Generic economic data), as well as;
- The production, which is a necessary ingredient –with the trade figures—to calculate the "apparent consumption", a derived parameter that is also given (case reports, par. 2.1, Generic economic data).

The table on the next page summarizes the outcomes for the Product Cases. Please note that the table just shows the extra-EU trade. For the intra-EU trade we refer to the separate Report on Product Cases (Appendix 2). The table shows that all products answer to the requirement of a volume of sales/trade of a minimum of 200,000 units per year.

[81] Link: http://europa.eu.int/comm/eurostat/newcronos/reference/display.do?screen=welcomeref&open=/industry/prod&language=en&product=EU_industry_trade_services&root=EU_industry_trade_services&scrollto=0

6.5 Market and stock data

For all its merits as a "quick-scan" tool for economic significance, the PRODCOM data also have –for our purpose- some serious flaws:

- It does not provide data on the stock of products already in use (a.k.a. "Installed Base"), nor does it say anything about the average product life, which would help in calculating that stock;
- It does not incorporate end-year stock effects;
- The PRODCOM sub-categorisation was designed for customs use and is not conform the sub-categorisation normally used by industry and other stakeholders, and;
- Last but not least, for several technical reasons, the PRODCOM data have a limited reliability and –if one wants a reasonable coverage of data of all Member States—runs several years behind.

The limited reliability is caused by:

1. Customs definitions of products are on a practical level still being harmonised;
2. The definitions keep changing, which sometimes gives very strange bumps in time series for specific products;
3. Old habits die hard: Once manufacturers are used to report under one specific PRODCOM number, most will continue to do so even if the definitions change;
4. For production figures industry is allowed to report with a 3 year delay, which they all do. So "2002" means "1999";
5. Very big (almost monopolist) manufacturers with a high-market share are sometimes exempt from reporting their data publicly because it would reveal confidential company information. This is still indicated with "n.a." in the national MS statistics, but in the larger and aggregated Eurostat data this would be to complicated and they are just not counted ("0");
6. Very small manufacturers (SME) are sometimes also allowed not to report annually but it is sufficient to do this only with large census questionnaires. So these data can lag more than 3 years behind or not be a part of the statistics at all.

Table 43. MEEUP Product Cases: EU production and (extra-) EU trade 2002 according to PRODCOM (source: Eurostat, 2005)

PRODCOM Category (Cases)	EU production		EU Exports		EU Imports		EU consumption	
	000 units	mln. Euro	000 units	mln. Euro	000 units	mln. Euro	000 units	mln. Euro
1. CH Boilers 2002	**6948**	**5622**	**-**	**1842**	**-**	**1329**	**6283**	**5109**
of which								
28221200 (no HS 8402)	5241	4041	-	1842	-	1329	4576	3528
28221203 (gas)	1125	853	-	-	-	-	1125	853
28221205 (oil)	367	423	-	-	-	-	367	423
28221207 (other fuel)	215	305	-	-	-	-	215	305
2. Circulators CH systems 2000								
29122417 (glandless impeller pumps for..)	12480	699	1450	81	162	11	11192	629
3. Street Lighting '02								
31501553 (mercury vapour)	-	207	-	7	-	16	-	216
31501556 (sodium vapour other than UV)	5942	85	-	19	-	23	5942	89
4. Fridges & Freezers 2000-'02	**21216**	**4361**	**2000**	**763**	**3000**	**918**	**22216**	**4516**
29711110 (fridge-freezer)	5034	1145	-	-	-	-	-	-
29711133 (fridge, free-standing)	7380	1325	-	-	-	-	-	-
29711135 (fridge, built-in)	2767	563	-	-	-	-	-	-
29711150 (chest-freezer)	1884	362	-	-	-	-	-	-
29711170 (upright freezer)	4151	966	-	-	-	-	-	-
5. Dishwashers '02								
29711200 (Household DW)	**6779**	**1945**	**-**	**334**	**-**	**39**	**6779**	**1650**
6. Vacuum cleaners '02								
29712113 (domestic VC)	**10196**	**1111**	**-**	**274**	**-**	**530**	**10196**	**1367**
7. Copiers '02								
30012170 (electrostatic copiers)	298	193	-	279	-	1131	298	1045
30012183 (blueprinters)	-	-	-	8	-	1	-	-7
30012185 (copiers with optical system,)	-	114	-	79	-	371	-	406
8. TVs '02								
32302050 (CRT)	19079	5090	-	670	-	3009	19079	7429
32302060 , Flat panel colour TV				79		185		106
9. PCs '02								
30021300, Desk top PCs	1638	1550	-	470	-	800	1638	1880
30021200, Laptop PCs	4179	4805	-	1127	-	5164	4179	8842
10. RACs '02 (room air conditioners)								
29231220 (window or wall ac)	**843**	**940**	**-**	**94**	**-**	**256**	**843**	**1102**

Therefore, in other to arrive at more reliable market data that meet the consensus of the stakeholders, the PRODCOM data have to be supplemented by data from e.g.

- market analyses of specialised market research firms (e.g. GfK, CGB);
- market data derived from stock models (e.g. VHK stock models for whitegoods and heating appliances);
- data from sector-specific databases, as supplied by stakeholders.

The latter are databases that supply sales-weighted data through a notary procedure. They are based on information supplied by industry to the European Commission in the context of a **unilateral voluntary agreement**. Examples are the CECED databases for cold appliances, dishwashers, etc. and the EICTA data on standby power of consumer electronics. These data are designed to withstand scrutiny in the context of the unilateral agreement and therefore. However, the dataset is limited by this purpose and they are not intended to provide a comprehensive picture of the market.

To this end the industry and retail sector uses **specialist market researchers**. In almost every sector there are market data from market research firms that "everybody" uses. In the appliances-sector this is GfK, which measures at point-of-sales. In the heating sector the most used source is ConsultGB (CGB), which uses interviews and statistics. In the ICT sector there are several firms like DataQuest or InfoQuest. All these firms specialize in providing very comprehensive, marketing oriented data covering the whole of Europe. The data are generally not public, but in the form of multi-client annual or quarterly reports. In exceptional cases some of these firms may accept an assignment from a public body, leading to a public report with market information of an older date (e.g. 1 year old).

The fact that market data are not publicly available is one problem of this source. A second problem is, that there are considerable differences in quality, depending on experience, sources and network of a specialist. It is therefore very important to use the right specialist. A third problem, even with a high-quality specialist, is in the continuity of the data for long-term analysis. When reporting market trends there is a tendency to look at last year, the current year and the expectation for next year. However, very few –if any—market research specialists bother to use a time series of sales that extends to the product life (10-15 years) to make their projections. As a result the year-to-year market projections seem to be rather volatile, more based on incidents than long-term continuity.

6.6 Stock data

This is where the **stock models** come in: using the product life, end-of-life spread and installed stock over at least a 10-25 year time period they provide a robust long-term sales trend and a sound basis for projections of environmentally relevant parameters. Stock models are not available for all products and many of the existing stock models can be improved, so there are serous data gaps. So far, stock models exist e.g. for white-goods (CECED 2001), heating boilers (SAVE study, BRE, 2001) and circulators (SAVE study, Grundfos 2001). The product-life estimate, which is a crucial element for stock models, comes not only from national statistics offices and surveys of discarded products: When trying to match reliable sales data and growth rates over a long time series, the product-life becomes also apparent from the internal consistency of the model. This consistency is the greatest merit of the stock model, as it combines all relevant parameters into one, which makes them very suitable for a "*baseline*" or "*Business-as-Usual (BaU)*" scenario for long-term projections.

For products where there is no stock model available, the time series can be assessed using simplified parameters such as

- Growth rates (derived from a time series of sales volume);
- Replacement rates and average product life (i.e. distinguishing between 'new' and 'replacement' market);
- Substitution trends (replacement by competing products, e.g. 'fuel-switch' with heating appliances).

Important additional parameters, preferably also part of the time series, are market data on functional characteristics and consumer behaviour. A time series needs to be established including some of the important reference years in the past (e.g. 1990 as a Kyoto reference year) and in the future (2010, 2020). The time series should relate to the volume of installed products (the 'park') over the 1990-2020 period.

All sources above --industry databases, specialist market research and stock models—were taken into account in the Product Cases, usually under the heading "*Par. 2.2 Market and Stock Data*". The table below summarizes the sales data according to the above sources and compares them with apparent consumption according to PRODCOM statistics.

Table 44. MEEUP Product Cases: PRODCOM vs. Other Sources

PRODCOM Category and No.	EU consumption PROD-COM 000 units	Other source 000 units	Remark/ "other source"
1. CH Boilers 2002 28221200-28221207	6,283	4,914	VHK stock model (SAVE 2002) for residential only
2. Circulators CH systems 2000 29122417	11,192	11,300	VHK stock model (SAVE 2001) for pumps <250W
3. Street Lighting '02 31501553-31501556	20,412	18,750	estimate based on 50 mln. stock and 3 years product life
4. Fridges & Freezers 2000-'02 29711110-29711170	22,216	17,510	CECED EU-15 stock model 2001, extrapol. EU-25 --> 21000
5. Dishwashers '02 29711200	6,779	6,200	EU-25 in 2004 (EU-15=5400)
6. Vacuum cleaners '02 29712113	10,196	22,000	projected NL sales data + stock/product life calc.
7. Copiers '02 30012170-30012185	298	1,401	Dataquest (MFD), Infoquest 11 high volume copiers
8. TVs '02 32302050-32302060	19,079	30,310	EU-25, AEAT for JRC Seville 2005
9. PCs '02 30021300,-30021200	5,817	38,000	EU-25 2004, VHK calc. Misc. Sources
10. RACs '02 29231220 (window or wall ac)	843	4,500	JRAIA 2004, EERAC 1996 study=1600

The table shows that for CH boilers (taking into account that the stock data are only residential), circulators, street lamps, refrigerators & freezers, dishwashers the PRODCOM data are reasonable in line with the data from other market sources. For vacuum cleaners and TVs there are differences, which to a large extend can be traced back to the fact that the PRODCOM data are older and relate to EU-25 and not EU-15. For Copiers, PCs --especially the desktop PCs-- and Room Air Conditioners (RACs) the PRODCOM figures are simply much too low. For Copiers this is probably due to a classification problem, whereby e.g. digital copiers and Multi-Functional Devices (MFDs) are not identified as such, whereas specialist market research would take them into account. Also for PCs and RACs there is probably a classification problem with PRODCOM. For instance, both are assembled products where the final assembly could take place even at shop-level or at the consumer's home. Therefore, the desktop PCs are rarely traded as complete products and also a part of the RACs market will be registered not at the level of the final product but at the level of components.

But apart from that also the rapid growth rate of PCs and especially RACs plays a considerable role, given that PRODCOM is lagging so far behind. For instance the sales of RACs --which was around 1.6 mln pcs. in 1996 according to the EERAC study-- has tripled over the last 9 years.

A preliminary conclusion is, that if the PRODCOM data indicate a significant volume of sales and trade, this is most likely true. If the PRODCOM data do not indicate a significant volume of sales and trade, other market data sources have to be consulted before giving a final answer.

6.7 Market trends

As mentioned, general market trends, e.g. changes in design features and functionality, are a relevant input for the impact analysis. If an implementing directive is in line with one or more market trends, the legislator acts as a catalyst for those trends and --although by doing so the legislator is suppressing parallel trends that are less environmentally-friendly—this is commercially much more acceptable to stakeholders than implementing directives that have no foothold in current trends. Although it is difficult to derive quantitative indicators for this, the ongoing market trends are a very important qualitative consideration.

