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中华人民共和国国家标准

GB/T XXXXX—20XX/ISO 14045:2012

环境管理 产品系统生态效率评价 原则、要求和指南

Environmental management — Eco- efficiency assessment of product systems — Principles, requirements and guidelines

(ISO 14045:2012 IDT)

（征求意见稿）

在提交反馈意见时，请将您知道的相关专利连同支持性文件一并附上。

XXXX－XX－XX 发布　　XXXX－XX－XX 实施

国家市场监督管理总局
国家标准化管理委员会 发布

目　　次

前　言

本文件按照GB/T 1.1—2020《标准化工作导则　第1部分：标准化文件的结构和起草规则》的规定起草。

本文件使用翻译法等同采用ISO 14045：2012《环境管理　产品系统生态效率评价　原则、要求和指南》。

为便于使用，本文件作出了下列编辑性修改：

a）“ISO 14045：2012”一词改为“GB/T XXXXX”；

b)规范性引用文件中由“下列文件中的内容通过文中的规范性引用而构成本文件必不可少的条款。其中，注日期的引用文件，仅该日期对应的版本适用于本文件；不注日期的引用文件，其最新版本（包括所有的修改单）适用于本文件。

ISO 14040:2006 环境管理 生命周期评价 原则与框架

ISO 14044:2006 环境管理 生命周期评价 要求与指南

ISO 14050:2009 环境管理 术语”改为

“下列文件中的内容通过文中的规范性引用而构成本文件必不可少的条款。其中，注日期的引用文件，仅该日期对应的版本适用于本文件；不注日期的引用文件，其最新版本（包括所有的修改单）适用于本文件。

GB/T 24040 环境管理 生命周期评价 原则与框架（ISO 14040:2006）

GB/T 24044 环境管理 生命周期评价 要求与指南（ISO 14044:2006）

GB/T 24050 环境管理 术语（ISO 14050:2009）”。

c）用小数点“.”代替作为小数点的逗号“,”；

d）删除ISO 14045：2012的前言，增加了中文前言；

e）对于ISO 14045：2012引用的其它国际标准中有被等同采用为我国标准的，本文件采用我国的这些国家标准或行业标准代替对应的国际标准，其余未等同采用为我国标准的国际标准，在本文件中均被直接引用。

请注意本文件的某些内容可能涉及专利。本文件的发布机构不承担识别专利的责任。

本文件由全国环境管理标准化技术委员会（SAC/TC 207）提出并归口。

本文件起草单位：中国标准化研究院……

本文件主要起草人：

引　　言

Eco-efficiency assessment is a quantitative management tool which enables the study of life-cycle environmental impacts of a product system along with its product system value for a stakeholder.

生态效率评价是一种定量管理工具，可用于研究产品系统在生命周期内的环境影响以及产品系统对利益相关者的价值。

Within eco-efficiency assessment, environmental impacts are evaluated using Life Cycle Assessment (LCA) as prescribed by other International Standards (ISO 14040, ISO 14044). Consequently, eco-efficiency assessment shares with LCA many important principles such as life cycle perspective, comprehensiveness, functional unit approach, iterative nature, transparency and priority of a scientific approach.

在生态效率评价中，本文件使用GB/T 24040、GB/T 24044中规定的生命周期评价（LCA）方法对环境影响进行评价。因此，生态效率评价与生命周期评价的重要原则相一致，如生命周期视角、全面性、功能单元法、迭代性、透明性以及科学方法的优先性。

The value of the product system may be chosen to reflect, for example, its resource, production, delivery or use efficiency, or a combination of these. The value may be expressed in monetary terms or other value aspects.

可选用资源、生产、交付或使用效率及其组合等来反映产品系统的价值，也可用货币或其他价值方面来表示。

The key objectives of this International Standard are to:

本文件的主要目的是：

— establish clear terminology and a common methodological framework for eco-efficiency assessment;

— 为生态效率评价建立明确的术语和通用方法学框架；

— enable the practical use of eco-efficiency assessment for a wide range of product (including service) systems;

— 实现各种产品（包括服务）系统生态效率评价的实际应用；

— provide clear guidance on the interpretation of eco-efficiency assessment results;

— 为生态效率评价结果的解释提供明确指导；

— encourage the transparent, accurate and informative reporting of eco-efficiency assessment results.

— 鼓励进行透明、准确和信息详实的生态效率评价结果报告。

环境管理 产品系统生态效率评价 原则、要求和指南

1 范围 Scope

This International Standard describes the principles, requirements and guidelines for eco-efficiency assessment for product systems, including:

a) the goal and scope definition of the eco-efficiency assessment;

b) the environmental assessment;

c) the product system value assessment;

d) the quantification of eco-efficiency;

e) interpretation (including quality assurance);

f) reporting;

g) critical review of the eco-efficiency assessment.

本文件给出了产品系统生态效率评价的原则、要求和指南，包括生态效率评价的目的和范围界定、环境评价、产品系统价值评价、生态效率的量化、解释（包括质量保证）、报告、鉴定性评审。

Requirements, recommendations and guidelines for specific choices of categories of environmental impact and values are not included. The intended application of the eco-efficiency assessment is considered during the goal and scope definition phase, but the actual use of the results is outside the scope of this International Standard.

本文件不涉及对环境影响和产品系统价值的类别进行指定选择的要求、建议和指南。

2 规范性引用文件 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14040:2006, *Environmental management — Life cycle assessment — Principles and framework*

ISO 14044:2006, *Environmental management — Life cycle assessment — Requirements and guidelines*

ISO 14050:2009, *Environmental management — Vocabulary*

下列文件中的内容通过文中的规范性引用而构成本文件必不可少的条款。其中，注日期的引用文件，仅该日期对应的版本适用于本文件；不注日期的引用文件，其最新版本（包括所有的修改单）适用于本文件。

GB/T 24040 环境管理 生命周期评价 原则与框架

GB/T 24044 环境管理 生命周期评价 要求与指南

GB/T 24050 环境管理 术语

3 术语和定义 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14050 and the following apply.

GB/T 24050界定的以及下列术语和定义适用于本文件。

3.1

产品 product

any goods or service

任何商品或服务。

[来源：GB/T 24021，3.1.11]

3.2

产品流 product flow

products (3.1) entering from or leaving to another product system

产品从其他产品系统进入到本产品系统或离开本产品系统而进入其他产品系统。

[来源：GB/T 24040，3.27]

3.3

产品系统 product system

collection of unit processes with elementary and *product flows* (3.2), performing one or more defined functions, and which models the life cycle of a *product* (3.1)

拥有基本流和产品流，同时具有一种或多种特定功能，并能模拟产品生命周期的单元过程的集合。

[来源：GB/T 24040，3.28]

3.4

环境因素 environmental aspect

element of an organization's activities or products or services that can interact with the environment

一个组织的活动、产品或服务中与环境或能与环境发生相互作用的要素。

Note 1 to entry: A significant environmental aspect has or can have a significant environmental impact.

注：重大环境因素具有或可能具有重大环境影响。

[来源：GB/T 24001，3.2.2]

3.5

环境绩效 environmental performance

measurable results related to *environmental aspects* (3.4)

与环境因素有关的可量化结果。

3.6

生态效率 eco-efficiency

aspect of sustainability relating the *environmental performance* (3.5) of a *product system* (3.3) to its *product system value* (3.7)

产品系统中与其价值关联的产品系统环境绩效可持续发展要素。

3.7

产品系统价值 product system value

worth or desirability ascribed to a *product system* (3.3)

产品系统的作用或预期价值。

Note 1 to entry: The product system value may encompass different value aspects, including functional, monetary, aesthetic, etc.

注：产品系统价值可以包含不同的价值方面，包括功能价值、货币价值、美学价值等。

3.8

产品系统价值指标　product system value indicator

numerical quantity representing the *product system value* (3.7)

表征产品系统价值的数值。

Note 1 to entry: To express the product system value indicator, various kinds of units such as physical and monetary units or relative gradings and scoring may be used.

注：可以使用实物单位、货币单位等各种单位，也可以使用相对等级和分数来表示产品系统价值指标。

3.9

生态效率指标　eco-efficiency indicator

measure relating *environmental performance* (3.5) of a *product system* (3.3) to its *product system value* (3.7)

产品系统环境绩效与其系统价值的关系的衡量。

3.10

生态效率概述　eco-efficiency profile

eco-efficiency (3.6) assessment results relating the life cycle impact assessment results to the *product system value* (3.7) assessment results

生命周期影响评价结果与产品系统价值评价结果相关联的生态效率评价结果。

3.11

权重因子　weighting factor

<eco-efficiency> factor derived from a weighting model, which is applied to convert an assigned life cycle inventory result, a life cycle impact category indicator result, or a product system value indicator to the common unit of the weighting indicator

由加权模型得到的权重因子，用于统一指定的生命周期清单结果、生命周期影响类别指标结果或产品系统价值指标的公共单位。

3.12

敏感性分析　sensitivity analysis

systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study

用来估计所选用方法和数据对研究结果影响的系统化程序。

[来源：GB/T 24040，3.31]

3.13

不确定性分析　uncertainty analysis

systematic procedure to quantify the uncertainty in the results of a life cycle inventory analysis and/or product system value assessment due to the cumulative effects of model imprecision, input uncertainty and data variability

用来量化由于模型的不准确（或不精确）性、输入的不确定性和数据变动的累积而给生命周期清单分析和（或）产品系统价值评估结果带来的不确定性的系统化程序。

Note 1 to entry: Either ranges or probability distributions are used to determine uncertainty in the results.

注：用区间或概率分布来确定结果中的不确定性。

[来源：GB/T 24040，3.33，有修改]

3.14

单元过程　unit process

smallest element considered in the life cycle inventory analysis or product system value assessment for which input and output data are quantified

进行生命周期清单分析或产品系统价值评价时为量化输入和输出数据而确定的最基本部分。

[来源：GB/T 24040，3.34，有修改]

3.15

鉴定性评审　critical review

<eco-efficiency> process intended to ensure consistency between an *eco-efficiency* (3.6) assessment and the principles and requirements of the International Standards on eco-efficiency assessment

确保生态效率评价和生态效率评价标准的原则与要求保持一致的过程。

[来源：GB/T 24040，3.45，有修改]

3.16

生态效率对比声明　comparative eco-efficiency assertion

claim in *eco-efficiency* (3.6) regarding the superiority or equivalence of one *product* (3.1) versus a competitor's *product* that performs the same function

对于一种产品优于或等同于具有相同功能的竞争产品的生态效率声明。

Note 1 to entry: This definition does not interpret, change, or subtract from the requirements of ISO 14044 on comparative assertions.

注：该定义不解释、更改或减少GB/T 24044中关于对比声明的要求。

4　生态效率评价总则 General description of eco-efficiency

4.1　生态效率评价原则 Principles of eco-efficiency

4.1.1　概述 General

The following principles are fundamental and serve as guidance for decisions relating to both the planning and the conducting of an eco-efficiency assessment.

下列基本原则可作为进行生态效率评价规划和实施相关决策的指南。

4.1.2　生命周期视角 Life cycle perspective

An eco-efficiency assessment considers the entire life cycle from raw material extraction and acquisition, through energy and material production and manufacturing, to use and end-of-life treatment and final disposal. Through such a systematic overview and perspective, the shifting of a potential impact between life cycle stages or individual processes can be identified and assessed with a view to an overall eco-efficiency.

生态效率评价应考虑产品系统的整个生命周期，包括原材料的提取和获取、能源和材料的生产、产品的制造和使用、末端处理与最终处置。通过这种系统的概览和视角，可以确定和评估生命周期各阶段或各环节之间的潜在影响变化，以实现全面的生态效率评价。

4.1.3 迭代法 Iterative approach

Eco-efficiency assessment is an iterative technique. The individual phases of an eco-efficiency assessment (see Figure 1) use results of the other phases. The iterative approach within and between the phases contributes to the comprehensiveness and consistency of the eco-efficiency assessment and the reported results.

生态效率评价是一种迭代技术。生态效率评价的各个阶段（见图1）都需要使用其他阶段的结果。在每个阶段内和各阶段之间使用迭代方法将使生态效率评价和报告结果具有全面性和一致性。

4.1.4 透明性 Transparency

Due to the inherent complexity in eco-efficiency assessment, transparency is an important guiding principle in executing an eco-efficiency assessment, in order to ensure a proper interpretation of the results.