Some examples from the Product Cases:

- CH Boilers: More wall-hung, gas-fired, modulating, condensing and away from coal, floor-standing;
- PCs: More laptops, more silent, more LCD monitors;
- TVs: , bigger screen size, premium for shallow profile/ flat panel;
- RACs: Rapid growth overall, more inverter technology, reversible (heat pump);
- Street Lighting: More mercury vapour;
- Vacuum Cleaners: More power (in W), smaller dimensions (portability);
- Copiers: More multi-function, more digital, more colour;
- Fridges & freezers, dishwashers, circulators: No strong trends.

For a more extended discussion of the trends see the Product Cases (Appendix 2).

6.8 Inputs for the BaseCase

Finally, under the heading "Market Analysis" we will discuss a series of economic/commercial data that serve as an input for defining the base-case, i.e. the average EU machine:

- The consumer price of the product;
- the rates of the resources used, the economic product life, etc.

All these inputs are needed to make a comprehensive calculation of the financial Life Cycle Costs that serve to determine the Improvement Potential at the so-called "Least-Life Cycle Costs" (LLCC).

6.8.1 Discount rates

As regards the discount rates, which is the difference between interest and inflation, there will only be small differences in the EU. The official inflation rate is 2% and the interest rate (for consumer loans[82]) is around 4%. This leads to a discount rate of 2%.

6.8.2 Energy Prices

As for the electricity prices, Eurostat has for years insisted that the EU-15 electricity price is around € 0.103 per kWh, also for 2003.[83] This indicator *"presents electricity prices charged to final domestic consumers, which are defined as follows: annual consumption of 3 500 kWh of which 1 300 kWh is overnight (standard dwelling of 90m2). Prices are given in euro (without taxes) per kWh corresponding to prices applicable on 1 January each year."*

Most Middle European consumer's associations, based on actual tariffs in Belgium, the Netherlands, Germany, etc., find significantly higher electricity prices: more in the neighborhood of € 0.16 to € 0.18 per kWh (2004). Certainly a part of the discrepancy between Eurostat and other sources like Test-Achats, Consumentenbond and Stiftung Warentest can be explained by taxes and another part can be explained by some very low tariffs in other countries, but still it is difficult to explain the total difference. To make matters more complicated for a Life Cycle Cost calculation, some energy suppliers have a progressive tariff –charging more per kWh at higher consumption levels—whereas others are using a regressive tariff, charging less per kWh at higher consumption levels. This is on top of the peak-tariff and night-tariff differentiation and the differentiation between the fixed and variable component of the electricity bill.

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[82] Not the ECB long-term rate, which is around 2%, but the interest rate a consumer theoretically would have to pay for lending money to pay for a more expensive product.

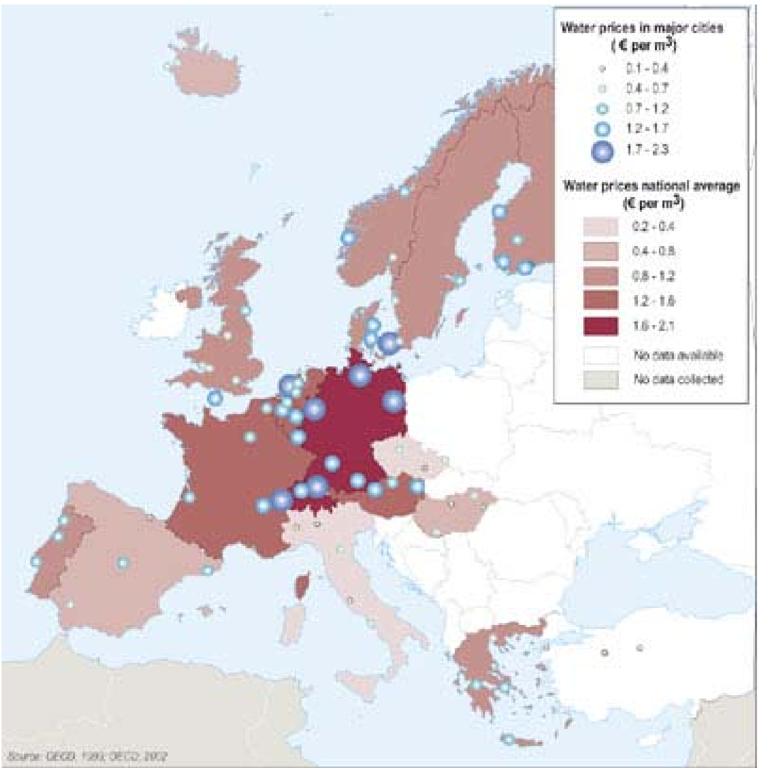
[83] Eurostat Yearbook 2004

For gas and oil prices, there is less differentiation in tariff-structure, but still there can be wide disparities with respect of the Eurostat price of € 8.40 per GJ –without taxes and based on 83.7 GJ per household per year – and the real national rates.

The exact assessment of average energy prices is outside the scope of our assignment. Also, as mentioned, it is less straightforward than it seems. We recommend to use the real tariffs including taxes in the LCC-calculations and look on a case-by-case basis which electricity and gas prices are more appropriate and what price range is appropriate for a sensitivity analysis. As default values to illustrate the methodology in this report we will use € 0.15/kWh electricity and € 0.045/ kWh gas[84].

6.8.3 Water prices

The differentiation between water prices is at least as high as with energy prices. Some countries charge a combined water supply/ sewage tariff, whereas in other countries the sewage costs are charged separately. Furthermore there is a wide disparity between communes/ provinces. As an illustration (the price data are from 1996-1998) the figure below shows the differences.[85]



[84] lower heating value

[85] Source: http://www.grid.unep.ch/product/publication/freshwater_europe/consumption.php

Another –more recent- example of the price differences in one small country –The Netherlands—is given below. Prices vary between € 1.09 per m³ and € 1.92 per m³ (avg. of fixed plus variable price at 46 m³ /year).[86]

Table 45. Water tariffs Netherlands water companies (source: VEWIN, 2005)

All tariffs in Euro per m3 water	2003	2004	2005
WB Groningen	-	-	1.09
WMD Drente	1.23	1.23	1.28
Vitens Friesland	1.39	1.39	1.40
Vitens Overijssel	1.33	1.34	1.35
Vitens Gelderland	1.29	1.31	1.33
PWN Noord-Holland	1.65	1.62	1.62
WLB Amsterdam	1.67	1.50	1.58
DZH Zuid-Holland	1.68	1.68	1.68
Hydron Zuid-Holland	1.90	1.92	1.92
Evides Z-H en Zeeland	-	-	1.60
Hydron Flevoland	1.26	1.30	1.36
Hydron M-Nederland	1.20	1.20	1.20
Brabant Water	1.22	1.22	1.23
TWM Tilburg	1.17	1.19	1.19
WML Limburg	1.51	1.52	1.52

In the Netherlands, sewage costs (Verontreinigingsheffing) are charged separately at around € 40 to € 65,- per year/household[87]. Per m³ (at 46 m³) this would add another € 1,- to € 1.40. In that way the Dutch waterprices (incl. sewage) would already be in the range of € 2.09 to € 3.32. In Germany, e.g. Badem-Würtemberg, prices are already charged combined at € 3.77/ m³ (water and sewage).[88] In France, already in 2002, water prices varied between € 0.80 and € 3.50 per m³ [89]. In the same year, the water tariff in Italy was as low as € 1,-/ m³ [90].

Again, the exact assessment of average water prices is outside the scope of our assignment. We recommend to investigate on a case-by-case basis. The same goes for other inputs like toner, paper (for copiers) as well as detergents (dishwashers).

[86] http://www.waterforum.net/

[87] The actual charge is per "vervuilingseenheid" (ve, unit of pollution).

[88] Source: http://www.statistik.baden-wuerttemberg.de/SRDB/Tabelle.asp?22025050GE416041

[89] Source: europa.eu.int/comm/environment/water/water-framework/pdf/brochure_nl.pdf

[90] http://www.waycasa.net/root/bollette_art_2271.html

As default values to illustrate the methodology in this report we will use a rate of € 3,-/m³ water and average price increase rate of 5%/year[91]. Default rates for other auxiliary inputs are e.g. € 0.09 per dishwash-cycle for detergent (€ 0.06) plus rinsing agent and salt (€ 0.03) or –for about the same price—a 3in1 tablet (€ 0,09)[92]. For copiers the cost is € 0.07 (black-and-white) or € 0.20 (colour) per page A4 for inkjet printer/MFD toner, whereas the paper is around € 0.01 per standard quality page.[93] Toner costs for laser-type printers are one third of that (€ 0.025 and € 0.075 for black-and-white and colour respectively). Reliable data sources for prices are consumer's association tests.

6.8.4 Product prices

Product prices are actual consumer prices including VAT and other levies (e.g. take-back levy). Sources for street-prices are consumer's association tests. For installed appliances list prices can be applied. Examples of product prices are given in the Product Cases Report.

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[91] This means that e.g. for an EuP with 15 year product life, an average rate of around € 4,-/m3 applies (€ 3,- + 7.5 years of 5% price increase)

[92] "*2:0 für Somat*", Test, Stiftung Warentest, 8/2005, pp. 60-64.

[93] "*Farbpaletten, Tintendrucker von 60 bis 220 Euro*", c't, 8/2003, pp. 112-116.

7 IMPROVEMENT POTENTIAL

7.1 Introduction

The importance of assessing the improvement potential is addressed in Article 12, sub 2c of the 2005/32/EC Directive. It says that '*the EuP shall present significant potential for improvement in terms of its environmental impact without entailing excessive costs, taking into account in particular the absence of other relevant Community legislation or failure of market forces to address the issue properly and a wide disparity in the environmental performance of EuPs available on the market with equivalent functionality*'.

As mentioned this indicates that costs, existing Community legislation and self-regulation as well as the environmental performance and functionality of a wider range of the existing EuP need to be assessed.

The definition of Community legislation and self-regulation needs no further explanation. In Chapter 6 (Market Analysis) we already investigated legislation at Member State level and global level in the context of identifying possible trade barriers. Here we specifically look at Community legislation, like WEEE, RoHS, EPBD and directives for refrigerators, ballasts and boilers for minimum efficiency performance standards, to see *ex-post* –i.e. once we have established the improvement potential—whether this potential will not be sufficiently realised through existing Community legislation. The same goes for unilateral agreements by CECED regarding certain large domestic appliances and EICTA regarding certain (aspects of) consumer electronics.

The functionality-concept has been discussed in par. 3.3.8 and chapter 6.

The methodology of the Environmental Impact Assessment, as well as the retrieval of non-product specific Unit Indicators was the subject of Chapters 3 to 5. The product-specific parameters during the life cycle, like the Bill-of-Materials (BOM), volume and weight (for the distribution phase), the energy and other resources consumption during use and an indication of how the product will be treated at end-of-life (disposal/recycling, etc.) are discussed in Chapter 4. In this context, also Annex II, sub 1 of the 2005/32/EC directive helps in defining the scope, saying that '*A technical, environmental and economic analysis will select a number of representative models of the EuP in question on the market…*'.

What "costs" entail is indicated in Article 12, sub 5, imposing that the implementing measure shall not have a significant negative impact on

a) the functionality of the product for the user;
b) health, safety and the environment;
c) the affordability and life cycle costs to the consumer;
d) industry's competitiveness.

as well as not leading to

e) imposing proprietary technology or;
f) an excessive administrative burden for industry.