由于生态效率评价的固有复杂性，透明性是进行生态效率评价中的一个重要指导原则，用于确保对评价结果做出正确的解释说明。

4.1.5 全面性 Comprehensiveness

An eco-efficiency assessment considers all attributes and aspects of environment and product system value. By considering all attributes and aspects within one eco-efficiency assessment, potential trade-offs can be identified and assessed.

生态效率评价需考虑环境和产品系统价值的所有属性和因素。在一个生态效率评价中，通过全面的属性和因素分析，可以确定和评价所进行的取舍。

4.1.6 科学方法的优先性 Priority of scientific approach

Decisions within an eco-efficiency assessment are preferably based on scientific data, methodology and other evidence. If this is not possible, decisions based on international conventions may be used. If neither a scientific basis exists nor international conventions can be referred to, then decisions may be based on value choices.

生态效率评价中的决策优先以科学数据、方法和其他证据为依据。如果没有，可以采用基于国际公约的决策。如果既没有科学基础存在也不能参考国际公约，那么可根据价值选择做出决策。

4.2 生态效率评价的各个阶段 Phases of an eco-efficiency assessment

An eco-efficiency assessment comprises five phases:

生态效率评价应包括以下5个阶段：

a) goal and scope definition (including system boundaries, interpretation and limitations);

a）目的和范围的界定（包括系统边界、解释和局限性）；

b) environmental assessment;

b）环境评价；

c) product system value assessment;

c）产品系统价值评价；

d) quantification of eco-efficiency;

d）生态效率的量化；

e) interpretation (including quality assurance).

e）解释（包括质量保证）。

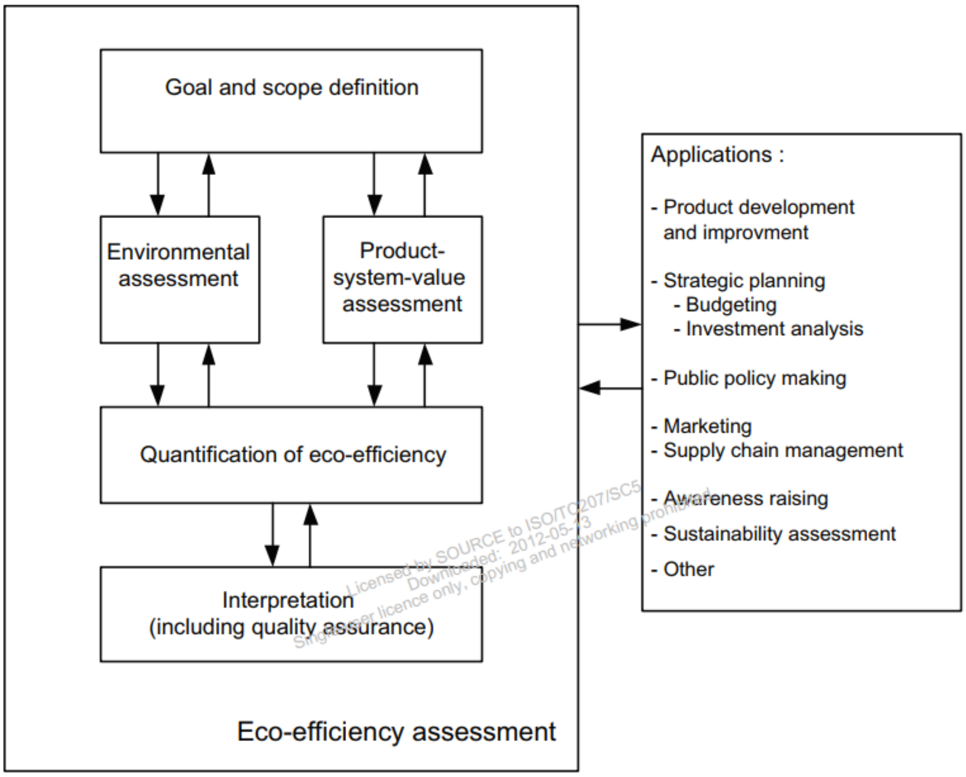


Figure 1 — Phases of an eco-efficiency assessment

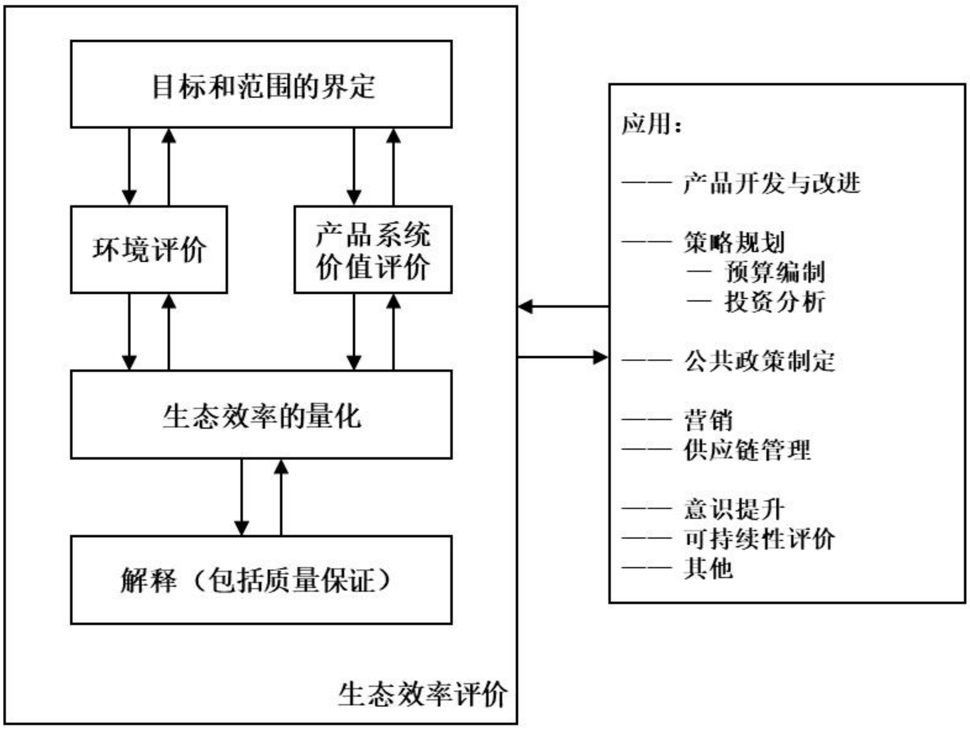


图1　生态效率评价的各个阶段

4.3 生态效率评价的关键特点 Key features of an eco-efficiency assessment

An eco-efficiency assessment is an assessment of the environmental performance of a product system in relation to its value.

生态效率评价是对产品系统的环境绩效与其价值的关系进行评价。

Eco-efficiency is a practical tool for managing environmental and value aspects in parallel.

生态效率是一种并行管理环境和价值方面的实用工具。

The result of the eco-efficiency assessment relates to the product system, not the product per se. A product cannot be eco-efficient, only its product system which includes the production, use, disposal, i.e. the full life cycle, can be. Also, eco-efficiency is a relative concept and a product system is only more-or-less eco-efficient in relation to another product system.

生态效率评价的结果与产品系统有关，而与产品自身无关。对一种产品而言，只有其产品系统在整个生命周期（包括生产、使用、处置）具有生态效率的情况下，这种产品才具有生态效率。此外，生态效率是一个相对的概念，一种产品系统在相对于另一种产品系统时才能进行生态效率的比较。

5 方法学框架 Methodological framework

5.1 总体要求 General requirements

Eco-efficiency assessments shall include goal and scope definition, environmental assessment, product system value assessment, quantifications of eco-efficiency and interpretation.

生态效率评价应包括目的和范围的界定、环境评价、产品系统价值评价、生态效率的量化以及解释说明。

5.2 目的和范围的界定（包括系统边界、解释和局限性） Goal and scope definition (including system boundaries, interpretation and limitations)

5.2.1 概述 Overview of requirements

In defining the goal, the following items shall be considered and clearly described:

a）界定目的时，应明确考虑和说明下列各项情况：

— the purpose of the eco-efficiency assessment;

——生态效率评价的目的；

— the intended audience;

——目标受众；

— the intended use of the results.

——结果的预期用途。

In defining the scope, the following items shall be considered and clearly described:

b）界定范围时，应明确考虑和说明下列各项情况：

— the product system to be assessed;

——待评价的产品系统；

— the function and functional unit;

——功能和功能单元；

— the system boundary of the product system;

——产品系统的系统边界；

— the allocations to external systems;

——外部系统的分配；
— the environmental assessment method and types of impacts;
——环境评价方法和影响类别；
— the value assessment method and type of product system value;
——价值评价方法和产品系统价值类别；
— the choice of eco-efficiency indicator(s);
——生态效率指标的选择；
— the interpretation to be used;
——解释说明；
— the limitations;
——局限性；
— the reporting and disclosure of results.
——结果的报告和披露。

5.2.2 待评价的产品系统 The product system to be assessed

The product system shall be defined by its name and the scale, location, time and main stakeholders which are involved.

应通过名称、规模、地理位置、时间和所涉及的主要利益相关者来定义产品系统。

5.2.3 功能和功能单元 Function and functional unit

The scope of an eco-efficiency assessment shall clearly specify the functions (performance characteristics) of the product system being studied. A functional unit shall be defined that is consistent with the goal and scope of the eco-efficiency assessment.

生态效率评价的范围中应明确规定所研究的产品系统的功能（性能特征）。功能单位应与生态效率评价的目的和范围保持一致。

One of the primary purposes of a functional unit is to provide a reference for the environmental assessment and for the product system value assessment. Therefore, the functional unit shall be measurable and clearly defined.

功能单元的主要目的之一是为环境评价和产品体系价值评价提供基准，因此功能单元应明确确定并可测量。

5.2.4 系统边界 System boundary

The system boundary shall be described as specified in ISO 14044.

应按照GB/T 24044中的规定来界定系统边界。

The system boundary shall be the same for the environmental and the product system value assessment.

环境评价和产品系统价值评价的系统边界应保证选择一致。

5.2.5 外部系统的分配 Allocations to external systems

Allocations to adjacent systems outside the system boundary shall be identified and allocation principles used shall be described.

应识别向系统边界外的相邻系统的分配，还应说明所使用的分配原则。

5.2.6 环境评价方法和影响类别 Environmental assessment method and types of impacts

It shall be determined which elementary flows, cut-off criteria, allocation rules, impact categories, category indicators, characterization models and weighting methods will represent the environmental aspect in the ecoefficiency assessment. The selection of elementary flows, cut-off criteria, allocation rules, impact categories, category indicators, characterization models and weighting methods shall be consistent with the goal of the study.

应确定反映生态效率评价中环境因素的要素，包括基本流、取舍准则、分配规则、影响类别、类别指标、表征模型和加权方法。基本流、取舍准则、分配规则、影响类别、类别指标、表征模型和加权方法的选择应与评价的目的保持一致。

Exclusions made for the purpose of the eco-efficiency assessment shall be described and justified.

为进行生态效率评价所做的排除情况应予以说明并提供理由。

5.2.7 产品系统价值 The product system value

Different stakeholders may encounter different values for the same product system. For instance, the product system value to the consumer may be different from the product system value to the producer, and in turn different from the product system value to the investor.

对于同一种产品系统，不同的利益相关者可能会具有不同的价值观点。例如，产品系统对于消费者的价值可能不同于产品系统对于生产者的价值，又不同于产品系统对于投资者的价值。

It shall be described which stakeholder’s value(s), type of value(s) and methods used to determine the product system value(s) are to be used in the assessment. The value(s) shall be quantifiable with reference to the functional unit according to the goal and scope of the eco-efficiency assessment.

应说明在评价中使用的利益相关者的价值、价值类型以及产品系统价值的确定方法。应根据生态效率评价的目的和范围并参考功能单元对价值进行量化。

NOTE The types of product system values can be as follows:

— functional value;

— monetary value;

— other values.

注：产品系统价值的类别包括功能价值、货币价值和其他价值。

5.2.8 生态效率指标的选择 Choice of eco-efficiency indicator(s)

There are several types of eco-efficiency indicators that may be chosen to express a quantitative statement on eco-efficiency.

生态效率指标具有多种类型，均可选用来表示对生态效率的定量说明。

The eco-efficiency indicator(s) to be used in the assessment shall be described. The evaluation method(s) and the presentation format of the eco-efficiency assessment shall be defined.