The boundary conditions a) and b) are to be defined per product to a large extent in harmonised EN standards to provide an objective basis for assessment. As mentioned in paragraph 3.3.8 it is difficult to give a general rule, but it should be reviewed per product whether these standards are present and appropriate (i.e. accurate, reproducible, cost-effective and close enough to real-life conditions). Condition e) is relatively easy to assess from desk-research and discussions with stakeholders. The question of which characteristics of an implementing directive would create 'an excessive administrative burden' was briefly discussed in Chapter 2, but can only truly be established *ex-post* if one or more proposals for legislation are known.

Which leaves us with two conditions c) and d), which are –in part—linked and which play a key role in the methodology that will discussed hereafter.

7.2 Methodology

As mentioned above, the choice for a methodology for the assessment of an improvement potential was made on the basis of the criteria of affordability to the consumers and the competitiveness of the industry, both captured in the Life Cycle Costs. The method, introduced in the 1980s by LBNL[94] in the US, is very similar to what has been successfully applied –both in the US and the EU-- in the policy making for energy labels and minimum energy efficiency performance standards. In that sense, the method itself is a '*proven design*' : It has been widely accepted in at least some sectors (esp. domestic appliances) and in those sectors it has proven to bring about energy efficiency. In the Product Case of Dishwashers some preliminary results of a draft of an ongoing study by ISIS/ENEA for CECED are presented, that evaluate –more than 10 years after the assessment of the improvement potential—how things went. And it clearly shows that

- the vast majority of the design options identified were wholly or partially implemented, leading to energy and water savings >30%; so it is possible –technically-- to look into the future with the proper research;
- this hasn't led to consumer dissatisfaction; quite the contrary, the machine price is now 8% higher than 10 years ago which is lower than inflation (16%), the energy and water consumption of new machines have been reduced by >30% and more and the consumer's associations have never been happier with the wash performance;
- this hasn't led to a loss of EU competitiveness; the EU market is still 90% dominated by EU manufacturers and although there has been an 8% price erosion over 10 years (see above) and profit margins remain very low (as 10 years ago), this is almost nothing compared to other manufacturing sectors e.g. in the electronics sector which had far less stringent (if any) mandatory measures. For PCs the current price erosion is >12% per year (see Product Case PCs), for small imaging equipment (printers, MFDs) the recent price erosion has even been more dramatic. Both sectors never represented a EU industry stronghold, but now there is hardly any EU industry left.

The rest of this chapter will deal with:

- Definition of BaseCase;
- Technical Analysis Best Available Technologies (BAT);
- Improvement Potential (design options and Least Life Cycle Costs);
- Policy-, Scenario-, Impact and Sensitivity Analysis.

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7.3 Step 1: Definition of Base-Case

7.3.1 Introduction

The starting point of the methodology is an abstraction of reality, whereby all products in the market place are summarized in an average EU 'Base-Case'. Please note that here and in the Product Cases Report we try to summarize the product sector in one Base Case; in the preparatory studies several --more than one-- Base Cases can be distinguished per subcategory (see Chapter 6). But it has to be considered that the addition of each Base Case increases the amount of analysis substantially and that at one point –e.g. to arrive at EU totals (see par. 7.3.5)-- the market share of each of the Base Cases has to be assessed. Therefore it is recommended to limit the number of different Base Cases as much as possible. Especially if there is a large overlap between the subcategories it could more appropriate to make the split in subcategories at a later stage in the study, e.g. when defining implementing measures or singling out those design options that do not apply to all subcategories.

The 'BaseCase' is the reference for the improvement and is described in terms of environmental impact during its life cycle (production, distribution, use, end-of-life), for which we have proposed the EuP EcoReport form. But the 'BaseCase' is also described in terms of its financial Life Cycle Costs (LCC), which includes the machine purchase price and the running costs (energy, water, repairs, etc.) discounted over the product life.

This is not where it stops. Regarding the environmental impact the BaseCase can give and preferably should give several characteristics that explain the impact. For instance for the use phase these would be items like an energy balance, identifying motor and heat losses, etc. As mentioned in paragraph 4.4.2 it is important for EuP to make a distinction between the Standard BaseCase –with energy measured according to the harmonised test standard, being the basis for any implementing measures—and the Real-Life BaseCase –providing the policy maker with an insight in the real energy consumption in the EU taking into account the consumer behaviour and varying load situations.

For the impact of the production and end-of-life phase it is important to identify materials that cause a 'spike' in the environmental profile and what exactly is their technical function. Also –if need be—an extra effort could be made to investigate the Unit Indicator values for these critical materials or processes, to establish the variation that occurs in real-life production plants and whether this can be influenced in some way by the product design. For instance, it could well be that a slight modification of the surface quality requirements or the coating method would make all the difference. There are no fixed rules, but these items should be decided on a case-by-case basis.

But also regarding the financial Life Cycle Costs, the analysis doesn't stop at the purchase price. At the very least there should be a breakdown of the product price in margins for distribution, production and taxes on one hand and the estimated production costs on the other. E.g. for large domestic appliances there is typically a factor 2 to 3 between strict production costs and purchase price. In the BaseCase this margin is usually applied as a fixed percentage.

Furthermore, a detailed breakdown of those product costs by component, assembly activities, etc. is necessary to provide a reference for the cost evaluation of improvements. This may seem like an impossible task, because the companies that have this information would not easily part from it for reasons of confidentiality. However, in practice the production of many components is outsourced and for an experienced external engineer in the sector it has proven to be perfectly possible to retrieve OEM-prices and make an estimate of average assembly costs to provide an "average" cost picture that the stakeholders would agree on. Furthermore, for completely new components there are several 'rules-of-thumb' to make product cost calculations. Again, these would not be confidential, but part of the schooling and experience of an engineer.

In the Product Cases of the underlying study no production cost inventories are given, because for none of the products recent data are readily available and the effort –together with the feedback from the stakeholders—to make these calculations is substantial and outside the scope of the assignment. Older examples can be found in the GEA2 SAVE studies, e.g. downloadable from www.vhk.nl or the project website www.eupproject.org .

The rest of this paragraph will deal with the specific subtasks.

7.3.2 Product-specific inputs

From the results of the broader technical analysis in paragraph 4.4 a selection has to be made of product-specific inputs that will be regarded representative of the EU average product, specifically

- Avg. EU product weight and Bill-of-Materials, distinguishing materials fractions (weight) at the level of the EuP EcoReport Unit Indicators as proposed in the MEEUP report. This includes packaging materials;
- Primary scrap production during sheet metal manufacturing (avg. EU)[95];
- Volume and weight of the packaged product avg. EU;
- Annual resources consumption (energy, water, detergent) and direct emissions[96] during product life according to the test standards defined in subtask 1.2 [“EU Standard Base-Case”];
- Annual resources consumption (energy, water, detergent) and direct emissions during product life according to the real-life situation as defined in subtask 3.2 [“EU Real-life Base-Case”];
- Selected EU scenario at end-of-life of materials flow[97] for:
    - Disposal (landfill, pyrolytic incineration);
    - Thermal Recycling (non-hazardous incineration optimised for energy recovery);
    - Re-use or Closed-loop Recycling.

7.3.3 Base-Case Environmental Impact Assessment.

Using the VHK EuP EcoReport in Chapter 5, the environmental impact analysis has to be determined, specifying

- Emission/resources categories as mentioned in the MEEUP Report.

for:

- Raw Materials Use and Manufacturing;
- Distribution;
- Use;
- and End-of-Life Phase.

distinguishing for the Use phase between the Standard Base-Case and the Real-life Base-Case[98], as indicated in Chapter 4.4.

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[95] Necessary input into the EuP EcoReport

[96] This only relates to emissions that are not already taken into account in the VHK EcoReport Unit Indicators

[97] At least for plastics and electronics, as defined in the EuP EcoReport. For metals and glass this may also be indicated if the recycling percentage is less than 95%.

[98] Making two analyses

Furthermore, if more than one type of resource is used in the Use phase, a split-up between resources and their individual impacts has to be made.

7.3.4 Base-Case Life Cycle Costs

Combining the results from paragraph 6.8 (prices and rates) and the previous paragraph, the Life Cycle Costs can be defined for the Standard and Real-Life Base-Case. Annex II provides some guidance regarding the definition of Life Cycle Costs (LCC). The LCC analysis method '*uses a real discount rate on the basis of data provided from the European Central Bank and a realistic lifetime for the EuP; it is based on the sum of the variation in purchase price (resulting from variations in industrial costs) and in operating expenses, which result from the different levels of technical improvement options, discounted over the lifetime of the representative EuP. The operating expenses cover primarily energy consumption an additional expenses in other resources (such as water or detergent).*'

LCC = PP + PWF * OE,

where LCC is Life Cycle Costs, PP is the purchase price, OE is the operating expense and PWF (Present Worth Factor) is

$$\mathbf{PWF= \{1 - 1/(1+ r)^{N}\}/r} \;,$$

in which N is the product life and r is the discount (interest-inflation) rate.

Other requirements regarding the LCC calculation and the required cost calculation and technical characteristics have been discussed in the introductory paragraph 7.3.1.

7.3.5 EU Totals

Aggregating the Real-Life Base-Case environmental impact data and the Life Cycle Cost data to EU-25 level, using stock and market data from the Market Analysis (Ch. 6), we find

- The life cycle environmental impact and total LCC of the new products designed in 2005 (this relates to a period of 2005 up to 2005+product life);
- The annual (2005) impact of production, use and (estimated) disposal of the product group, assuming post-RoHS and post-WEEE conditions.[99]

7.3.6 EU-25 Total System Impact

Using the estimates of par. 4.5 to estimate the total environmental impact of the product system and compare with outputs from e.g. input/output analysis.

[99] "Business-as-Usual" scenario to be based on this assumption.

7.4 Step 2: Identifying Design Options

Once we have established the BaseCase, the next step is the identification of the Design Options. For this step there are no fixed rules. Different from what outsiders may think, this is not the most difficult part of assessing the improvement potential. Already the

- characteristics of the best (in terms of eco-design) products in the market;
- and the characteristics of the best components (idem) available.

give a good –and fairly indisputable-- impression of what design options are technically feasible and at what economical costs. The technical analysis of existing products was discussed in par. 4.4 and precedes the definition of the basecase in the previous paragraph, because it supplies necessary inputs (Bill=of-Materials, energy consumption in the use phase, etc.). At the same time the technical analysis of existing products will identify the 'best-performing products available on the market'[100] and serves as an input for the above.

The technical analysis of the Best Available Technology at component/material level is complementary to this because its focus is not on current products but on currently available technology (components, materials), expected to be introduced at product level within 2-3 years. It provides part of the input for the identification of part of the improvement potential.

It entails an assessment of

- State-of-the-art in applied research for the product (prototype level);
- State-of-the-art at component level (prototype, test and field trial level);
- State-of-the-art of best existing product technology outside the EU.

Of course the economic data of these new components/ materials must not be taken at face value but need to be interpreted by an experienced engineer, who is aware of what is sold at a 'premium' (higher margin) and who knows of the typical 'learning curve' and cost optimisation effort that will still apply to certain new components and designs. But –depending on the engineer and the technical-economical know-how of his/her counterparts in industry of course—it will not require a major effort to reach consensus with stakeholders on these options, which will constitute a considerable part of the improvement potential. An exception would be if any of these options would be proprietary and adequately protected by patents. This has always to be checked, but usually –even if some specific ways would be blocked— the general direction of a design option is often not found impossible.

Consensus with stakeholders is more difficult concerning components and products that are only at the prototype stage or that are subject to fundamental research. The technical and economical feasibility of these developments may be watched very critically by industry, especially –although the theoretical direction may be interesting— regarding the quality, 'produce-ability' and longevity. Often there are situations where OEMs are making substantial claims regarding the performance, eager also to attract capital/ funding, that cannot be substantiated on the short term but may lead policy makers in thinking otherwise. On the other hand, once a promising prototype has been evaluated by the industry in a premature stage and has failed, the sector is very reluctant to look at it again whilst it might have been improved. Design options at this level –vacuum insulated cold appliances, OLED TVs, PEM fuel cells, etc.—are very difficult to handle in a policy context and options at this level will only be acceptable with very indisputable proof e.g. of longevity and accessible OEM prices.

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[100] Cit. Annex II of dir. 2005/32/EC

And then there is the third category of design options that is usually much more acceptable, but requires a good technical knowledge not only of the product area, but –across products—of the technological disciplines involved (e.g. thermodynamics, hydro- and aerodynamics, acoustics, mechanics, etc.). A good engineer and an R&D department that is worth its salt will be able to mention several technical ways to improve e.g. the energy efficiency of the product or to reduce the quantity of materials employed (see text boxes below), which –as the environmental assessment of many products will often show-- are often valid ways to reduce the environmental impact. They often haven't done it, because there was no request e.g. from the marketing management to do so, but they would be quite able to do so –also at a reasonable cost- if requested. Technical/ mathematical modelling can certainly play a role in this and has done so in the past, but if the improvement potential can be demonstrated through experiments (tests) or if stakeholders can accept analogies from other products this is just as valid. The method proposed here does not have fixed rules: The whole toolbox of design engineering is at the disposal. In that sense, also mathematical modelling directly linking up to the environmental impact parameters to a function analysis of technical design parameters is perfectly admissible[101], as long as it provides realistic design options.

Identifying design options for energy efficiency

Some notes from the Product Cases:

- In a situation with a variable load it saves vast amounts of energy to use a device with an equally variable capacity rather than a device with the maximum capacity that you switch on and off or 'squeeze'. This goes for most products: heating boilers (modulating burner), circulators (Variable Speed Drive), Room Air Conditioners (inverter), PCs (e.g. CPU clock speed control) and even TVs (backlight capacity locally tuned to the picture-frame shown),
- The most effective way of heat transfer is through conduction, then radiation and only then through convection.
- The most effective way of stopping heat transfer is through avoiding conduction ("cold bridges"), radiation (reflection) and convection (vacuum).
- Air resistance and leakage are the main issues in any energy-efficient air handling device including dry vacuum cleaners,
- The Second Law of Thermodynamics implies that it is very wasteful to heat your home or water tank very indirectly with a steam turbine,
- Water and detergent that is not in contact with the object to be cleaned doesn't do anything useful,
- Some drinks do not need to be stored cool but need to be served cool
- Products that interact directly with humans to function (TVs, PCs, etc.) shouldn't function (unless at a base level required to detect whether this is true) when humans do not interact with them,
- There is a trade-off between energy and time at equal performance. So if your product can spare some time, use it e.g. to lower the temperature (example washing machines and dishwashers).
- Etc.

[101] e.g. EPIC-ICT

What is important is that especially in this category of options the legislator can play a major role as a catalyst, allowing the R&D departments to innovate and --by doing so—enhancing the global competitiveness of EU industry.

Identifying design options for product weight reduction

In 9 out of 10 cases creating a lighter (less heavy) product will reduce the environmental impact. And the obvious way to do that is to integrate functions, reduce parts, use the right material in the right place at no more than the right quantity for that material and that place. Sure, the environmental impact per kg will go up and a designer should always check whether the "eco-balance" is still positive, but in 9 out of 10 cases the weight-saving will make the environmental impact of the total product go down. And this is caused not only by reduced environmental impact of distribution, but also of materials production.

7.5 Step 3: Costs and environmental benefits of design options

The third step is the assessment of the production costs and the environmental benefit of the design option. Traditionally this estimated production cost is an abstraction from reality in the sense that the cost always adds on to the product price. However, as has been proven by actual price developments over the last 10-15 years, that in reality this doesn't happen or –if it happens—it happens only for a very brief period, e.g. if the legislation is introduced on very short notice.

If changes are taken into account at a complete platform change (e.g. every 3-4 years), the 'costs' will be negligible or even negative. In order to get an estimate of that effect, the stakeholders will have to look at the costs of the design feature not as a short-term add-on item, but a complete review of the product design. With respect to the old method of estimating the costs this is new.

Furthermore, the method should take into account that –through rationalisation of the production, outsourcing to low-labour-cost countries, etc.—production costs in most sectors are continuously being reduced e.g. by something in the order of 3-4% per year in the white goods sector. It is not said that this trend continuous, but it has to be a subject of discussion with the stakeholders to determine the normal sector-rate of cost reduction.

The Ecodesign method is also new in a sense that it has to estimate the consequences of environmental improvements that are not linked to reductions in resources consumption (energy, water, etc.) during the use of the product. If these improvement options do not lead to reduced production costs (which they often would) and/or recycling costs (which will be a whole new field under the WEEE directive), then they just simply add-on to the purchase price with no compensation for the consumer in terms of lower running costs. For the policy maker the internalised external costs of the avoided greenhouse potential or other emissions could be a consideration (see Sensitivity Analysis, par. 7.8.3 and Annex II of the directive).

7.6 Step 4: Analysis LLCC and BAT

Once the design options and their 'costs' have been established, we need to evaluate what options and/or combinations of options would be an appropriate basis for implementing measures under the 2005/32/EC directive. Here we can distinguish between two types of design options. Annex II of the aforementioned directive explicitly mentions that "Concerning energy consumption in use, the level of energy efficiency or consumption will be set aiming at the life-cycle cost minimum to end-users…”. In this report we will refer to this point as the LLCC, “Least Life-Cycle Costs” and we consider it an important reference for not only energy consumption but all consumables during product life that are being reduced by design options. The Annex II specifically mentions also the operating expenses of water and detergent as examples, but in our Product Cases Report this also relates to toner and paper for copiers, vacuum cleaner bags, etc.

A second set of design options relates to ecodesign possibilities to reduce the environmental impact without a reduction in operating costs or End-of-Life costs for the end user. For these options Article 15, sub 2 (c) applies, stating in more general terms that realizing the environmental improvement potential should not be “entailing excessive costs”. Further on, in Art. 15, sub 4 (c) and (d), the directive mentions “no significant negative impact” on consumers regarding affordability and life-cycle costs, as well as on industry’s competitiveness. Annex I speaks of a “reasonable balance” between the environmental, functional and economic aspects. Finally, Annex II adds the dimension of “..where appropriate, external environmental costs, including avoided greenhouse gas emissions..” as a part of the sensitivity analysis. In short, the evaluation whether a design option can be used as a basis for an implementing measure under directive 2005/32/EC is largely qualitative and at the discretion of the European Commission with the Consultation Forum. The methodology can only deliver the ingredients:

- The increase of the production costs and –by using the appropriate multipliers—purchase price to be expected (LCC is restricted to that, because there is no change in operating and end-of-life costs);
- The improvement of the environmental impact that can be expected from the design option;
- and a full description of the design option that would allow an evaluation an appropriate impact and sensitivity analysis (see par. 7.8).

If there is more than one design option to improve the same environmental indicator (Global Warming, Acidification, etc.), then the only additional methodology support could come from ranking those design options per environmental indicator. Furthermore, if the combination of single design options has a lower yield than each single design option, this also has to be indicated. This would show the European Commission which (combinations of) design options are the “best performing” and give the best environmental “value for money” per environmental indicator.

For design options that do have an impact on the operating expenses, the methodology can be more precise about the target level, aiming at the Least Life Cycle Costs (LLCC). Furthermore, the “Best-performing Available products and Technologies” (BAT) would in this context be more clearly defined as the point that gives the highest possible environmental benefit in absolute terms. The difference between BAT and LLCC would be an indication of the possibilities for product differentiation if the LLCC were to be used as a minimum target.

The assessment of LLCC entails:

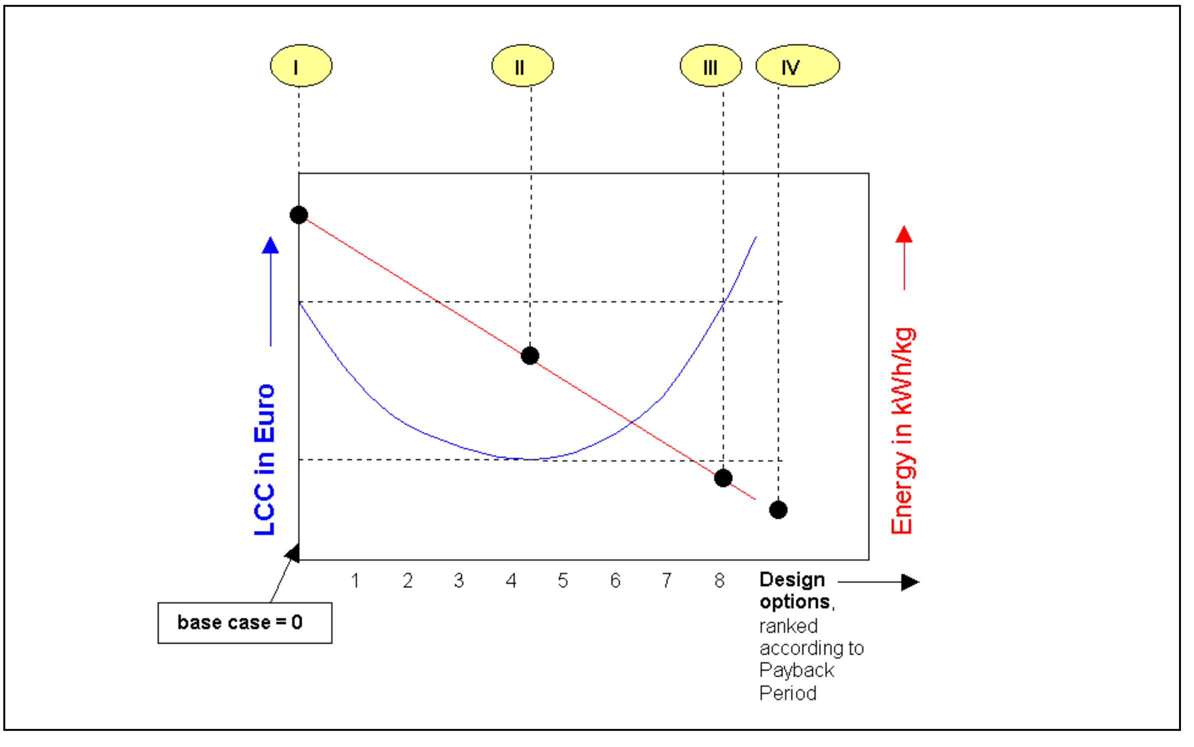
- Ranking of the individual design options by LCC (e.g. option 1, option 2, option 3);
- Determination/ estimation of possible positive or negative (‘rebound’) side effects of the individual design measures;
- Estimating the accumulative improvement and cost effect of implementing the ranked options simultaneously (e.g. option 1, option 1+2, option 1+2+3, etc.), also taking into account the above side-effects;

- Ranking of the accumulative design options, drawing of a LCC-curve (Y-axis= LLCC, X-axis= options) and identifying the Least Life Cycle Cost (LLCC) point and the point with the Best Available Technology (BAT).[102]

The individual design options usually have very different effects: Some may generate huge savings on running costs at hardly any extra production costs, others may be very expensive, deliver only small environmental improvements and give little reduction on running costs. This phenomenon is the basis for ranking the individual design options in terms of Life Cycle Costs versus environmental benefits.