应说明在评价中使用的生态效率指标，应确定生态效率评价的评价方法和呈现形式。

For the choice of eco-efficiency indicators, the following requirements apply:

在选择生态效率指标时，应符合下列要求：

——increasing efficiency at the same product system value shall represent an improved environment;

——在相同的产品系统价值下，提高生态效率应代表环境的改善；

——increasing efficiency at the same environmental impact shall represent an improved product system value.

——在相同的环境影响下，提高生态效率应代表产品系统价值的改进。

5.2.9 解释说明 Interpretation to be used

The need for the following aspects of interpretation shall be clearly defined:

解释说明需要包含下列要素：

——an identification of the significant issues based on the results of the environmental and product system value assessment phases;

——根据环境和产品系统价值评价阶段结果为基础的重大问题识别；

——an evaluation that considers aspects of completeness, sensitivity, uncertainty and consistency;

——考虑了完整性、敏感性、不确定性和一致性的评价；

——the formulation of conclusions, limitations and recommendations;

——表述结论、局限性和建议；

——a comparison of eco-efficiency assessment results.

——生态效率评价结果的比较。

5.2.10 局限性 Limitations

The scope in itself defines the conditions under which the assessment is made. In principle, the results are not valid outside the scope.

范围本身定义了评价的条件。所得结果原则上在范围之外无效。

Choices made to define the scope for the eco-efficiency assessment implicitly also define and limit the applicability of the results from the assessment.

为界定生态效率评价范围所做的选择也隐含地界定和限制了评价结果的适用性。

To prevent misuse of the results, the specific applications for which the results are not intended to be used may be identified.

为防止对结果的误用，可明确结果不适用的情景。

5.2.11 结果报告和披露 Reporting and disclosure of results

The type and format of the report and the means of disclosure shall be defined.

应规定报告的类型和格式以及披露方式。

5.3 环境评价 Environmental assessment

5.3.1 概述 General

Environmental assessment shall be based on life cycle assessment according to ISO 14040 and ISO 14044.

环境评价应符合GB/T 24040和GB/T 24044中规定的生命周期评价的要求。

5.3.2 生命周期清单（LCI）结果 Life cycle inventory (LCI) results

The result of an LCI study may be used directly as input to an eco-efficiency assessment. For instance, where resource use and emissions predominantly originate from the use of fossil oil, the crude oil flow may be used as the sole environmental input.

生命周期清单研究的结果可直接作为生态效率评价的输入（如资源使用和排放主要来自石油的使用，则原油流可作为唯一的环境输入）。

5.3.3 生命周期影响评价 Life cycle impact assessment

5.3.3.1 概述 General

Life cycle impact assessment (LCIA), if it is done, shall be in accordance with ISO 14040 and ISO 14044.

生命周期影响评价（LCIA）应按照GB/T 24040和GB/T 24044的要求进行。

5.3.3.2 影响类别指标结果 Impact category indicator results

Life cycle impact category indicator results, as determined according to ISO 14044, may be used for ecoefficiency assessments. Such data will typically result in an eco-efficiency profile, where several environmental aspects are considered in parallel.

根据GB/T 24044进行生命周期影响评价得到的类别指标结果可用于生态效率评价。同时，这些综合考虑多个环境因素的数据要反映在生态效率概述中。

5.3.3.3 加权 Weighting

Weighting shall not be used in eco-efficiency assessments for comparative eco-efficiency assertions intended to be disclosed to the public.

加权不适用于向公众披露的生态效率评价对比声明。

If weighting is used for eco-efficiency assessment, additional requirements to those in ISO 14044 apply. The following shall be described:

若在生态效率评价中使用加权，宜按照GB/T 24044中的附加要求。具体描述包括下列内容：

— weighting principles;

a）加权原则；

— weighting factors;

b）权重因子；

— how the weighting factors were determined including:

c）如何确定权重因子，包括：

——methodology;

——方法学；

——which stakeholder values have been used to determine the weighting factors.

——确定权重因子时利益相关方的价值选择。

5.4 产品系统价值评价 Product system value assessment

5.4.1 概述 General

The product system value assessment shall consider the full life cycle of the product system.

产品系统价值评价应考虑产品系统的整个生命周期。

There are many ways to assess the product system value, as the product system may encompass different value aspects, including functional, monetary and aesthetic aspects.

产品系统价值可能体现在不同的方面（包括功能、货币和美学方面），因此产品系统价值评价方法具有多样化。

In business economics, values created by businesses are equal to profit, that is income minus costs. For customers, it may be the willingness to pay minus costs, often called surplus value. The costs may include price, rental fee, operating charge, etc. Such values are difficult to determine on a life cycle basis because some actors in the supply chain are unwilling to communicate their costs and profits. However, one may estimate changes in such values, either through functional performance (functional value) or through financial costs (monetary value).

在商业经济学中，企业创造的价值等于利润，即等于收入减去成本。对于客户来说，这种价值可能等于支付意愿减去成本的费用，通常称为剩余价值。成本可能包括价格、租金、运营费用等。由于供应

链中的一些参与者不愿意分享其成本和利润信息，因此难以在生命周期基础上确定这些价值，但可通过功能性能（功能价值）或财务成本（货币价值）来估计这些价值的变化。

5.4.2 合理的产品系统价值类别 Possible product system value types

5.4.2.1 功能价值 Functional value

The functional value of a product system reflects a tangible and measurable benefit to the user and other stakeholders. The functional value is a numerical quantity representing functional performance or desirability of a product system, and is subject to improvement.

产品系统的功能价值反映了用户和其他利益相关者的有形且可衡量的利益。功能价值是代表产品系统功能或期望的数值，并可以进行改进。

In the eco-efficiency assessment, the functional value is different from the functional unit. The functional value should be measured and related to the functional unit in a quantification of the product system performance. The functional unit provides a reference to which the input and output data are normalized (in a mathematical sense). Therefore, within an eco-efficiency assessment, the functional value may change, e.g. because of product improvement, whereas the functional unit remains the same.

在生态效率评价中，功能价值不同于功能单元。在产品系统性能的量化中，应测算功能价值并将其与功能单元联系起来。功能单元为输入和输出数据的归一化（数学意义上）提供了参考基准。在生态效率评价中，功能价值可能会变化（例如由于产品改进同时功能单元保持不变）。

5.4.2.2 货币价值 Monetary value

Monetary value may be expressed in terms of costs, price, willingness to pay, added value, profit, future investment, etc.

货币价值可以用成本、价格、支付意愿、附加价值、利润、未来投资等来表示。

Changes in costs for a single company may represent changes in the product system value over the entire life cycle. If other parts of the product system are affected, for example if the price from suppliers is negotiated to be lower or the price to the customer is raised for the same products, then there is no net change in the product system value.

单独公司的成本变化可能代表整个生命周期中产品系统价值的变化。如果产品系统的其他部分受到影响（例如供应商提供的价格经协商而降低，或者相同产品卖给客户的价格提高），则产品系统价值没有净变化。

5.4.2.3 其他价值 Other values

Other values may include intangible values such as aesthetic, brand, cultural and historical values. These values may be determined by means of interviews, surveys, market research, etc.

其他价值可包括无形价值，如美学、品牌、文化和历史价值。这些价值可以通过访谈、调查、市场研究等方式确定。

5.4.3 产品系统价值指标的计算 Calculation of product system value indicator

The quantification of the product system value shall be carried out by using relevant product system value indicators, as defined in the goal and scope of the eco-efficiency study.

根据生态效率研究的目的和范围，采用相关的产品系统价值指标对产品系统价值进行量化。

NOTE Examples of functional value, monetary value, other values and value indicators can be found in Annex A.

注：功能价值、货币价值、其他价值和价值指标的示例见附录A。

5.5 生态效率的量化 Quantification of eco-efficiency

The eco-efficiency results shall be determined by relating the results of the environmental assessment to the results of the product system value assessment, according to the goal and scope definition.

应根据生态效率评价的目的和范围，对环境评价结果与产品系统价值评价结果进行关联从而得到量化结果。

For eco-efficiency assessments intended to be communicated to the public, an eco-efficiency profile shall be determined by relating the LCIA profile to the product system value.

若生态效率评价向公众公布，应通过将生命周期影响评价与产品系统价值相关联从而形成生态效率概述。

5.6 敏感性和不确定性分析 Sensitivity and uncertainty analysis

Sensitivity analysis is a procedure used to determine how changes in data and methodological choices affect the results of the eco-efficiency assessment. A sensitivity analysis may provide additional information on data choice(s). In an eco-efficiency assessment, several different methods for determination of environmental and product system value indicators may be used. Therefore, a sensitivity analysis should be conducted to assess the consequences on the eco-efficiency assessment results of different choices of methodology and data.

敏感性分析是一种用于确定数据和方法学的选择对生态效率评价结果产生多大影响的程序。敏感性分析可为数据选择提供附加信息。在生态效率评价中，可采用多种方法来确定环境和产品系统价值指标。因此，通过敏感性分析可以确定不同方法学和数据选择对生态效率评价结果的影响。

An uncertainty analysis should be conducted to determine how uncertainties in data and assumptions affect the reliability of the results of the eco-efficiency assessment.

不确定性分析是一种用于确定数据和假设的不确定性对生态效率评价结果可靠性产生多大影响的程序。

An analysis of results for sensitivity and uncertainty shall be conducted for eco-efficiency assessments intended to be used in comparative eco-efficiency assertions intended to be disclosed to the public.

对于计划向公众公布的生态效率评价对比声明，应在生态效率评价中进行敏感性分析和不确定性分析。

5.7 解释说明 Interpretation

5.7.1 概述 General

The interpretation phase of an eco-efficiency assessment comprises the following elements, according to the goal and scope of the study:

根据研究的目的和范围，生态效率评价的解释说明应包括以下要素：

——the identification of significant issues based on the results of the environmental and product system value assessment phases;

——根据环境和产品系统价值评价阶段结果为基础的重大问题识别；

——an evaluation that considers aspects of completeness, sensitivity, uncertainty and consistency;

——考虑了完整性、敏感性、不确定性和一致性的评价；

——the formulation of conclusions, limitations and recommendations.

——表述结论、局限性和建议。

The requirements and recommendations in ISO 14044:2006, 4.5, shall also apply for the interpretation of an eco-efficiency assessment. In addition, the interpretation shall consider the relationship between the environmental results and the product system value results.

GB/T 24044中4.5的要求和建议同样适用于对生态效率评价的解释说明。此外，解释说明还应考虑环境影响结果与产品系统价值结果之间的关联。

5.7.2 环境影响与产品系统价值指标之间的权衡 Trade-offs between environmental and product system value indicators

Eco-efficiency indicators address both environmental and value aspects and there are potential trade-offs between changes in environmental and product system value performances. The interpretation of results shall be done transparently and with proper justification.

生态效率指标涉及环境方面和价值方面，并且在环境绩效和产品系统价值绩效的变化之间存在潜在的权衡关系。对评价结果的解释说明应透明化并提供合理解释。

NOTE Trade-offs can also apply within the environmental aspects themselves, but this is covered by ISO 14040.

注：也可对环境各方面自身进行权衡，具体详见GB/T 24040。

5.7.3 生态效率评价结果的比较 Comparison of eco-efficiency assessment results

When a comparison of eco-efficiency results between product systems or within the same product system is made, it shall be based on the same eco-efficiency indicator. The comparative environmental assessment results and the product system value assessment results shall then be separately included in the eco-efficiency assessment report.

对比不同产品系统之间或同一产品系统内的生态效率评价结果时，应基于相同的生态效率指标进行。应将可比较的环境评价结果和产品系统价值评价结果分别纳入生态效率评价报告。

If improvements in eco-efficiency assessment results are identified or comparisons based on eco-efficiency assessment results are performed, the following cases should be differentiated:

若要说明产品系统的生态效率评价结果得到改进或优于其他产品系统，则应区分下列情况：

a) improvement or superiority in both aspects (environmental performance and product system value);

a）两个方面（环境绩效和产品系统价值）都有改进或具有优越性；

b) improvement or superiority in just one of the two aspects;

b）两个方面中其中一个有改进或具有优越性；

c) no improvement or superiority in either one.

c）两个方面均无改进和具有优越性。

The first and the third cases do not contain trade-offs between the two dimensions. In the first case, an improvement/superiority in eco-efficiency can be unambiguously determined.

In the third case, an improvement/superiority in eco-efficiency can be unambiguously denied.