A second phenomenon is the interaction between the design-options. When implementing multiple design options in the same product, the resulting environmental improvement is usually smaller than the sum of the environmental improvements per individual design option. In other words, if you have already improved a product with one design option, every consequent design option will only realize a part of its individual potential. How exactly this interaction works depends very much on the product technology, but it may well lead to a different ranking of accumulated options than the ranking of the individual options in terms of total effect and costs.

After the ranking process we will end up with graph that will look like the one below for parameters that have an impact on the running costs to the end-user (energy, water, detergent, toner, paper, etc.).



Starting at the Life Cycle Costs (left y-axis) and Environmental performance parameter (right y-axis) of the Basecase (design option “0” on the left of the x-axis). With the introduction of the first 3 design options the LCC-curve will decrease due to savings on running costs. After design option nr. 4, the improvement of the environmental parameter will continue, but the extra saving on the discounted running costs will be less than the increase of the purchase point and the LCC will go up. This lowest point on the LCC-curve is called the point of

[102] This is usually the last point of the curve showing the product design with the lowest environmental impact, irrespective of the price.

the Least Life-Cycle Costs (LLCC). And the value of the Environmental Parameter (energy, water, etc.) at that point is proposed as the threshold value for minimum requirements (legislation) or the target for voluntary agreements.

Further up the LCC curve, as more and more design options are being implemented there are still two interesting points: The 'break-even point', where the purchasing power of the consumer remains equal to the current situation. Beyond this point any minimum requirement would usually become socially unacceptable, i.e. *there would be a significant negative impact on consumers in particular as regards the affordability and the life cycle costs of the product* (*compare Art. 15.1. (b) (iv) of 2005/32/EC*).

And finally there is the last point on the LCC curve indicating the costs at the maximum technical potential, the so-called Best Available Technology (BAT) As mentioned, in the context of design options that have an effect on the running costs, this BAT-point is ***not*** intended as a target level for legislation. It indicates what is technically feasible with the best-performing products and technologies available. And as such it indicates whether –after the LLCC has been established as a minimum target—there is enough room for product differentiation on the short term (see also BNAT, par. 7.7., which also looks at the long term).

From the point of view of social-economic feasibility the LLCC is optimal: such a threshold value would not only result in an environmentally superior product but even increase the purchasing power of the consumers as the total expenditure over the product-life decreases. This message is also of interest to retailers, consumer's associations and industry and others that have the best interest of all stakeholders in mind. . Naturally, even at LLCC, the price increase must remain within the bounds of what is affordable for the end-user; this will be an explicit task of the impact analysis.

It must be stressed that this LCC curve is typical for most energy-using products (EuP), i.e. where the improvements lead to lower running costs for the end-user (lower consumption of energy, water and auxiliary materials etc.) at the expense of a higher product-price. As we will analyse the LCC consequences for each of the main environmental parameters per relevant product (a selection will have to be made), we will see other types of trades-off, e.g. between higher direct production costs and the costs of take-back obligations under the new WEEE directive. Long-term targets (BNAT) and systems analysis

One of the factors influencing the competitiveness of the industry is when a target value would reduce the product differentiation up to a level where all products are more or less the same. If we concentrate just on the cost side, as is done previously, it might appear that this will be the case. For that reason it is important to sketch also the long term perspective, typically addressing experimental designs that e.g. would first be introduced in the highest price segments. For that reason, the structure for the methodology (Chapter 1, Annex II) also comprises the discussion of technologies that are not yet available (BNAT, Best Not Available Technologies) and design options that would come from systems considerations. Specific tasks are:

- Discussion of long-term technical potential on the basis of outcomes of applied and fundamental research, but still in the context of the present product archetype;
- Discussion of long-term potential on the basis of changes of the total system to which the present archetype product belongs: Societal transitions, product-services substitution, dematerialisation, etc.

7.7 Scenario-, policy-, impact- and sensitivity analysis

This task looks at suitable policy means to achieve the potential e.g. implementing LLCC as a minimum and BAT as a promotional target, using legislative or voluntary agreements, labelling and promotion. It draws up scenarios 1990 – 2020 quantifying the improvements that can be achieved vs. a Business-as-Usual scenario and compares the outcomes with EU environmental targets, the societal costs if the environmental impact reduction would have to be achieved in another way, etc.

It makes an estimate of the impact on consumers (purchasing power, societal costs) and industry (employment, profitability, competitiveness, investment level, etc.) as described in Annex II of the Directive, explicitly describing and taking into account the typical design cycle (platform change) in a product sector. Finally, in a sensitivity analysis of the main parameters it studies the robustness of the outcome.

The following subparagraphs describe the tasks:

7.7.1 Policy- and scenario analysis

In order to arrive at the total environmental impact of policy measures, we need to assess

- The effect of existing EU legislation and voluntary agreements, estimating the extra effect that an Eco-design implementing directive would have;
- The distribution ('spread') in the environmental characteristics of the products installed. Considering that a part of the products –those not meeting the requirements--will be replaced by products meeting the minimum threshold values, it is important for the projection to establish how and at what rate this substitution will take place: Will the new products be positioned again at the low-end of the market or will the whole market distribution shift upwards? The estimated answer to these questions can probably be derived from the experience with existing product-related legislation;
- The replacement rate, taking into consideration that an improvement in environmental performance is never an absolute figure, but always linked to a reference year (2010, 2015, 2020). Depending on the (distribution of) product life, which can vary widely for the relevant products selected, only a part of the total park will be replaced by the new and improved products;
- Growth rates and substitution effects (e.g. fuel switching with heating appliances).

Together with the outcomes of the Market Analysis (Task 2) it is now possible to calculate the total environmental impact of an Eco-design measure. The best way to do this, is a 'stock model' such as the one that VHK has developed for white goods and heating appliances in the context of various SAVE studies. (See product cases)

7.7.2 Impact analysis industry and consumers

Although intended as an ex-post assessment of the robustness and economic feasibility (costs, investments, employment impact) of a suggested threshold value, this analysis also adds a very important function in determining an appropriate timing of policy measures.

Although the design options and their economic impact established stage 3 of the LCC approach are very real, they constitute a 'snapshot' at the time of the analysis, assuming all other things to remain equal (c.p.). In reality every industry sector has its own dynamics in production development, continuously decreasing costs, and its own R&D dynamics in realizing a truly innovative step in product development. The annual rate of production cost reduction may be as low as 2% or as high as 20%. The R&D period needed to develop a new, innovative product platform, incorporating and integrating all ‘add-on’ features from may be as low as 6 months or as high as 4 years or more.

Unaffordable products with no economic gain for the consumer over the product life (‘life cycle costs’) have a higher probability of affecting short-term sales and on the long-term consumers looking for alternative solutions.

Finally, the impact analysis will look at “affordability” for the end-user, i.e. cases where the absolute price increase at the LLCC point would make the product unattainable for the lower-income households. Experience from e.g. similar analysis for the EU SAVE programme has indicated that this is seldom the case at LLCC, but it should be checked. Statistics on household budgets at national and EU scale should give an indication.

7.7.3 Sensitivity analysis of the main parameters.

The sensitivity analysis investigates how robust the targets, especially the LLCC, are given fluctuations in the main economic parameters such as energy and water prices, as well as the product life. In Annex II of the Directive it says: ‘*A sensitivity analysis covering the relevant factors (such as the price of energy or other resource, the cost of raw materials or production costs, discount rates) and, where appropriate, external environmental costs, including avoided greenhouse gas emissions, will be carried out to check if there are significant changes and if the overall conclusions are reliable. The requirement will be adapted accordingly.’*

Apart from the parameters mentioned above, the recycling credits should be taken into account in the sensitivity analysis as a variable (par. 7.8.3) if there is a significant (>10% of original product weight) material substitution of sheet products. This was explained in paragraph 3.3.6.

Assuming a 35% overall recycling rate minus 5% for the recycling effort this would mean that the consultant in the preparatory study has to recalculate a particular ecodesign option with 25 (steel sheet) and/or 19% (aluminium sheet/extrusions) lower impacts for the relevant fractions. This would constitute an extra piece of information to the Commission and the Consultation Forum on how robust the environmental improvement from this particular ecodesign option is in the light of the different opinions on the attribution of recycling credits.

APPENDIX I : STRUCTURE OF PARAMETERS

Eco-Design of EuP Methodology, Article 12: Structure of relevant Parameters and Indicators (Draft v1)

Contents

The following is a proposal for the methodological elements and parameters that should be a part of the methodology to determine the relevance of a product group for the EuP Ecodesign-Directive. The proposal is an abstraction of the aforementioned Directive, which is of course the legal priority document, e.g. in case of real or perceived contradictions.

PART I – PRESENT SITUATION

1 DEFINITION

Scope: This task should define the product category and define the system boundaries of the 'playing field' for eco-design. It is important for a realistic definition of design options and improvement potential and it is also relevant in the context of technically defining any implementing legislation or voluntary measures (if any).

1.1 Product category and performance assessment

- Prodcom category or categories (Eurostat);
- Categories according to EN- or ISO-standard(s);
- Labelling categories (EU Energy Label or Eco-label), if not defined by the above.

Categorisation will often be linked to the assessment of

- The primary product performance parameters (the "functional unit").

If needed, on the basis of functional performance characteristics and not on the basis of technology, a further segmentation can be applied on the basis of

- Secondary product performance parameters.[103]

1.2 Test Standards

Identify and shortly describe

- the harmonised test standards;
- and additional sector-specific directions for product-testing.

regarding the test procedures for:

- the primary and secondary functional performance parameters mentioned above;
- resources use (energy, water, paper, toner, detergent, etc.) and emissions (NO_x, CO, particulate matter) during product-life;
- safety (gas, oil, electricity, EMC, stability of the product, etc.);
- noise and vibrations (if applicable);

[103] For instance, for washing machines and dishwashers the primary product performance parameter is given in x kg of laundry washed or x standard settings of dishes over de lifetime (following ISO 14040 series). The cleaning performance, rinsing performance, etc. can be secondary parameters. The number of (sub) categories should be kept to the minimum necessary, based on functional aspects and not on the basis of the technology or price.

- other product specific test procedures.

Apart from mentioning these standards, including a short description, it should also be reported which new standards are being developed, which problems (e.g. regarding tolerances, etc.) exist and what alternatives are being developed. Furthermore, the (ongoing) work on an ecodesign-standard, mandated by the European Commission to standardisation bodies, should be considered.[104]

1.3 Existing legislation

Task 1.3 should identify the relevant legislation for the product. This task can be subdivided in three parts:

1.3.1 Legislation and Agreements at European Community level

Apart from the obvious environmental directives (RoHS, WEEE, Packaging directive), this could building regulations (e.g. developed under the Performance of Buildings Directive), regulations on health and labour conditions (e.g. for air conditioners, copiers), minimum efficiency directives (boilers, refrigerators, ballasts, etc.), product liability, safety, EMC etc. Also EU Voluntary Agreements and already existing eco-design standards (e.g. ECMA, EIA) of the sector or related sectors need to be identified. And finally, especially in a Business-to-business context it needs to be described which quality requirements (e.g. “proven design”, maximum failure rate) are customary.

1.3.2 Legislation at Member State level

This section deals with the subjects as above, but now for legislation that has been indicated as being relevant by the Member States.

1.3.3 Third Country Legislation

This section again deals with the subjects as above, but now for legislation and measures in Third Countries (extra-EU) that have been indicated by stakeholders (NGOs , industry, consumers) as being relevant for the product group

2 ECONOMIC AND MARKET ANALYSIS

Scope: To place the product group within the total of EU industry and trade policy (subtask 2.1). To provide market and cost inputs for the EU-wide environmental impact of the product group (subtask 2.2). To provide insight in the latest market trends so as to indicate the place of possible Eco-design measures in the context of the market-structures and ongoing trends in product design (subtask 2.3, also relevant for the impact analyses in Task 3). And finally, to provide a practical data set of prices and rates to be used in a Life Cycle Cost (LCC) calculation (Subtask 2.4).