第一种和第三种情况不包含两个方面之间的权衡。在第一种情况下，可明确确定生态效率的改进或优越性。在第三种情况下，可明确否定生态效率的改进和优越性。

The second case is the most challenging, because of the trade-off between environmental and product system value aspects. In this case, an improvement or superiority of eco-efficiency shall only be reported if the trade-off is clearly communicated and the underlying product system value assumptions are documented and justified.

第二种情况最难以判定，因为要权衡环境影响和产品系统价值两个方面。在这种情况下，只可在两个方面之间的权衡被清楚表达，且产品系统价值假设认定合理并有文本记录时，才能报告生态效率的改进或优越性。

If a claim of improved eco-efficiency or of superiority of the eco-efficiency is disclosed to third parties for the purpose of comparative eco-efficiency assertions, the eco-efficiency assessment results shall demonstrate an equal or better environmental performance.

如果出于对比生态效率的目的，向第三方披露生态效率改进或优越性的主张，则生态效率评价结果应证明产品系统具有同等或更优的环境绩效。

6 结果报告和披露 Reporting and disclosure of results

6.1 总体要求 General requirements

The eco-efficiency results shall be reported as defined in the goal and scope definition phase of the study.

生态效率评价结果应按照研究目的和范围界定阶段中的要求予以报告。

The results and conclusions of the eco-efficiency assessment shall be completely and accurately reported without bias to the intended audience. The results, data, methods, assumptions and limitations shall be transparent and presented in sufficient detail to allow the reader to comprehend the complexities and tradeoffs inherent in the eco-efficiency assessment. The report shall also allow the results and interpretation to be used in a manner consistent with the goals of the eco-efficiency assessment.

生态效率评价的结果和结论应完整地、准确地、不带偏向性地向目标受众予以报告。结果、数据、方法、假设和局限性应是透明的，并应提供足够详细的说明，以使读者能理解生态效率评价中固有的复杂性和所做权衡。报告还应以符合生态效率评估目的的方式进行结果报告和解释说明。

The results of the environmental assessment and the product system value assessment shall be documented separately.

环境影响评价和产品系统价值评价的结果应分别记录。

6.2 向公众披露生态效率对比声明的进一步报告的要求 Further reporting requirements for comparative eco-efficiency assertion intended to be disclosed to the public

For eco-efficiency assessments used in comparative eco-efficiency assertions intended to be disclosed to the public, the following issues shall also be addressed by the report, in addition to those identified in 6.1.

计划向公众公布生态效率评价中的生态效率对比声明，除6.1中包含的内容外，报告还应说明下列问题：

For the environmental assessment, the following shall be addressed:

a）对于环境影响评价，应涉及以下内容：

a) an analysis of material and energy flows to justify their inclusion or exclusion;

——对物质流和能量流是否包含或排除的分析；

b) an assessment of the precision, completeness and representativeness of data used;

——对所用数据的准确性、完整性和代表性进行的评价；

c) a description of the equivalence of the systems being compared;

——对用于比较的系统等价性的描述；

d) a description of the critical review process;

——对鉴定性评审过程的描述；

e) an evaluation of the completeness of the LCIA;

——对生命周期影响评价完整性的评估；

f) a statement as to whether or not international acceptance exists for the selected LCIA category indicators and a justification for their use;

——对所选用的生命周期影响评价类别指标是否获得了国内或国际认可的声明，以及使用这些指标的理由；

g) an explanation for the scientific and technical validity and environmental relevance of the LCIA category indicators used in the eco-efficiency assessment;

——对生态效率评价中所用生命周期影响评价类别指标的科学性、技术可行性和环境相关性的解释说明；

h) the results of the uncertainty and sensitivity analyses;

——不确定性和敏感性分析的结果；

i) an evaluation of the significance of the differences found.

——对所发现差异的重要性的评价。

For the product system value assessment, the following shall be addressed:

b）对于产品系统价值评价，应涉及以下内容：

a) the assumptions made in the product system value assessment phase shall be clearly reported and justified;

——对产品系统价值评价阶段所作的假设应清晰报告并论证；

b) the methodologies and product system value indicators used in the product system value assessment phase shall be clearly reported and justified;

——对产品系统价值评价阶段使用的方法和产品系统价值指标应清晰报告并论证；

c) an assessment of the precision, completeness and representativeness of data used;

——对所用数据的准确性、完整性和代表性进行的评价；

d) a description of the critical review process;

——对鉴定性评审过程的描述；

e) an evaluation of the completeness of the product system value assessment;

——对产品系统价值评价完整性的评估；

f) the results of the uncertainty and sensitivity analyses;

——不确定性和敏感性分析的结果；

g) an evaluation of the significance of the differences found.

——对所发现差异的重要性的评价。

If the results from an eco-efficiency assessment are intended to be used in comparative eco-efficiency assertions disclosed to the public, neither the environmental nor the eco-efficiency assessment results shall be reported as a single overall score or number.

若生态效率评价结果计划用于向公众公布生态效率对比声明，则环境影响和生态效率评价的结果均不得作为一个整体分数或数字进行报告。

7 鉴定性评审 Critical review

7.1 概述 General

The critical review process shall ensure that

鉴定性评审过程应确保下列原则：

— the methods used to carry out the eco-efficiency assessment are consistent with this International Standard;

——生态效率评价所用方法应符合本文件的要求；

— the methods used to carry out the eco-efficiency assessment are scientifically and technically valid;

——生态效率评价所用方法具有科学性和技术可行性；

— the data used are appropriate and reasonable in relation to the goal of the eco-efficiency assessment;

——所用数据适当合理，且与生态效率评价目的相关；

— the interpretations reflect the limitations identified and the goal of the eco-efficiency assessment;

——解释说明应反映已识别的局限性以及生态效率评价的目的；

— the eco-efficiency assessment report is transparent and consistent;

——生态效率评价报告透明且一致；

— the final results reflect the scenarios, the variety of data, and the impact of different methods of weighting and allocation identified in the eco-efficiency assessment.

——最终结果应反映生态效率评价中的各种情景、数据多样性以及不同权重和分配方法的影响。

The scope and type of critical review desired shall be defined in the scope phase of an eco-efficiency assessment, and the decision on the type of critical review shall be recorded.

鉴定性评审的范围和类型应在生态效率评价的范围界定阶段所确定，并应记录对鉴定性评审类别的决定。

In order to decrease the likelihood of misunderstandings or negative effects on external interested parties, a panel of interested parties shall conduct critical reviews on eco-efficiency assessment where the results are intended to be used in a comparative eco-efficiency assertion intended to be disclosed to the public.

对于结果计划用于向公众公布生态效率对比声明的生态效率评价，为减少误解或对外部利益相关方的负面影响，应由利益相关方组成的专家组对生态效率评价进行鉴定性评审。

7.2 内部或外部专家进行的鉴定性评审 Critical review by internal or external expert

A critical review may be carried out by an internal or external expert. In both cases, an expert independent of the eco-efficiency assessment shall perform the review. The review statement, comments of the practitioner and any response to recommendations made by the reviewer shall be included in the eco-efficiency assessment report.

鉴定性评审可由内部或外部专家进行。这两种情况下，均应由独立于生态效率评价的专家进行评审。评审声明、专业人员的意见以及对评审人建议的全部回复均应包含在生态效率评价报告中。

If the eco-efficiency assessment results are intended to be disclosed to the public, a critical review by an external expert shall be performed.

如果拟向公众披露生态效率评价结果，则应由外部专家进行鉴定性评审。

7.3 利益相关方专家组进行的鉴定性评审 Critical review by panel of interested parties

If the eco-efficiency assessment is intended to be used for a comparative eco-efficiency assertion intended to be disclosed to the public, a critical review by interested parties shall be carried out.

若生态效率评价旨在用于计划向公众公布的生态效率对比声明，则应由利益相关方进行鉴定性评审。

In such a case, an external independent expert should be selected by the original study commissioner to act as chairperson of a review panel of at least three members. Based on the goal and scope of the study, the chairperson should select other independent qualified reviewers. This panel may include other interested parties affected by the conclusions drawn from the eco-efficiency assessment, such as government agencies, non-governmental groups, competitors and industries.

这种情况下，应由原研究专员选择一名外部独立专家担任评审专家组主席，评审专家组不少于三名成员。主席应根据研究的目的和范围选择其他具有独立评审资格的专家。该专家组可能包括受生态效率评价结论影响的其他相关方，如政府机构、非政府组织、竞争对手和实业公司。

The expertise of reviewers in the scientific disciplines relevant to the environmental and product system value assessment phases, in addition to other expertise and interest, shall be considered.

评审专家应具有在环境影响和产品系统价值评价阶段相关的科学专业知识，还需考虑其他专业知识和兴趣。

The review statement and review panel report, as well as comments of the chairperson and any responses to recommendations made by the reviewer or by the panel, shall be included in the eco-efficiency assessment report.

评审声明和评审专家组报告以及对主席意见和评审专家组建议的全部回复均应包含生态效率评价报告中。

附 录 A
（资料性）
Examples of functional value, monetary value, other values and value indicators
功能价值、货币价值、其他价值及价值指标的示例

Table A.1 — Light source life cycle example

Terms	Example	Value indicator (unit)
Product system	Light source life cycle	
Function	Illumination	
Functional value	Brightness	Luminous flux (lumen)
Monetary value	Market price	Price (euro/piece)
Other values	Shape	Consumer ranking (numerical value from 1 to 5)

表 A.1 照明器具生命周期示例

术语	示例	价值指标（单位）
产品系统	照明器具生命周期	
功能	照明	
功能价值	亮度	光通量（流明）
货币价值	市场价格	价格（欧元/件）
其他价值	外形	消费者评级（数值从 1 到 5）

Table A.2 — Mobile phone example

Terms	Example	Value indicator (unit)
Product system	Mobile phone	
Function	Possibility to use the product for a long time	
Functional value	Durability	Warranty lifetime (years)
Monetary value	Depreciation	Trade-in value (USD)
Other values	Aesthetics	Colour preference by consumer value (numerical from 1 to 5)

表 A.2 移动电话示例

术语	示例	价值指标（单位）
产品系统	移动电话	
功能	产品长时间使用的可能性	
功能价值	耐用性	保证使用寿命（年）

货币价值	折旧	以旧换新价值（美元）
其他价值	美观	消费者对颜色偏好的打分（数值从 1 到 5）

Table A.3 — Ecotourism service example

Terms	Example	Value indicator (unit)
Product system	Ecotourism service	
Function	Provision of accommodation and ecotours	
Functional value	Hotel accommodation for tourists	Number of room-nights
Monetary value	Contribution to GDP or contribution to local economy	Turnover (USD)
Other values	Employment opportunities	Number of jobs created

表 A.3 生态旅游服务示例

术语	示例	价值指标（单位）
产品系统	生态旅游服务	
功能	提供住宿和生态旅游	
功能价值	游客酒店住宿	房间住宿天数
货币价值	对国内生产总值（GDP）或当地经济的贡献	营业额（美元）
其他价值	就业机会	创造的就业岗位数量

附 录 B
（资料性）
Examples of eco-efficiency assessment
生态效率评价示例

B.1 概述 General

These examples illustrate the eco-efficiency assessment procedure. The choices made, and methods used, are not prescribed by this International Standard; rather it addresses the way in which they are performed and presented. The given examples are not intended to be used for comparative eco-efficiency assertions.

以下示例展示了生态效率评价的流程。本文件不规定如何选择和方法使用，而是给出执行和呈现的方式。所列示例不会用于生态效率对比声明。

B.2 根据日本电子工业指南对电子产品进行生态效率评价的示例 Example of eco-efficiency assessment applied to electronics products according to the guidelines for the Japanese electronics industry

B.2.1 概述 General

Eight major electronics companies in Japan voluntarily agreed to develop guidelines for eco-efficiency assessment in order to provide rationalized indicators as a powerful communication tool between manufacturers and customers[1].

日本有8家主要的电子公司自愿制定了生态效率评价指南，以提供合理化的指标作为制造商和消费者间有力的沟通工具[1]。

In 2006, an eco-efficiency evaluation method was designed to create the indicators for air conditioners, refrigerators, lamps, and lighting equipment; it designated life cycle GHG emissions as their environmental impact. Then, in March 2009, with the addition of a washing/drying machine and a personal computer to the list of products by the Japan Eco-efficiency Forum of Japan Environmental Management Association for Industry (JEMAI), the guidelines were established.

2006年，一种为空调、冰箱、灯具和照明设备创建了指标的生态效率评价方法被设计提出，该方法将生命周期内的温室气体排放选定为产生的环境影响。2009年3月，日本产业环境管理协会（JEMAI）在日本生态效率论坛时将洗衣机/烘干机和个人电脑添加到了产品清单中，并建立了指南。

These guidelines lay down the methods of calculation and other relevant details regarding the eco-efficiency of six product systems and a “Factor-X” (which expresses the relative level of improvement in eco-efficiency in simple numeric terms), and provide uniform eco-efficiency indicators that can help customers select and purchase more environmentally conscious products on the market.

指南规定了6种产品系统生态效率的计算方法和有关细节，以及“因子X”（用数字表示生态效率的相对改进水平），并提供了统一的生态效率指标，以帮助消费者选择和购买市场上更环保的产品。

Based on the “Guidelines for Standardization of Electronics Product Eco-Efficiency Indicators Ver. 2.1” published by JEMAI[2], an example of eco-efficiency assessment for electric lamps is presented below.

根据日本产业环境管理协会发布的《电子产品生态效率指标标准化指南（版本2.1）》[2]，下文给出了一个电灯具生态效率评价的示例。

B.2.2 目的和范围的界定 Goal and scope definition

B.2.2.1 目的的界定 Goal definition

Purpose of the eco-efficiency assessment:	To promote the change from a conventional product [an incandescent light bulb (Product A)] to an alternative product [a bulb-shaped fluorescent lamp (Product B)], by presenting the difference of eco-efficiencies between these two products
生态效率评价的目的	通过展示两种产品的生态效率差异，促进由传统产品（白炽灯泡（产品 A））向可替代产品（球茎形荧光灯（产品 B））的转变。
Intended audience:	Customer and everybody who is interested
目标受众	消费者和感兴趣人群。
Intended use of the results:	Calculation of a “Factor-X” (the ratio of the eco-efficiency indicator of Product B compared to that of Product A) and presentation to customers
结果的预期用途	计算“因子 X”（产品 B 的生态效率指标与产品 A 的生态效率指标之比）并向消费者展示。

B.2.2.2 范围的界定 Scope definition

1) Product system to be assessed

a）待评价的产品系统

Name:	Product A: incandescent light bulb, type 60 (54 W) Product B: bulb-shaped fluorescent lamp, type 60 (10 W) These two products are made by the same company
名称	产品A：60型白炽灯泡（54 W） 产品B：60型球茎形荧光灯（10 W） 两种产品由同一家公司生产。
Scale of production:	Product A and Product B: large quantity
生产规模	产品A和产品B：量产
Location of life cycle stages:	Production: Product A, Japan; Product B, Indonesia Use and waste management: Product A and Product B, Japan
生命周期各阶段的地理位置	生产：产品A：日本；产品B：印度尼西亚 使用与废物管理：产品A和产品B：日本
Time of life cycle stages:	Production: Product A and Product B, 2008 model Use: Product A, 2008; Product B, 2008-2014 (5,5 h/d) Waste management: Product A, 2008; Product B, 2014
生命周期各阶段时间	生产：产品A和产品B：2008年 使用：产品A：2008年；产品B：2008-2014年（5.5小时/天） 废物管理：产品A：2008年；产品B：2014年
Main stakeholders involved:	Customer
主要利益相关方	消费者

2) Function and functional unit

b）功能和功能单元

— The function of the product system is illumination. The reason for this choice is because illumination clearly indicates a primary characteristic of lamps and is intuitively understandable by general customers.

该产品系统的功能是照明，理由是“照明”明确表现为灯具的一个主要特征，并能被大多消费者直观理解。

— Its functional unit is defined as the illumination of the same luminous flux during 1 000 h of use.

其功能单元定义为在 1000 小时内同等光通量的照明。

3) System boundary

c）系统边界

— Each stage of the product life cycle is included, such as material acquisition, parts production, manufacturing of lamps, packaging staffs, domestic distribution and use.

产品生命周期内的各个阶段，包括材料获取、零部件生产、灯具制造、包装、国内分销和使用。

— For the product system value assessment, the use stage is chosen to represent the product system value.

在产品系统价值评价时，选择使用阶段来体现产品系统价值。

4) Allocations to external systems

d）外部系统的分配

— No allocation to adjacent systems is made.

没有为相邻系统分配。

5) Environmental assessment method and types of impacts

e）环境评价方法和影响类别

— An ordinary life cycle assessment is carried out in accordance with ISO 14040 and 14044.

按照 GB/T 24040 和 GB/T 24044 的要求进行生命周期评价。

— Life cycle GHG emissions are selected to simply evaluate the environmental impact of these products due to the significant effects to global warming and the big concern of customers.

考虑到这些产品对全球变暖带来的显著影响以及消费者的高度关注，因此选择生命周期温室气体排放量来简要评价产品的环境影响。

— An environmental impact indicator is quantified by using the total amount of the life cycle GHG emissions according to the functional unit.

基于功能单元，采用生命周期温室气体排放总量对环境影响指标进行量化。

— Other life cycle impact categories (for example arising from mercury and UV and electromagnetic radiation from fluorescent lamps) are excluded from the study. After a relevance check, their impacts are considered to be small compared to GHG emissions.

其他生命周期内的影响类别（例如汞、紫外线和荧光灯电磁辐射引起的影响）被排除在本研究之外。相关检验表明，相比温室气体排放，这些类别的影响相对较小。

6) Value assessment method and type of product system value

f）价值评价方法和产品系统价值类型

— The functional value for customers is assessed, and a physical quantity is used to express the functional value.

对消费者角度的功能价值进行了评价，并采用一个物理量来表示该功能价值。

— Each product system’s brightness throughout its entire life is selected as the functional value.

每个产品系统在其全生命周期内的亮度被选为功能价值。

— A product system value indicator that represents the functional value is quantified by using the total amount of the life cycle brightness, i.e. the brightness multiplied by the lifetime using a usage scenario based on average and constant conditions. Then, the indicator is normalized according to the functional unit.

采用生命周期内的亮度总量来量化表示功能价值的产品系统价值指标，即利用基于平均和恒定条件使用情景下的亮度与使用寿命的乘积，然后根据功能单元对指标进行归一化处理。

7) Choice of eco-efficiency indicator(s)

g）生态效率指标的选择

— In this example, the eco-efficiency indicator is defined as a “product system value indicator divided by the environmental impact indicator”.

在该示例中，生态效率指标定义为“产品系统价值指标与环境影响指标之比”。

8) Interpretation to be used

h）解释说明

— The following aspects of interpretation are needed for the intended use of the results:

为实现结果的预期用途，需要提供以下方面的解释：

— the identification of significant issues;

——重大问题识别；

— an evaluation that considers aspects of completeness and consistency;

——考虑完整性和一致性方面的评价；

— the formulation of conclusions, limitations and recommendations;

——表述结论、局限性和建议；

— a comparison of eco-efficiency results.

——生态效率结果的比较。

9) Limitations

i）局限性

— In the environmental assessment, the results of the LCI study or LCIA except life cycle GHG emissions are not considered to form the environmental impact indicator.

在环境评价中，生命周期清单研究或生命周期影响评价的结果（不包括生命周期温室气体排放量）不作为环境影响指标。

— In the product system value assessment, the functional values other than life cycle brightness are not considered to form the product system value indicator.

在产品系统价值评价中，除生命周期亮度外的其他功能价值不作为产品系统价值指标。

10) Reporting and disclosure of results

j）结果报告和披露

— An independent review will be conducted. The Factor-X results will be presented in product declarations. A full report will be available on the Internet.

将进行独立评审。应在产品声明中提供因子X结果，并在互联网上公布完整报告。

B.2.3　环境评价 Environmental assessment

— Life cycle assessment in accordance with ISO 14040 and 14044 was carried out using the process analysis method based on the JEMAI-LCA1.10 Database for each product.

按照 GB/T 24040 和 GB/T 24044 的要求，采用基于 JEMAI-LCA1.10 数据库的过程分析方法对每种产品进行了生命周期评价。

— Only the materials and parts used in the final products were considered. Domestic distribution of “1 000 km by using 4-t trucks” was assumed. In the manufacturing stage, primary and average data were collected and used. For use, the “rated electricity consumption” throughout the product lifetime was adopted, so that the power change over the same duration was ignored in the calculations. The lifetimes are: 13 000 h for Product B and 1 000 h for Product A.

只考虑最终产品使用的材料和部件。假设“使用 4 吨级卡车运输 1000 公里”进行国内分销。在制造阶段，主要数据和平均数据被收集与利用。在使用阶段，计算中仅考虑产品寿命内的“额定耗电量”，忽略同一时间内的功率变化。使用寿命：产品 A 为 1000 小时，产品 B 为 13000 小时。

— As a result of assessment, it was found that 98 % or more of life cycle GHG emissions were emitted in the use stages for both products. Other impacts produced almost the same results.

评价结果发现，两种产品 98%以上的温室气体是在生命周期内的使用阶段所排放，其他影响产生的结果几乎相同。

— The total amount of the life cycle GHG emissions was presented in units of [kg-CO_2e] to form the environmental impact indicator.

环境影响指标（生命周期温室气体排放总量）以千克二氧化碳当量（kg CO_2e）为单位。

— The total amount of the life cycle GHG emissions for Product B was quite a bit larger than that of Product A due to its long lifetime. However, as the indicator for Product B must be calculated according to the functional unit, the numerical quantity of it became smaller than that of Product A in this study.

产品 B 由于其使用寿命长，在生命周期内的温室气体排放总量比产品 A 大很多。然而由于产品 B 的指标需基于功能单元进行计算，因此本研究中产品 B 的数值相比产品 A 要小。

— The indicators of two products were calculated as follows:

两种产品的指标计算如下：

— environmental impact indicator of Product A = 2,32 E+01 [kg-CO_2e];

——产品 A 的环境影响指标 = 23.2 kg CO_2e；

— environmental impact indicator of Product B = 4,66 E+00 [kg-CO_2e].

——产品 B 的环境影响指标 = 4.66 kg CO_2e。

B.2.4 产品系统价值评价 Product system value assessment

— In order to create the product system value indicator which is mathematically based on its average and constant conditions, life cycle brightness was defined as “all luminous flux (unit: lm)” multiplied by “utility duration (unit: hour)” according to the guidelines for the Japanese electronics industry[2].

为建立基于平均和恒定条件下的产品系统价值指标，依据日本电子工业指南[2]，将生命周期亮度定义为“全光通量（单位：lm）”与“效用持续时间（单位：h）”的乘积。

— The measurement method of “all luminous flux” is provided in the following Japanese Industrial Standard: JIS C7801: *Measuring methods of lamps for general lighting*.

全光通量的测量方法依照以下日本工业标准：JIS C7801 一般照明灯具的测量方法。

— The decrease of “all luminous flux” through the same utility duration as the environmental assessment was not considered.

未考虑全光通量在与环境评价相同效用时间段内的降低。

— The utility duration of each product is defined by its “rated lifetime”. The definition of it is provided in the several Japanese Industrial Standards, such as JIS Z7501, Z7617-2 and Z7620-2.

每种产品的效用持续时间由其“额定使用寿命”来确定。日本工业标准 JIS Z7501、JIS Z7617-2 和 JIS Z7620-2 等对效用持续时间进行了定义。

— The “rated lifetime” of Product B is 13 000 h instead of 1 000 h of Product A.

产品 B 的额定使用寿命为 13000 小时，产品 A 的额定使用寿命为 1000 小时。

— The total amounts of the life cycle brightness for these two product systems are quite different. However, as the indicator for Product B must be normalized according to the functional unit, the numerical quantity of it became the same as that of Product A in this study.

两种产品系统在生命周期内的亮度总量相差很大，但由于产品 B 的指标必须按照功能单元进行归一化，所以在本研究中产品 B 与产品 A 的系统价值数值相同。

— The indicators of two products were calculated as follows:

两种产品的指标计算如下：

— product system value indicators of Products A and B = 8,10 E+05 [lm · h]

产品 A 和产品 B 的产品系统价值指标 = 8.10×10^5 lm·h。

B.2.5 生态效率的量化 Quantification of eco-efficiency

— The eco-efficiency indicator was calculated by dividing the product system value indicator by the environmental impact indicator for each in the units of [lm · h/kg-CO_2e].