2.1 Generic economic data

- EU Production;

[104] See http://www.europa.eu.int/comm/enterprise/eco_design/mandate.pdf

- Extra-EU Trade;
- Intra-EU Trade;
- Apparent EU-consumption.[105]

Data should relate to the latest full year for which at least half of the Member States have reported. Preferably data should be in physical volume and in money units and split up per Member State.

Information for this subtask should be derived from official EU statistics so as to be coherent with official data used in EU industry and trade policy.

2.2 Market and stock data

In physical units, for EU-25, for each of the categories as defined in 1.1 and for reference years

- 1990 or 1995 (Kyoto ref.);
- 2003-2005 (most recent real data);
- 2010-2012 (forecast, end of Kyoto phase 1, relevant also for Stockholm, etc.);
- 2020-2025 (forecast, year in which all new eco-designs of today will be absorbed by the market).

the following parameters are to be identified:

- Installed base ("stock")106 and penetration rate;
- Annual sales growth rate (% or physical units);
- Average Product Life (in years), differentiated in overall life time and time in service, and a rough indication of the spread (e.g. standard deviation);
- Total sales/ real EU-consumption[107], (also in €, when available);
- Replacement sales (derived);
- New sales (derived).

2.3 Market trends

- Latest consumer tests (anecdotal, not necessarily valid for the whole of the EU);
- Description of the market and production structure and identification of the major players;
- General trends in product-design and product-features.[108]

2.4 Consumer expenditure base data

For each of the categories defined in subtask 1.1:

- Average consumer prices, incl. VAT, in Euro.

Determination of applicable rates for running costs and disposal, per EU Member State, specifically[109]:

[105] Calculated from production, imports and exports. If available, changes in product stock should be taken into account, but usually this will not be the case.

[106] Forecasts 2010 and 2020 are to take into account population growth rates and/or building growth rates

[107] The objective is to define the actual consumption as reliably as possible for the categories defined in task 1.1, for the latest full year for which consistent data could be retrieved. Significant differences between the actual consumption and the apparent consumption in subtask 2.2 may occur.

[108] From the marketing point of view, not from the perspective of a detailed technical analysis

- Electricity rates (€/ kWh);
- Water (and sewage) rates (€/m³);
- If applicable: fossil fuel rates (€/ GJ);
- Consumer prices of other consumables (detergent, toner, paper, etc.) (€/kg or €/piece);
- Repair and Maintenance costs (€/product life);
- Installation costs (for installed appliances only);
- Disposal tariffs/ taxes (€/product);
- Interest and inflation rates (%).

3 CONSUMER BEHAVIOUR AND LOCAL INFRASTRUCTURE

Scope: Consumer behaviour can —in part- be influenced by product-design but overall it is a very relevant input for the assessment of the environmental impact and the Life Cycle Costs of a product. One aim is to identify barriers and restrictions to possible eco-design measures, due to social, cultural or infra-structural factors. A second aim is to quantify relevant user-parameters that influence the environmental impact during product-life and that are different from the Standard test conditions as described in Subtask 1.2. [110]

3.1 Real Life Efficiency

This includes:

- Load efficiency (real load vs. nominal capacity);
- Temperature- and/or timer settings;
- Dosage, quality and consumption of auxiliary inputs (detergents, paper- and toner use, etc.);
- Frequency and characteristic of use;
- Identification of use of second hand auxiliary inputs during product life (e.g. toner, recycled paper);
- Power management enabling-rate and other user settings;
- Best Practice in sustainable product use, amongst others regarding the items above.

3.2 End-of-Life behaviour

Identification of actual consumer behaviour (avg. EU) regarding end-of-life aspects. This includes:

- Economical product life (=actual time to disposal);
- Repair- and maintenance practice (frequency, spare parts, transportation and other impact parameters);
- Present fractions to recycling, re-use and disposal;
- Estimated second hand use, fraction of total and estimated second product life (in practice);
- Best Practice in sustainable product use, amongst others regarding the items above.

[109] Note that a part of these data could be harmonised for all product groups.

[110] Examples are the actual temperature-settings for laundry and dishwashing equipment, the loading efficiency (real load vs. nominal capacity) for a whole range of appliances, power management enabling rate for ICT equipment, etc.

3.3 Local Infra-structure

Description, identification of barriers and opportunities relating to the local infra-structure regarding

- Energy: reliability, availability and nature: e.g. storage tanks and distribution of solid and liquid fuels (incl. bio-mass), availability of gas-grid, state of chimneys, gaseous fuel (use of “hot-fill” dishwashers), special local tariffs influencing consumer behaviour (night-tariffs, progressive tariffs, etc.);
- Water (e.g. use of rain water, possibilities for “hot fill” dishwashers);
- Telecom (e.g. hot spots, WLAN, etc.);
- Installation, e.g. availability and level of know-how/training of installers;
- Physical environment, e.g. fraction of shared products, possibilities for shared laundry rooms, etc.

4 TECHNICAL ANALYSIS EXISTING PRODUCTS

Scope: This entails a general technical analysis of current products on the EU-market and provides general inputs for the definition of the Base cases (task 5) as well as the identification of part of the improvement potential (task 7), i.e. the part that relates to the best existing product on the market.

4.1 Production phase

- Product weight and Bill-of-Materials, distinguishing materials fractions/ electronics modules (weight) at the level of the EuP EcoReport Unit Indicators as proposed in the MEEUP report. This includes packaging materials and an assessment of the primary scrap production during sheet metal manufacturing.[111]

4.2 Distribution phase

- Volume and weight of the packaged product.

4.3 Use phase (product)

- Rated annual resources consumption (energy, water, detergent) and direct emissions[112] during product life according to the test standards defined in subtask 1.2 ;
- Assessment of resources consumption (energy, water, detergent) and direct emissions during product life in off-standard conditions, i.e. at variable load.

4.4 Use phase (system)

Almost every product has a clear interface with the surrounding system and often there are alternative routes to fulfil the same or a similar function. A CH boiler has an interface with the (heat load of the) house, the dishwasher has a manual alternative (hand-wash), PCs, TVs and mobile phones have overlapping functionality, refrigeration is only one way of food conservation and fridges interface with health/food waste/ packaging/shopping trips, etc. This paragraph should identify and describe the functional system to which the product in question belongs and identify and possibly quantify those product features that can reduce the environmental impact not only of the product but of

[111] Necessary input into EuP EcoReport

[112] This relates to product-specific emissions during product-life, e.g. ozone for certain imaging equipment, radiation for certain televisions, etc.

the system as a whole. Please note that the scope of the system analysis is restricted only to issues that can be influenced by technical features of the product under investigation as defined in task 1. Furthermore, the system analysis serves as an addition to the more traditional product-specific analysis in paragraph 4.3, i.e. to design product-specific legislation (if any) in such a way that it would not make system-oriented innovations impossible.

4.5 End-of-life phase

Considerations regarding the end-of-life of materials flow[113] for

- Handling as pure waste (landfill, pyrolytic incineration);
- Heat Recovery (non-hazardous incineration optimised for energy recovery);
- Re-use or Closed-loop Recycling.

5 DEFINITION OF BASE-CASE

Scope: For this assessment one or two average EU product (s) have to be defined or a representative product category as the “Base-case” for the whole of the EU-25 has to be chosen. On this Base-Case most of the environmental and Life Cycle Cost analyses will be built throughout the rest of the study. The Base-Case is a conscious abstraction of reality, necessary one for practical reasons (budget, time). Having said that, the question if this abstraction leads to inadmissible conclusions for certain market segments will be addressed in the impact- and sensitivity analysis.

The description of the Base-Case is the synthesis of the results of Tasks 1 to 4 and the point-of-reference for tasks 6 (improvement potential) and 7 (impact analysis).

5.1 Product-specific inputs

- Avg. EU product weight and Bill-of-Materials, distinguishing materials fractions (weight) at the level of the EuP EcoReport Unit Indicators as proposed in the MEEUP report. This includes packaging materials;
- Primary scrap production during sheet metal manufacturing (avg. EU);[114]
- Volume and weight of the packaged product avg. EU;
- Annual resources consumption (energy, water, detergent) and direct emissions[115] during product life according to the test standards defined in subtask 1.2 [“EU Standard Base-Case”];
- Annual resources consumption (energy, water, detergent) and direct emissions during product life according to the real-life situation as defined in subtask 3.2 [“EU Real-life Base-Case”];
- Selected EU scenario at end-of-life of materials flow [116] for:
    - Disposal (landfill, pyrolytic incineration);

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[113] At least for plastics and electronics, as defined in the EuP EcoReport. For metals and glass this may also be indicated if the recycling percentage is less than 95%.

[114] Necessary input into the EuP EcoReport

[115] This only relates to emissions that are not already taken into account in the VHK EcoReport Unit Indicators

[116] At least for plastics and electronics, as defined in the EuP EcoReport. For metals and glass this may also be indicated if the recycling percentage is less than 95%.

- Thermal Recycling (non-hazardous incineration optimised for energy recovery);
- Re-use or Closed-loop Recycling.

5.2 Base-Case Environmental Impact Assessment.

Using the VHK EuP EcoReport indicate the environmental impact analysis, specifying:

- Emission/resources categories as mentioned in the MEEUP Report;

for:

- Raw Materials Use and Manufacturing;
- Distribution;
- Use;
- and End-of-Life Phase.

distinguishing for the Use phase between the Standard Base-Case and the Real-life Base-Case.[117]

Furthermore, if more than one type of resource is used in the Use phase, make a split-up between resources and their individual impacts.

5.3 Base-Case Life Cycle Costs

Combining the results from tasks 2 and 3 define — for the Standard and Real-Life Base-Case the Life Cycle Costs[118]

5.4 EU Totals

Aggregate the Real-Life Base-Case environmental impact data (subtask 5.3) and the Life Cycle Cost data (subtask 5.4) to EU-25 level, using stock and market data from task 2, indicating

- The life cycle environmental impact and total LCC of the new products designed in 2005 (this relates to a period of 2005 up to 2005+product life);
- The annual (2005) impact of production, use and (estimated) disposal of the product group, assuming post-RoHS and post-WEEE conditions.[119]

5.5 EU-25 Total System Impact

Using the estimates of task 4 to estimate the total environmental impact of the product system and compare with outputs from input/output analysis (e.g. EIPRO study).

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[117] Making two analyses

[118], LCC = PP + PWF * OE, where LCC is Life Cycle Costs, PP is the purchase price, OE is the operating expense and PWF (Present Worth Factor) is PWF= $\{1 - 1/(1+r)^N\}/r$, in which N is the product life and r is the discount (interest-inflation) rate.

[119] "Business-as-Usual" scenario to be based on this assumption.

6 TECHNICAL ANALYSIS BAT

Scope: This entails a technical analysis not of current products on the market but on currently available technology, expected to be introduced at product level within 2-3 years. It provides part of the input for the identification of part of the improvement potential (task 7), i.e. the part that relates especially to the best available technology

It entails an assessment of :

6.1 State-of-the-art in applied research for the product (prototype level)

6.2 State-of-the-art at component level (prototype, test and field trial level)

6.3 State-of-the-art of best existing product technology outside the EU

7 IMPROVEMENT POTENTIAL

Scope: Identify design options, their monetary consequences in terms of Life Cycle Cost for the consumer , their environmental costs and benefits and pinpointing the solution with the Least Life Cycle Costs (LLCC) and the Best Available Technology (BAT).