通过计算产品系统价值指标与环境影响指标的比值得到每种产品的生态效率指标（单位：lm·h/kg CO_2e）。

— The indicators of two products were calculated as follows:

两种产品的指标计算如下：

— eco-efficiency indicator of Product A = 3,49 E+04 [lm · h/kg-CO_2e];

产品 A 的生态效率指标 = 3.49×10^4 lm·h/kg CO_2e；

— eco-efficiency indicator of Product B = 1,74 E+05 [lm · h/kg-CO_2e].

产品 B 的生态效率指标 = 1.74×10^5 lm·h/kg CO_2e。

B.2.6 敏感性和不确定性分析 Sensitivity and uncertainty analysis

— Sensitivity and uncertainty analysis was not carried out in this assessment.

该评价未进行敏感性和不确定性分析。

B.2.7 解释说明 Interpretation

— Factor-X, the ratio of the eco-efficiency indicator of Product B compared to that of Product A is used to clarify the difference of the eco-efficiencies between the two products assessed.

使用因子 X（即产品 B 的生态效率指标与产品 A 的生态效率指标之比）来阐明被评价的两种产品之间的生态效率差异。

— The Factor-X result (eco-efficiency indicator of Product B/eco-efficiency indicator of Product A) was 4,98. This means the eco-efficiency indicator of Product B (bulb-shaped fluorescent lamp) is about 5 times larger than that of Product A (incandescent light bulb).

因子 X（产品 B 的生态效率指标/产品 A 的生态效率指标）的数值为 4.98，表明产品 B（球茎形荧光灯）的生态效率指标比产品 A（白炽灯）大 5 倍左右。

— The decrease of power for illumination and the prolongation of lifetime contribute significantly to the improvement of eco-efficiency because the GHG emissions derived from electricity consumption in the use phase is critical to the environmental assessment results.

照度功率的减少和使用寿命的延长可显著提高生态效率，在使用阶段电力消耗所产生的温室气体排放对环境评价结果至关重要。

— Since several assumptions and simplifications were made in environmental and product system value assessments, this conclusion should be understood with a couple of limitations. For example, if other functional values and indicators focusing on the different aspects were adopted, the eco-efficiency assessment might reach different results.

由于在环境和产品系统价值评价中作了若干假设和简化，因此在理解所得结论时应注意相关局限性。例如，如果采用其他侧重于不同方面的功能价值和指标，则生态效率评价可能会得到不同的结果。

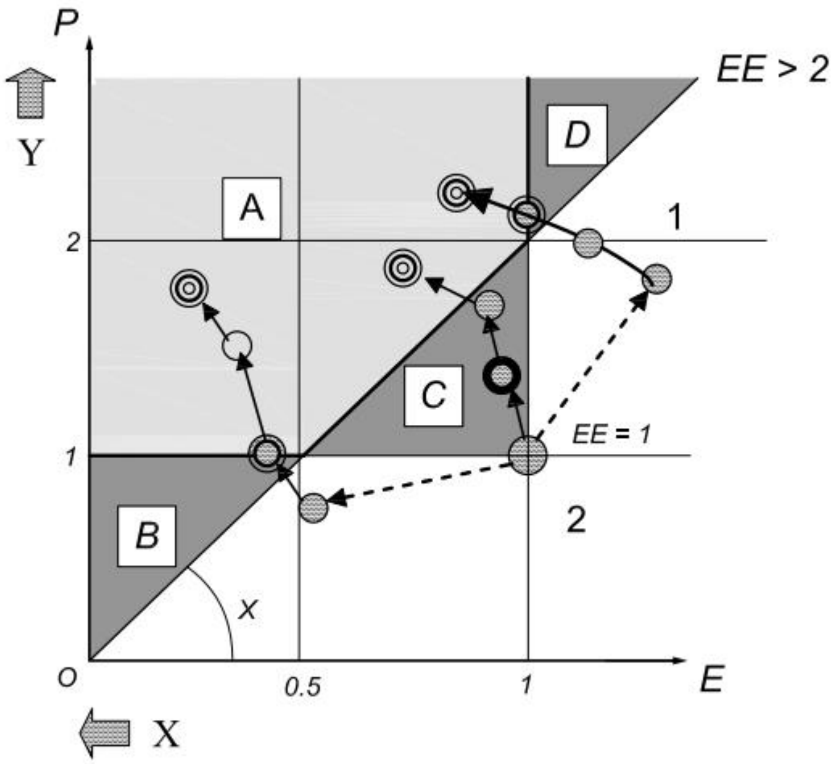
B.2.8　讨论 Discussion

— Figure B.1 shows the product development paths. When an existing product is at the “benchmark product” point, its eco-efficiency (*EE* = *P*/*E*) is defined as 1. Going left and up increases the eco-efficiency, and tan*X* expresses the eco-efficiency of the development target. If the target is “eco-efficiency (*EE*) > 2”, area A is the goal and B is better in the environmental aspect only. Area C shows that the product is steadily developing toward Area A.

图 B.1 展示了产品开发路径。当现有产品处于“基准产品”点时，其生态效率（*EE* = *P*/*E*）界定为 1。向左上方向前进可提高生态效率，tan*X* 表示开发目标的生态效率。如果目标是“生态效率（EE）> 2”，则区域 A 是目标，区域 B 仅在环境方面更好。区域 C 表明产品正在向区域 A 稳步发展。

— As technology progresses, different paths may be followed; this sometimes involves a drop in environmental performance on the way to achieving the goal. Area D appears to be a bad area to be in due to the higher environmental impact, but passing through this area may be an inevitable step towards the goal as the best available technology is adopted. In this context, when the product system value is increased much more than the decrease of environmental impact, the eco-efficiency may be reported as an “improvement” in a series of product development.

随着技术进步可能会出现不同的路径，有时会导致在实现目的的过程中出现环境绩效下降的情况。区域 D 似乎是一个较差的区域（因为其环境影响较高），但或许不可避免地需要通过区域 D 向实现目的迈进（因为采用最优可用技术）。该情况下，当产品系统价值的增加量远远大于环境影响的减少量时，在一系列产品开发过程中生态效率可能被报告为“改进”。



Key

E environmental impact

P product system value

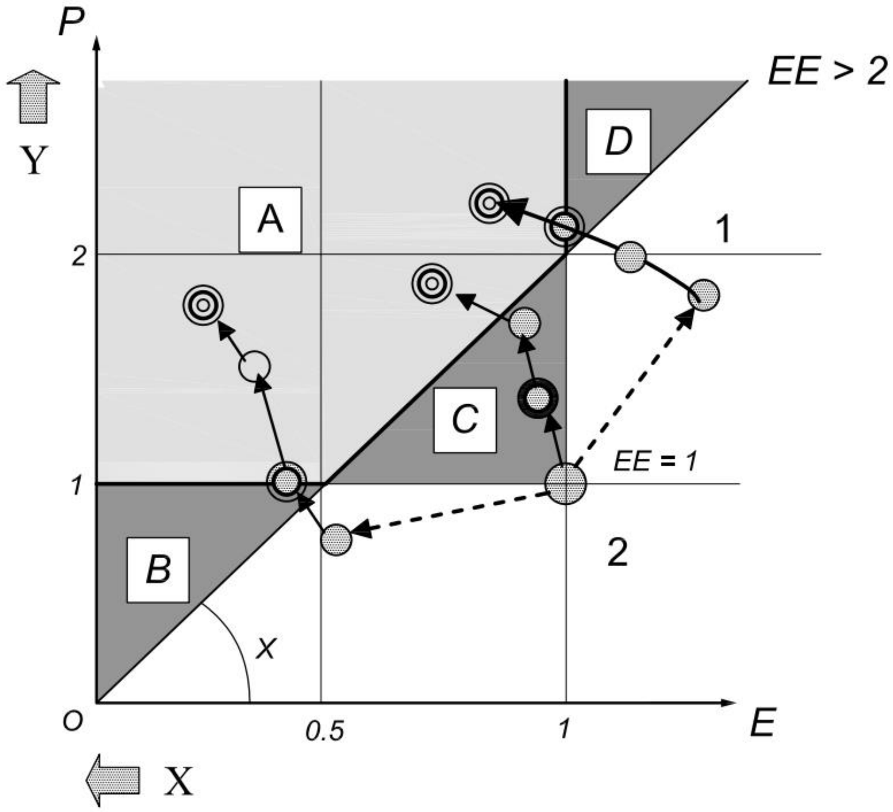
1 new products

2 benchmark product

X reduction of environmental impact

Y improvement of product functions

Figure B.1 — Product development paths



标引序号说明：

E——环境影响；

P——产品系统价值；

1——新产品；

2——基准产品；

X——环境影响的降低；

Y——产品功能的提升。

图 B.1 产品开发路径

B.3 基于综合评价方法的生态效率评价示例 Example of an eco-efficiency assessment based on the integrated assessment approach

B.3.1 概述 General

By using the QFD (quality function deployment) matrix in the product system value assessment, various characteristics of products are evaluated based on individual preferences; not only the main function but also its special features can be taken into account. Therefore, a business strategy for developing better products can be reflected in the product system value assessment. It will be useful for industry to apply this assessment to product development and improvement. An example of eco-efficiency assessment for home vacuum cleaners is presented.

采用质量功能展开（Quality Function Deployment，简称 QFD）矩阵对产品系统价值进行评价，根据个体偏好对产品的各种特性进行评估，不仅考虑其主要功能，还可以考虑其特殊功能。因此，为开发更好的产品而制定的商业策略可反映在产品系统价值评价中。将这种评价应用于产品开发与改进将会对工业具有很大帮助。这里给出了一个家用真空吸尘器生态效率评价的示例。

In this example, the evaluation method for quantifying the functional value based on the QFD is introduced and the total environmental performance was evaluated by the LCIA method.

在本示例中，介绍了基于 QFD 的功能价值量化评价方法，并采用 LCIA 方法对整体环境绩效进行了评价。

B.3.2 目的和范围的界定 Goal and scope definition

B.3.2.1 目的的界定 Goal definition

Purpose of the eco-efficiency assessment: 生态效率评价的目的	To promote a new product by evaluating its eco-efficiency compared with the old one. 通过评价对比新产品与旧产品的生态效率来推广新产品。
Intended audience: 目标受众	Business customers. 商业客户。
Intended use of the results: 结果的预期用途	Calculation of “Factor-X” (the ratio of the eco-efficiency indicator of Product B compared to that of Product A) and presentation to customers. 计算“因子X”（产品B的生态效率指标与产品A的生态效率指标之比）并向消费者展示。

B.3.2.2 范围的界定 Scope definition

1) Product system to be assessed

a）待评价的产品系统

Name: 名称	Product A: paper-dust-bag-type home vacuum cleaner Product B: cyclone-type home vacuum cleaner Both products are made by the same company. 产品A：集尘袋式家用真空吸尘器 产品B：旋风式家用真空吸尘器 两种产品由同一家公司生产。
Scale of production: 生产规模	Production: Product A and Product B, large quantity 产品A和产品B：量产
Location: 生命周期各阶段的地理位置	Production: Product A and Product B, Japan Use and waste management: Product A and Product B, Japan 生产：产品A和产品B：日本 使用与废物管理：产品A和产品B：日本
Time: 生命周期各阶段时间	Production: Product A, 2000 model; Product B, 2003 model Use and waste management: Product A, 2000-2006, Product B; 2003-2009

	生产：产品A：2000年；产品B：2003年
	使用与废物管理：产品A：2000-2006年；产品B：2003-2009年
Main stakeholders involved:	Customer
主要利益相关方	消费者

2) Function and functional unit

b）功能和功能单元

— The function of the product system is defined as its cleaning ability in a comfortable manner. This is because high cleaning ability consistent with usability and amenity is thought to indicate the primary characteristics of vacuum cleaners.

产品系统的功能定义为舒适的清洁能力，因为较优的清洁能力、可用性和便利性通常被认为是真空吸尘器的主要特征。

— Its functional unit is defined as one vacuum cleaner for each product system in its entire life cycle (7 years).

其功能单元定义为全生命周期（7 年）内每种产品系统中的一台真空吸尘器。

3) System boundary

c）系统边界

— Each stage of the product life cycle is included, such as material acquisition, parts production, manufacturing of products, distribution, use and end of life.

产品生命周期的各个阶段，包括材料获取、零部件生产、产品制造、分销、使用和寿命终止。

— For the product system value assessment, the use stage is chosen to present the product system value for customers.