The assessment of monetary Life Cycle Costs is relevant to indicate whether design solutions might negatively or positively impact the total EU consumer's expenditure over the total product life (purchase, running costs, etc.). The distance between the LLCC and the BAT indicates —in a case a LLCC solution is set as a minimum target— the remaining space for product-differentiation (competition). The BAT indicates a medium-term target that would probably more subject to promotion measures than restrictive action. The BNAT (subtask 6.5) indicates long-term possibilities and helps to define the exact scope and definition of possible measures.

7.1 Options

- Identification and description of individual design options for environmental improvement.

7.2 Impacts

- Quantitative assessment of the environmental improvement per option (using EuP EcoReport).

7.3 Costs

- Estimate of price increase due to implementation of these design options, either by looking at prices of products on the market and/or by applying a production cost model with sector-specific margins.

7.4 Analysis LLCC and BAT

- Ranking of the individual design options by LCC (e.g. option 1, option 2, option 3);
- Determination/ estimation of possible positive or negative ('rebound') side effects of the individual design measures;
- Estimating the accumulative improvement and cost effect of implementing the ranked options simultaneously (e.g. option 1, option 1+2, option 1+2+3, etc.), also taking into account the above side-effects;
- Ranking of the accumulative design options, drawing of a LCC-curve (Y-axis= LLCC, X-axis= options) and identifying the Least Life Cycle Cost (LLCC) point and the point with the Best Available Technology (BAT).[120]

7.5 Long-term targets (BNAT) and systems analysis

- Discussion of long-term technical potential on the basis of outcomes of applied and fundamental research, but still in the context of the present product archetype;
- Discussion of long-term potential on the basis of changes of the total system to which the present archetype product belongs: Societal transitions, product-services substitution, dematerialisation, etc.

8 SCENARIO-, POLICY-, IMPACT- AND SENSITIVITY ANALYSIS

Scope: This task summarizes and totals the outcomes of all previous tasks. It looks at suitable policy means to achieve the potential e.g. implementing LLCC as a minimum and BAT as a promotional target, using legislative or voluntary agreements, labelling and promotion. It draws up scenarios 1990 – 2020 quantifying the improvements that can be achieved vs. a Business-as-Usual scenario and compares the outcomes with EU environmental targets, the societal costs if the environmental impact reduction would have to be achieved in another way, etc.

It makes an estimate of the impact on consumers (purchasing power, societal costs) and industry (employment, profitability, competitiveness, investment level, etc.) as described in Appendix 2 of the Directive, explicitly describing and taking into account the typical design cycle (platform change) in a product sector. Finally, in a sensitivity analysis of the main parameters it studies the robustness of the outcome.

8.1 Policy- and scenario analysis

8.2 Impact analysis industry and consumers

8.3 Sensitivity analysis of the main parameters.

[120] This is usually the last point of the curve showing the product design with the lowest environmental impact, irrespective of the price.

APPENDIX II: ECCP TABLES

Introduction

One of the most important references both for the Ecodesign of EuP Directive and for the underlying methodology study is the European Climate Change Programme (ECCP) of the European Commission and more specifically the Second ECCP Progress Report "Can we meet our Kyoto targets?", European Commission, April 2003. This report contains the results of estimated CO_2-emissions and savings potentials at product group level. Results on fuel-related CO_2-emissions for EU-15 were generated in particular by ECCP-WG3, ECCP-JSWG and ECCP-WG2 during the 2001-2003 period and summarized/compiled amongst others in Annex I of the report. Annex I showed the 1990-1995 baseline, the 2010 "Business-as-Usual" (baseline) scenario and the 2010 ECCP scenario. The latter incorporated the effect of the measures proposed by the working groups (labelling, MEPS, promotion, etc.).

However, the compilation in Annex I of the Second ECCP Progress Report was only complete for the residential sector. For the tertiary and industrial sector the Annex I showed only the 1990-1995 baseline. Also on request of the European Commission, VHK has completed the dataset for the tertiary and industrial sector.

The result should not be perceived as the current (2005) best VHK-estimate of the fuel-related CO_2 emissions, but it is a compilation of the data —to the best of ability— of the output of the Working Groups as shown in the Second ECCP Progress Report and underlying working group reports on the basis of the information that was then available. Nor, as these specific tables have not been explicitly reviewed by e.g. the ECCP Steering Committee, should this perceived as the opinion of the European Commission.

Table 1. All Sectors 1990

Sector/function group	Residential	Tertiary	Industry	Total
	Fuel-Related CO_2 emissions in 1990 (in Mt CO_2)			
Total	**762**	**457**	**1031**	**2249**
of which				
Space heating/cooling, *of which*	**481**	**305**	**76**	**860**
Fossil, *of which*	371	227	57	653
Transmission losses	*190*	*116*	*29*	*334*
-windows	*75*	*46*	*11*	*132*
-walls	*55*	*34*	*8*	*97*
-floors	*30*	*18*	*5*	*53*
-roofs	*30*	*18*	*5*	*53*
Ventilation losses	*70*	*43*	*11*	*123*
Heating system losses	*111*	*68*	*17*	*195*
Electric, *of which*	90	78	19	187
Heating (incl. heatpump)	*73*	*33*	*8*	*114*
Cooling (airconditioners)	*2*	*32*	*8*	*42*
CH pump	*15*	*13*	*3*	*31*
District heating	*20*	*?*	*0*	*20*
Hot water, *of which*	**103**	**35**		**138**
Fossil	67	24		91
Electric	36	11		47
Whitegoods & Cooking, *of which*	**109**	**26**		**135**
Fossil (mainly hobs)	9			
Electric, *of which*	100	26		126
Refrigeration/freezers	*62*	*14*		*76*
Washing machines	*20*			*20*
Dishwashers	*7*			*7*
Laundry driers	*4*			*4*
Electric ovens	*7*	*12*		*19*
Lighting (electr.)	**40**	***65***	***16***	**121**
Electronics, *of which*	**16**	**14**	**4**	**34**
Consumer el. (TV, audio, IRD,etc.)	15			
Stand-by	*7*			
On'	*7*			
IT/ office equipment	1	14		
Industrial Motors, *of which*			293	268
Variable speed drives (VSDs)			147	147
Pumps			57	67
Compressors			47	47
Fans			42	42
System opt.				
Other(electric)	**13**	**12**	**82**	**133**
Ind. process heat			**560**	**560**
Autogeneration	**neg**	**neg**	**neg**	
Total (check)	**762**	**457**	**1031**	**2249**
of which (by energy source)				
Fossil	447	251	617	706
Electricity	295	206	414	501
Heat	20	?	?	20

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.

Table 2. Residential sector Baselines 1990-2010 (all values in Mt CO_2 eq.)

RESIDENTIAL SECTOR ***Sector/function group***	**Fuel-Related CO_2 emissions (in Mt CO_2)** ***Reference 1990***	***Baseline 2010***	***Baseline 2010 minus Reference 1990***	***%***
Total	**762**	**797**	**35**	**5%**
of which				
Space heating/cooling, *of which*	**481**	**466**	**-15**	**-3%**
Fossil, *of which*	**371**	**350**	**-21**	**-6%**
Transmission losses	***190***	***186***	***-4***	***-2%***
-windows	*75*	*70*	*-5*	*-7%*
-walls	*55*	*55*	*0*	*0%*
-floors	*30*	*30*	*0*	*0%*
-roofs	*30*	*30*	*0*	*0%*
Ventilation losses	***70***	***73***	***3***	***4%***
Heating system losses	***111***	***91***	***-20***	***-18%***
Electric, *of which*	**90**	**88**	**-2**	**-2%**
Heating (incl. heatpump)	***73***	***68***	***-5***	***-7%***
Cooling (airconditioners)	***2***	***3***	***1***	***50%***
CH pump	***15***	***17***	***2***	***13%***
District heating	***20***	***28***		
Hot water, *of which*	**103**	**115**	**12**	**12%**
Fossil	**67**	**84**	**17**	**25%**
Electric	**36**	**31**	**-5**	**-14%**
Whitegoods & Cooking, *of which*	**109**	**84**	**-25**	**-23%**
Fossil (mainly hobs)	9	9		
Electric, *of which*	100	75		0%
Refrigeration/freezers	*62*	*43*	*-19*	*-31%*
Washing machines	*20*	*11*	*-9*	*-45%*
Dishwashers	*7*	*8*	*1*	*14%*
Laundry driers	*4*	*6*	*2*	*50%*
Electric ovens	*7*	*7*	*0*	*0%*
Lighting (electr.)	**40**	**50**	**10**	**25%**
Electronics, *of which*	**16**	**64**	**48**	**300%**
Consumer el. (TV, audio, IRD,etc.)	15	35	20	**133%**
Stand-by	*7*	*12*	*5*	**71%**
On'	*7*	*23*	*16*	**229%**
IT/ office equipment	1	29	28	**2900%**
Other(electric)	**18**	**18**	**0**	**0%**
Autogeneration	**0**	**0**	**0**	
Total (check)	**767**	**797**	**30**	**4%**
of which (by energy source)				
Fossil	447	443	-4	-1%
Electricity	300	326	26	**9%**
Heat	20	28	8	**40%**

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.
Note: Conversion Electricity 1990: 1 TWh el. = 0.5 Mt CO_2; 2010 1 TWh el.= 0.45 Mt CO_2

Table 3. Residential Sector Baseline 2010 vs. ECCP 2010 (Values in Mt CO_2 eq.)

RESIDENTIAL SECTOR ***Sector/function group***	**Fuel-Related CO_2 emissions (in Mt CO_2)** *Baseline 2010*	*ECCP 2010*	*Baseline 2010 minus ECCP 2010*	*%*
Total	**797**	**618**	**179**	**22%**
of which				
Space heating/cooling, *of which*	**466**	**376**	**90**	**19%**
Fossil, *of which*	350	264	86	25%
Transmission losses	*186*	*153*	*33*	*18%*
-windows	*70*	*47*	*23*	*33%*
-walls	*55*	*50*	*5*	*9%*
-floors	*30*	*27*	*3*	*10%*
-roofs	*30*	*27*	*3*	*10%*
Ventilation losses	*73*	*71*	*2*	*3%*
Heating system losses	*91*	*40*	*51*	*56%*
Electric, *of which*	88	72	16	18%
Heating (incl. heatpump)	*68*	*56*	*12*	*18%*
Cooling (airconditioners)	*3*	*3*	*0*	*0%*
CH pump	*17*	*13*	*4*	*24%*
District heating	*28*	*40*	*-12*	-43%
Hot water, *of which*	**115**	**92**	**23**	**20%**
Fossil	84	63	21	25%
Electric	31	29	2	6%
Whitegoods & Cooking, *of which*	**84**	**70**	**14**	**17%**
Fossil (mainly hobs)	9	7	2	22%
Electric, *of which*	75	63	12	16%
Refrigeration/freezers	*43*	*36*	*7*	*16%*
Washing machines	*11*	*8*	*3*	*27%*
Dishwashers	*8*	*7*	*1*	*13%*
Laundry driers	*6*	*5*	*1*	*17%*
Electric ovens	*7*	*7*	*0*	*0%*
Lighting (electr.)	**50**	**38**	**12**	**24%**
Electronics, *of which*	**64**	**34**	**30**	**47%**
Consumer el. (TV, audio, IRD,etc.)	35	20	15	43%
Stand-by	*12*	*2*	*10*	*83%*
On'	*23*	*18*	*5*	*22%*
IT/ office equipment	29	14	15	52%
Other(electric)	**18**	**18**	**0**	**0%**
Autogeneration	**0**	**-10**	**10**	
Total (check)	**797**	**618**	**179**	**22%**
of which (by energy source)				
Fossil	443	334	109	25%
Electricity	326	244	82	25%
Heat	28	40	-12	-43%

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.
Note: Conversion Electricity 1990: 1 TWh el. = 0.5 Mt CO_2; 2010 1 TWh el.= 0.45 Mt CO_2

Table 4. Tertiary Sector Baselines 1990-2010

TERTIARY SECTOR	**Fuel-Related CO_2 emissions (in Mt CO_2)**			
Sector/function group	***Reference 1990***	***Baseline 2010***	***Baseline 2010 minus Reference 1990***	***%***
Total	**457**	**523**	**66**	**15%**
of which				
Space heating/cooling, *of which*	**305**	**308**	**3**	**1%**
Fossil, *of which*	227	214	-13	-6%
Transmission losses	*116*	*113*	*-3*	*-3%*
-windows	*46*	*43*	*-3*	*-7%*
-walls	*34*	*34*	*0*	*0%*
-floors	*18*	*18*	*0*	*0%*
-roofs	*18*	*18*	*0*	*0%*
Ventilation losses	*43*	*45*	*2*	*5%*
Heating system losses	*68*	*56*	*-12*	*-18%*
Electric, *of which*	78	94	16	21%
Heating (incl. heatpump)	*33*	*31*	*-2*	*-6%*
Cooling (airconditioners)	*32*	*48*	*16*	*50%*
CH pump	*13*	*15*	*2*	*15%*
District heating	*?*	*0*		
Hot water, *of which*	**35**	**39**	**4**	**11%**
Fossil	24	30	6	25%
Electric	11	9	-2	-18%
Whitegoods & Cooking, *of which*	**26**	**37**	**11**	**42%**
Fossil (mainly hobs)				
Electric, *of which*	26	37		0%
Refrigeration/freezers	*14*	*20*	*6*	*46%*
Washing machines				
Dishwashers				
Laundry driers				
Electric ovens	*12*	*17*	*5*	*38%*
Lighting (incl. Street lighting)	***65***	***89***	***24***	**37%**
Electronics, *of which*	**14**	**34**	**20**	**146%**
Consumer el. (TV, audio, IRD,etc.)				
Stand-by				
On'				
IT/ office equipment	14	34	20	
Industrial Motors, *of which*				
Variable speed drives (VSDs)				
Pumps				
Compressors				
Fans				
System opt.				
Other(conveyors & misc.)	**12**	**16**	**4**	**34%**
Ind. process heat				
Autogeneration	**neg**	**neg**	**neg**	
Total (check)	**457**	**523**	**66**	**15%**
of which (by energy source)				
Fossil	251	244	-7	-3%
Electricity	206	279	73	36%
Heat	?	?	?	

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.
Note: Conversion Electricity 1990: 1 TWh el. = 0.5 Mt CO_2; 2010 1 TWh el.= 0.45 Mt CO_2

Table 5. Tertiary Sector Baseline 2010 vs. ECCP 2010

TERTIARY SECTOR	**Fuel-Related CO_2 emissions (in Mt CO_2)**			
Sector/function group	***Baseline 2010***	***ECCP 2010***	***ECCP 2010 minus Baseline 2010***	***%***
Total	**523**	**398**	**-126**	**-24%**
of which				
Space heating/cooling, *of which*	**308**	**223**	**-85**	**-28%**
Fossil, *of which*	214	161	-53	-25%
Transmission losses	*113*	*92*	*-21*	*-19%*
-windows	*43*	*29*	*-14*	*-33%*
-walls	*34*	*31*	*-3*	*-9%*
-floors	*18*	*16*	*-2*	*-11%*
-roofs	*18*	*16*	*-2*	*-11%*
Ventilation losses	*45*	*44*	*-1*	*-2%*
Heating system losses	*56*	*25*	*-31*	*-55%*
Electric, *of which*	94	62	-32	-34%
Heating (incl. heatpump)	*31*	*25*	*-6*	*-19%*
Cooling (airconditioners)	*48*	*47*	*-1*	*-2%*
CH pump	*15*	*11*	*-4*	*-27%*
District heating	*0*	*0*		
Hot water, *of which*	**39**	**32**	**-7**	**-18%**
Fossil	30	23	-7	-23%
Electric	9	9	0	0%
Whitegoods & Cooking, *of which*	**37**	**37**	**0**	**0%**
Fossil (mainly hobs)				
Electric, *of which*	37	30		0%
Refrigeration/freezers	*20*	*15*	*-5*	*-25%*
Washing machines				
Dishwashers				
Laundry driers				
Electric ovens	*17*	*15*	*-2*	*-10%*
Lighting (incl. Street lighting)	***89***	***76***	***-12***	**-14%**
Electronics, *of which*	**34**	**15**	**-19**	**-56%**
Consumer el. (TV, audio, IRD,etc.)				
Stand-by				
On'				
IT/ office equipment	34	15	-19	-56%
Industrial Motors, *of which*				
Variable speed drives (VSDs)				
Pumps				
Compressors				
Fans				
System opt.				
Other (conveyors & misc.)	**16**	**14**	**-2**	**-13%**
Ind. process heat				
Autogeneration	**neg**	**neg**	**neg**	
Total (check)	**523**	**398**	**-126**	**-24%**
of which (by energy source)				
Fossil	244	184	-60	-25%
Electricity	279	214	-66	-24%
Heat	?	?	?	

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.
Note: Conversion Electricity 1990: 1 TWh el. = 0.5 Mt CO_2; 2010 1 TWh el.= 0.45 Mt CO_2

Table 6. Tertiary Sector Baselines 1990- 2010

INDUSTRIAL SECTOR	**Fuel-Related CO_2 emissions (in Mt CO_2)**			
Sector/function group	***Reference 1990***	***Baseline 2010***	***Baseline 2010 minus Reference 1990***	***%***
Total	**1031**	**959**	**-72**	**-7%**
of which				
Space heating/cooling, *of which*	**76**	**72**	**-4**	**-5%**
Fossil, *of which*	57	53	-4	-7%
Transmission losses	*29*	*28*	*-1*	*-3%*
-windows	*11*	*10*	*-1*	*-9%*
-walls	*8*	*8*	*0*	*0%*
-floors	*5*	*5*	*0*	*0%*
-roofs	*5*	*5*	*0*	*0%*
Ventilation losses	*11*	*11*	*0*	*0%*
Heating system losses	*17*	*14*	*-3*	*-18%*
Electric, *of which*	19	19	0	0%
Heating (incl. heatpump)	*8*	*7*	*-1*	*-13%*
Cooling (airconditioners)	*8*	*12*	*4*	*50%*
CH pump	*3*	*3*	*0*	*0%*
District heating	*0*	*0*	*0*	
Hot water, *of which*				
Fossil				
Electric				
Whitegoods & Cooking, *of which*				
Fossil (mainly hobs)				
Electric, *of which*				
Refrigeration/freezers				
Washing machines				
Dishwashers				
Laundry driers				
Electric ovens				
Lighting (incl. Street lighting)	***16***	***20***	***4***	**25%**
Electronics, *of which*	**4**	**10**	**6**	**143%**
Consumer el. (TV, audio, IRD,etc.)				
Stand-by				
On'				
IT/ office equipment				
Industrial Motors, *of which*	**293**	**355**	**62**	**21%**
Variable speed drives (VSDs)	147	187	40	27%
Pumps	57	66	9	16%
Compressors	47	54	7	15%
Fans	42	48	6	15%
System opt.				
Other electric (unspecified)*	**82**	**67**	**-15**	**-18%**
Ind. process heat *	**560**	**435**	**-125**	**-22%**
Autogeneration	**neg**	**neg**	**neg**	
Total (check)	**1031**	**959**	**-72**	**-7%**
of which (by energy source)				
Fossil	617	488	-4	-1%
Electricity	414	471	-5	-1%
Heat	?	?	?	

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.

** = rough estimates based on PRIMES figures for 2010 following The Shared Analysis project "Economic Foundations for Energy Policy", European Commission, Dec. 1999. PRIMES "full flexibility scenario incl. ACEA agreement" with a price of 20 EUR/t CO_2 abated. Accuracy plus or minus 10-15%*

Note: Conversion Electricity 1990: 1 TWh el. = 0.5 Mt CO_2; 2010 1 TWh el.= 0.45 Mt CO_2

Table 7. Industrial Sector Baseline 2010 vs. ECCP 2010

INDUSTRIAL SECTOR	**Fuel-Related CO_2 emissions (in Mt CO_2)**			
Sector/function group	***Baseline 2010***	***ECCP 2010***	***ECCP 2010 minus Baseline 2010***	***%***
Total	**962**	**802**	**-160**	**-17%**
of which				
Space heating/cooling, *of which*	**75**	**62**	**-14**	**-18%**
Fossil, *of which*	53	41	-12	-23%
Transmission losses	*28*	*24*	*-4*	*-14%*
-windows	*10*	*7*	*-3*	*-30%*
-walls	*8*	*7*	*-1*	*-13%*
-floors	*5*	*5*	*0*	*0%*
-roofs	*5*	*5*	*0*	*0%*
Ventilation losses	*11*	*11*	*0*	*0%*
Heating system losses	*14*	*6*	*-8*	*-57%*
Electric, *of which*	22	21	-2	-7%
Heating (incl. heatpump)	*7*	*6*	*-1*	*-14%*
Cooling (airconditioners)	*12*	*12*	*0*	*0%*
CH pump	*3*	*3*	*-1*	*-17%*
District heating	*0*	*0*	*0*	
Hot water, *of which*				
Fossil				
Electric				
Whitegoods & Cooking, *of which*				
Fossil (mainly hobs)				
Electric, *of which*				
Refrigeration/freezers				
Washing machines				
Dishwashers				
Laundry driers				
Electric ovens				
Lighting (incl. Street lighting)	***20***	***15***	***-5***	**-24%**
Electronics, *of which*	**10**	**5**	**-4**	**-45%**
Consumer el. (TV, audio, IRD,etc.)				
Stand-by				
On'				
IT/ office equipment				
Industrial Motors, *of which*	**355**	**238**	**-117**	**-33%**
Variable speed drives (VSDs)	187	138	-49	-26%
Pumps	66	64	-1	-2%
Compressors	54	47	-7	-14%
Fans	48	47	-1	-3%
System optimisation	0	-58	-58	
Other electric (unspecified)*	**67**	**67**	**0**	**0%**
Ind. process heat *	**435**	**415**	**-20**	**-5%**
Autogeneration	**neg**	**neg**	**neg**	
Total (check)	**962**	**802**	**-160**	**-17%**
of which (by energy source)				
Fossil	488	456	-12	-2%
Electricity	474	346	-11	-2%
Heat	?	?	?	

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.

** = rough estimates based on PRIMES figures for 2010 following The Shared Analysis project "Economic Foundations for Energy Policy", European Commission, Dec. 1999. PRIMES "full flexibility scenario incl. ACEA agreement" with a price of 20 EUR/t CO_2 abated. Accuracy plus or minus 10-15%*

Note: Conversion Electricity 1990: 1 TWh el. = 0.5 Mt CO_2; 2010 1 TWh el.= 0.45 Mt CO_2zz

APPENDIX III: REFERENCES & LITERATURE

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Please Note 2: The underlying study is the result of consulting a host of experts, for which we are very grateful. If for some reason we have forgotten to mention your contribution, we apologize beforehand.

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