在产品系统价值评价时，选择使用阶段将产品系统价值呈现给客户。

4) Allocations to external systems

d）外部系统的分配

— No allocation to adjacent systems is made.

没有为相邻系统分配。

5) Environmental assessment method and types of impacts

e）环境评价方法和影响类别

— In LCI, CO_2, SO_X, NO_X, HFC, PFC, SF_6, COD, total N, total P, waste, crude oil, natural gas, limestone and wood are considered to be elementary flows. A hybrid method based on input-output analysis (IOA) is applied to quantify these elementary flows[1].

在生命周期清单分析中，CO_2、SO_x、NO_x、HFC、PFC、SF_6、COD、总氮、总磷、废弃物、原油、天然气、石灰石和木材被视为基本流。采用一种基于输入-输出分析（IOA）的混合方法对这些基本流进行量化[1]。

— In LCIA, global warming, acidification, eutrophication, air pollution and resource depletion are considered. Other impact categories such as indoor air quality and water scarcity are excluded from this study. Category indicators and characterization models are based on the LIME method[2], which is one of the end-point types of the LCIA method developed by the National Project in Japan.

在生命周期影响评价中，考虑了全球变暖、酸化、富营养化、空气污染和资源耗竭等问题。其他影响类别如室内空气质量和水资源短缺被排除在本研究之外。类别指标和表征模型基于 LIME 方法[2]，该方法是日本国家项目所开发的生命周期影响评价方法之一。

— In addition, the weighting method of the LIME method is applied to evaluate the total environmental performance. The weighting factor in the LIME method was developed by a tried and tested statistical method, considering representativeness, completeness and consistency[2].

此外，采用 LIME 方法中的权重法对总环境绩效进行了评价。LIME 法中的权重因子由经验证的统计方法所得，并考虑代表性、完整性和一致性[2]。

— The result of the weighting is used as an environmental impact indicator.

权重结果被用于环境影响指标。

6) Value assessment method and type of product system value

f）价值评价方法和产品系统价值类别

— The functional value for customers is assessed. It is defined as each product system’s performance in comfortable cleaning through its entire life.

对消费者的功能价值进行评价。功能价值定义为每种产品系统在其全生命周期内的舒适清洁性能。

— In order to express the functional performance, several characteristics of a product are integrated into a single index, applying consumers’ preferences derived from a market survey, which means making inquiries about customer needs and/or interviewing customers[3].

为了表示产品的功能性能，使用市场调研得出消费者偏好并将产品的多项特征整合为一个单一指标，具体方法是调查消费者需求或访谈消费者[3]。

— The integrated single index is used as a product system value indicator.

集成后的单一指标作为产品系统价值指标。

7) Choice of eco-efficiency indicator(s)

g）生态效率指标的选择

— In this example, the eco-efficiency indicator is defined as the “product system value indicator divided by the environmental impact indicator”.

本示例中生态效率指标定义为“产品系统价值指标与环境影响指标之比”。

8) Interpretation to be used

h）解释说明

The following aspects of interpretation are needed for the intended use of the results:

为实现结果的预期用途，需要提供以下方面的解释：

— the identification of significant issues;

——重大问题识别；

— an evaluation that considers aspects of completeness, etc.;

——考虑完整性方面的评估；

— the formulation of conclusions, limitations and recommendations;

——表述结论、局限性和建议；

— a comparison of eco-efficiency results.

——生态效率结果的比较。

9) Limitations

i）局限性

— In the environmental assessment, the results depend on the conditions of the hybrid method[1] and the LIME method[2].

在环境评价中，结果取决于混合方法[1]和 LIME 方法[2]中的条件。

— The results of the product system value assessment are concluded with the method[3] and the limited set of quality characteristics.

产品系统价值评价结果是利用方法[3]和质量特征有限集合所得出。

10) Reporting and disclosure of results

j）结果报告和披露

— An independent review will be conducted. Factor-X, the ratio of eco-efficiency indicator of Product B compared to that of Product A, is disclosed with a disclaimer to avoid comparative eco-efficiency assertion. A full report will be available on the Internet.

将进行独立评审。公布因子 X（产品 B 的生态效率指标与产品 A 的生态效率指标之比）并附带免责申明，以避免生态效率对比声明。应在互联网上公布完整报告。

— The product system value factor and the environmental impact reduction factor are shown on the chart so that the trend of product development and the contribution of both indicators to the improvement of ecoefficiency can be visualized.

在图表中显示产品系统价值因子和环境影响降低因子，从而可以直观地看到产品开发的趋势以及两个指标对提高生态效率的贡献。

B.3.3 环境评价 Environmental assessment

— A hybrid method based on IOA[2] was utilized for the background data in the LCI analysis.

将基于 IOA[2]的混合方法用于生命周期清单分析中的背景数据。

— The materials and parts used in the final products and the paper bag consumed in the use phase were considered. However, for the cyclone-type vacuum cleaner, since the vacuumed dust is directly carried to a rubbish bin, no paper dust bag is required. In the manufacturing phase, average energy consumptions were applied. Distribution of “20 km by 2 t trucks and 330 km by 4 t trucks” was assumed. In the end-of-life phase, it was assumed that products were transposed to the recycling system, in which iron, copper, aluminium and several kinds of plastics were recycled and the other materials were incinerated and/or disposed of.

最终产品中使用的材料和部件以及使用阶段所消耗的纸袋被考虑在内。然而，对于旋风式真空吸尘器，由于吸入的灰尘直接输送至垃圾桶，因此不需要纸质集尘袋。制造阶段采用平均能耗。假设采用“2 吨级卡车运输 20 公里以及 4 吨级卡车运输 330 公里”进行产品分销。在寿命终止阶段，假设产品被转移到回收系统中，该回收系统回收了铁、铜、铝和几种塑料，并焚烧和/或处置了其他材料。

— Applying the LIME method, overall environmental impacts were calculated so as to avoid a trade-off amongst impact categories. LCI results were summarized into a single index in a monetary unit, the Japanese yen, to form the environmental impact indicator.

采用 LIME 方法计算了总体环境影响，以避免影响类别之间的权衡。将生命周期清单结果整合为以日元为货币单位的单一指数，并形成环境影响指标。

— The indicators of two products were calculated as follows:

两种产品的指标计算如下：

— environmental impact indicator of Product A = 326,5 [Japanese yen];

产品 A 的环境影响指标 = 326.5 日元；

— environmental impact indicator of Product B = 318,9 [Japanese yen].

产品 B 的环境影响指标 = 318.9 日元。

B.3.4 产品系统价值评价 Product system value assessment

— The functional performance of the products to express their functional value was defined in terms of their comfortable cleaning ability and quantified by comparing various quality characteristics in their own units.

将舒适的清洁能力定义为产品的功能性能。为表达功能价值，通过对比各自单位的各种质量特征来量化功能性能。

— First, customer requirements were correlated with the quality characteristics of a product in the QFD (Quality Function Deployment) matrix as shown in Table B.1. Customer requirements and their importance were derived from the market survey. By making a QFD matrix in this manner, relative important characteristics were identified from the viewpoint of customer satisfaction.

首先，将客户需求与产品质量特征联系起来，如表 B.1 所示的质量功能展开（QFD）矩阵。客户需求及其重要性来源于市场调查。通过这种方式绘制 QFD 矩阵，以从客户满意度的角度确定相对重要的特征。

— According to the method proposed by Kobayashi, Y. *et al.* (2005)[3], improvement ratios of quality characteristics were calculated by normalization on the basis of the maximum actual data between two products, as shown in Table B.2. Finally, the functional performance was quantified as a weighted average of improvement ratios to form the product system value indicator.

根据 Kobayashi. Y 等人（2005）[3]提出的方法，利用两种产品之间的最大实际数据，通过归一化计算出质量特征的改进率，如表 B.2 所示。最后，将改进率进行加权平均以得到功能性能的量化值，最终形成产品系统价值指标。

— The indicators of two products were calculated as follows:

两种产品的指标计算如下：

— product system value indicator of Product A = 0,74 [- (arbitrary unit)];

产品 A 的产品系统价值指标 = 0.74 (无量纲)；

— product system value indicator of Product B = 0,96 [- (arbitrary unit)].

产品 B 的产品系统价值指标 = 0.96 (无量纲)。

Table B.1 — TQFD matrix for a vacuum cleaner

(The full table can be found in Reference [3])

Quality characteristics

Customer requirements	**Importance**	**Dust suction**[W]	**Body weight** [kg]	**Total weight** [kg]	**Brush revolutions per minute** [rpm]	**Degree of luster** [times]	**Noise** [dB]	**Unique filters** [number]
Clean exhaust	3							9
Capacity to pick up anything	9	9			3	1		
Silent	3				1		9	
Ability to remove dust	3							
Capacity to clean in narrow space	3							
Capacity to clean flooring	9	3			9	9		
Easy-to-control body	3		3					
Capacity to clean along walls	9							
Capacity to clean ceiling, etc.	1							
Ease of operation	3		9	9				

High dust suction	9	9					9	
Light brush	3							
Various optional units	1							
Relative importance (%)		16,8	3,2	2,4	9,8	8,0	9,6	2,4
Relationship 9: Strong relation 3: Normal relation 1: Low relation								

表 B.1 真空吸尘器的 TQFD 矩阵

质量特征

客户需求	重要性	吸尘功率（W）	机身重量（kg）	总重量（kg）	刷子转速（rpm）	光泽度（倍数）	噪声（dB）	单独过滤器（数量）
洁净排气	3							9
捡起任意物品的能力	9	9			3	1		
静音	3				1		9	
除尘能力	3							
狭小空间内的清洁能力	3							
清洁地板的能力	9	3			9	9		
机身易于控制	3		3					
沿墙清洁的能力	9							
清洁天花板等的能力	1							
易于操作	3		9	9				
高吸尘力	9	9					9	
刷子轻	3							
各种可选单元	1							
相对重要性（%）		16.8	3.2	2.4	9.8	8.0	9.6	2.4
注：可在参考文献[3]中查看完整表格								
相关性： 9——强相关； 3——一般相关； 1——弱相关。								

Table B.2 — Summary of functional value of a vacuum cleaner

(Products assessed were different from those of Reference [3].)

Quality characteristics	Importance	Actual data	Direction	Normalization

	%	Product A	Product B		Product A	Product B
Dust suction [W]	16,8	570,0	560,0	↑	1,00	0,98
Body weight [kg]	3,2	3,7	3,6	↓	0,97	1,00
Total weight [kg]	2,4	5,3	5,2	↓	0,3	1,00
Brush revolutions per minute [rpm]	9,8	4 200,0	6 000,0	↑	0,70	1,00
Degree of luster [times]	8,0	10,0	2,2	↓	0,22	1,00
Noise [dB]	9,6	55,0	59,0	↓	1,00	0,93
Unique filters [number]	2,4	4,0	3,0	↑	1,00	0,75
			Weighted average		**0,74**	**0,96**

表 B.2 真空吸尘器的功能价值汇总

质量特征	重要性	实际数据		方向	归一化	
	%	产品 A	产品 B		产品 A	产品 B
吸尘功率（W）	16.8	570.0	560.0	↑	1.00	0.98
机身重量（kg）	3.2	3.7	3.6	↓	0.97	1.00
总重量（kg）	2.4	5.3	5.2	↓	0.3	1.00
刷子转速（rpm）	9.8	4200.0	6000.0	↑	0.70	1.00
光泽度（倍数）	8.0	10.0	2.2	↓	0.22	1.00
噪声（dB）	9.6	55.0	59.0	↓	1.00	0.93
单独过滤器（数量）	2.4	4.0	3.0	↑	1.00	0.75
			加权平均值		0.74	0.96
注：此处评价的产品与参考文献[3]中不同						

B.3.5 生态效率的量化 Quantification of eco-efficiency

— The eco-efficiency indicator was calculated by dividing the product system value indicator throughout its entire life by the environmental impact for each in the units of [-/Japanese yen].

通过计算每种产品全生命周期的产品系统价值指标与环境影响指标之比，即得到以（-/日元）为单位的生态效率指标。

— The indicators of the two products were calculated as follows:

两种产品的指标计算如下：

— eco-efficiency indicator of Product A = 0,015 8 [-/Japanese yen];

产品 A 的生态效率指标 = 0.0158 -/日元；

— eco-efficiency indicator of Product B = 0,021 1 [-/Japanese yen].

产品 B 的生态效率指标 = 0.0211 -/日元。

B.3.6 敏感性和不确定性分析 Sensitivity and uncertainty analysis

— Sensitivity and uncertainty analysis was not carried out in this example.

该示例未进行敏感性和不确定性分析。

B.3.7 解释 Interpretation

— The ratio of the eco-efficiency indicator of Product B compared to that of Product A is used to clarify the difference of the eco-efficiencies between the two products assessed.

使用产品 B 的生态效率指标与产品 A 的生态效率指标之比来说明所评价的两种产品的生态效率差异。

— Factor-X = 1,33 (eco-efficiency indicator of Product B/eco-efficiency indicator of Product A).

因子 X = 1.33（产品 B 的生态效率指标/产品 A 的生态效率指标）。

— This means the eco-efficiency indicator of Product B (cyclone-type home vacuum cleaner) is about 1,3 times larger than that of Product A (paper-dust-bag-type home vacuum cleaner).

产品 B（旋风式家用真空吸尘器）的生态效率指标比产品 A（集尘袋式家用真空吸尘器）大 1.3 倍左右。

— In addition, both the environmental impact reduction factor and the product system value factor are plotted in Figure B.2 to clarify the evolution strategies of assessed products. Factor-X can be derived by multiplying both the product system value factor and the environmental impact reduction factor together.

此外，在图 B.2 中标绘环境影响减少因子和产品系统价值因子，以阐明所评价产品的演化策略。因子 X 为产品系统价值因子与环境影响减少因子的乘积。

— The environmental impact reduction factor = 1,02 (Environmental impact indicator of Product A/ Environmental impact indicator of Product B).

环境影响减少因子 = 1.02（产品 A 的环境影响指标/产品 B 的环境影响指标）。

— The product system value factor = 1,30 (Product system value indicator of Product B/Product system value indicator of Product A).

产品系统价值因子 = 1.30（产品 B 的产品系统价值指标/产品 A 的产品系统价值指标）。

— As a result of the environmental assessment, it was found that environmental impacts in the use phase account for about 75 % of those in the entire life cycle for both products. CO_2 and SO_X emissions, which were mainly derived from electricity consumption in the use phase, were critical to the total results. Due to the increased electricity consumption of Product B, its global warming potential became worse. However, resource depletion indicator improved because the weight of Product B was partially reduced and no paper dust bag was required. As a result, from a life cycle perspective, the environmental impact indicator of Product B improved more than that of Product A. Reduction of the environmental impact in both the use phase and the production phase can make it possible to further improve the eco-efficiency in the future.

环境评价结果表明，两种产品在使用阶段的环境影响约占整个生命周期的 75%。CO_2 和 SO_x 排放量（主要来源于使用阶段的电力消耗）对总体结果至关重要。由于产品 B 的耗电量增加，因此其全球变暖潜势变得更大。但产品 B 的重量有所减少并且不需要集尘袋，因此其资源消耗指标有所改进。从生命周期视角看，产品 B 的环境影响指标比产品 A 的环境影响指标改进更大。减少产品 B 在使用阶段和生产阶段的环境影响，可使其在未来进一步提高生态效率。

— The product system value factor mainly contributes to Factor-X. Although Product B has both superior and inferior characteristics to Product A, the capacity to clean along walls and floors was improved. According to the customer requirements in QFD matrix, not only the suction power but also additional performances, such as the improved capacity to clean floors and along walls, etc., can provide enhanced value to customers.

产品系统价值因子主要影响因子 X。尽管产品 B 相比产品 A 同时具有相应的优缺点，但产品 B 对墙面和地板的清洁能力更强。根据 QFD 矩阵中的客户需求，除了吸尘功率外，还可提供额外的性能（如提高清洁地板和墙面的能力等），进而为客户提供更高的价值。

— In the environmental assessment, several assumptions are set in LCIA, for example, transport distances and the end-of-life scenario. The results depend on these conditions and the conclusion should be understood in the application of LCI data and the LCIA method.

在环境评价中，为生命周期影响评价设定了多个假设，例如运输距离和寿命终止情景。在应用生命周期清单数据和生命周期影响评价方法时应理解该结论取决于这些条件。

— In the product system value assessment, the consumer preferences derived from a market survey in Japan are thought to vary in other regions and also over time, according to the market situation, the competitors' situation, lifestyles, etc.

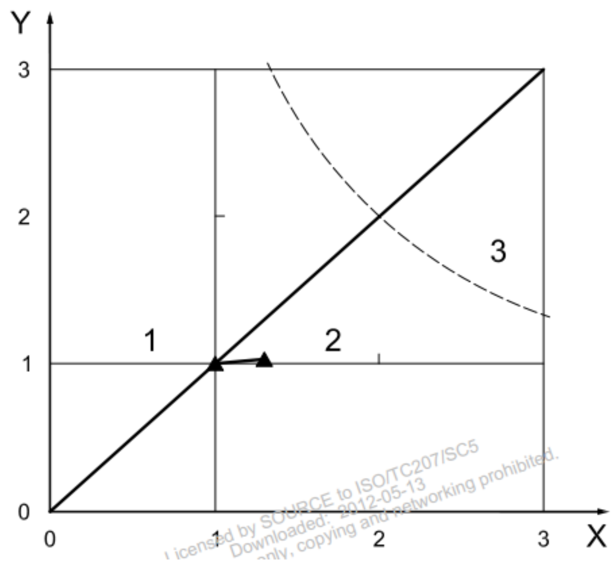
在产品系统价值评价中，根据市场情况、竞争对手情况、生活方式等因素，日本市场调查所得的消费者偏好在其他地区及随着时间的推移会有所不同。

— It is valuable for industry to utilize the eco-efficiency assessment as an internal management tool. While it is important to analyse trade-off among environmental impact categories carefully in the context of LCA practice, the definition and formulation of the eco-efficiency indicators depend on the business strategy of each company.

将生态效率评价作为内部管理工具将为企业带来重要价值。尽管在生命周期评价实践中详细分析各种环境影响类别之间的权衡非常重要，但生态效率指标的定义和制定取决于每一家公司的商业策略。

— This example was intended to focus on the trade-off between environmental impact and functional value, not the trade-off in environmental assessment. From the viewpoint of consistency with the weighted functional value, environmental impacts were summarized into a single score based on the sophisticated LCIA. In this sense, the eco-efficiency indicator in this example applies when presenting an outline of the product's development, as shown in Figure B.2.

本示例旨在关注环境影响与功能价值之间的权衡，而不是环境评价中的权衡。从功能加权价值保持一致的角度，将环境影响归纳为基于复杂生命周期影响评价的单一评分。在该意义上，本示例中的生态效率指标适用于对产品开发进行概述，如图 B.2 所示。



Key

X product system value factor

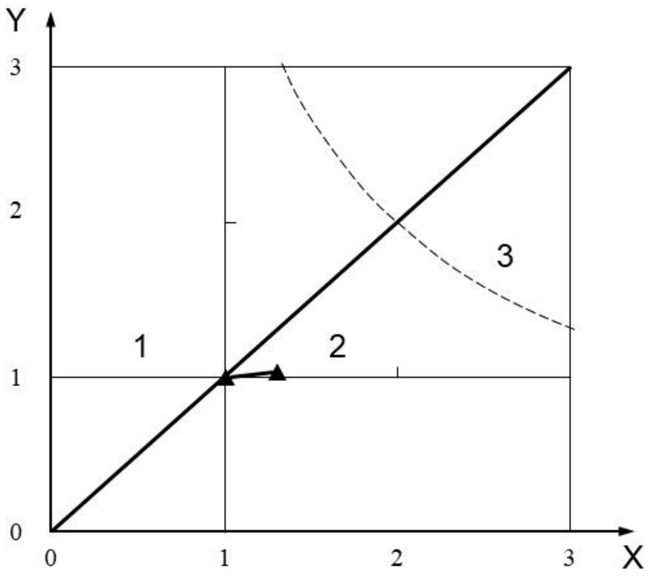
Y environmental impact reduction factor

1 Product A

2 Product B

3 factor 4

Figure B.2 — Factor-X chart



标引序号说明：

X——产品系统价值因子

Y——环境影响减少因子

1——产品 A

2——产品 B

3——因子 4

图 B.2 因子 X 图

B.4 基于综合评价的生态效率评价方法的应用 Application of eco-efficiency assessment based on integrated assessment

B.4.1 概述 General

A petrochemical company in Mexico conducted an analysis of eco-efficiency to evaluate two technology options for increasing the production of an ethylene plant. Ethylene is an olefin feedstock used for a variety of petrochemicals and can join other hydrocarbons such as benzene to produce ethyl benzene, styrene and other olefins useful in obtaining polymers such as different types of polyethylene.

墨西哥一家石油化工公司通过生态效率分析以评价乙烯装置产能提升的两种技术方案。乙烯是用于多种石化产品生产的烯烃原料，可以与其他碳氢化合物（如苯）结合生成乙苯、苯乙烯和其他有助于聚合物（如不同类型的聚乙烯）生产的烯烃。

B.4.2 目的和范围界定 Goal and scope definition

B.4.2.1 目的的界定 Goal definition

Purpose of the eco-efficiency assessment: 生态效率评价的目的	Due to the increase in installed capacity from 600 000 t to 900 000 t of ethylene in the Morelos Petrochemical Complex, Mexico, two options

	of technological improvement have been evaluated with an eco-efficiency analysis: 墨西哥Morelos石油化工总公司中乙烯的装机容量从600000吨增加至900000吨，采用生态效率分析评价两种技术改进方案： Option A: Update of two cracking furnaces, two new cooling units in the refrigeration section and replacement of the tower which removes the methane (natural gas), minor changes in compression. 方案A：更新两台裂解炉，在制冷段新建两台冷却装置，更换甲烷（天然气）脱除塔，压缩系统略微改动。 Option B: Update of two cracking furnaces, a new cooling unit in the refrigeration section and replacement of the tower which removes the methane (natural gas) and a new compressor. 方案B：更新两个裂解炉，在制冷段新建一台冷却装置，更换甲烷（天然气）脱除塔，增加一台新压缩机。
Intended audience: 目标受众	Internal decision makers. 内部决策者。
Intended use of results: 结果的预期用途	To present a factor which expresses the relative level of improvement in eco-efficiency in simple numeric terms (the ratio of eco-efficiency indicator of Option A vs Option B). 提出一个以简单数值表示生态效率相对改进水平的因子（方案A与方案B的生态效率指标之比）。

B.4.2.2 范围的界定 Scope definition

1) Product system to be assessed

a）待评价的产品系统

Name: 名称	Ethylene production system 乙烯生产系统
Scale of production: 生产规模	600 000 t to 900 000 t per year 每年600000吨至900000吨
Location: 地理位置	Mexico 墨西哥
Time: 时间	Production: Product A, 2000 model; Product B, 2003 model 生产：产品A：2000年；产品B：2003年

2) Function and functional unit

b）功能和功能单元

— Production of ethylene to be used as raw material for polyethylene, monomer vinyl chloride, ethylene oxide, styrene, acetaldehyde, among others.

生产的乙烯可用作聚乙烯、单体氯乙烯、环氧乙烷、苯乙烯、乙醛等的原料。

— The functional unit is 1 t of ethylene produced.

功能单元为生产的 1 吨乙烯。

3) System boundary

c）系统边界

— The product system begins at raw materials extraction and ends when the ethylene is the raw material for other processes. Other life cycle stages are excluded because they do not change the overall conclusions of this study.

产品系统范围从原料提取开始到乙烯成为其他工艺的原料为止。其他生命周期阶段被排除在外，它们并不会改变本研究的总体结论。

4) Allocations to external systems

d）外部系统的分配

— No particular adjacent systems to be allocated exist.

没有为相邻系统分配。

5) Environmental assessment method and types of impact

e）环境评价方法和影响类别

— Environmental impacts were calculated using the life cycle impact assessment method ecoindicator 99 (H)[1], taking into consideration three category end points: human health, ecosystems quality, and resources.

环境影响采用生命周期影响评价方法生态指标 99 (H)[1]进行计算，并考虑三个类别终点：人类健康、生态系统质量和资源。

— The impacts were normalized with respect to the base case.

根据基本情况对计算的环境影响进行归一化处理。

6) Value assessment method and type of product system value

f）价值评价方法和产品系统价值类型

— The product system value is based on the functional value of production of ethylene per day.

产品系统价值基于每天乙烯生产的功能价值。

7) Choice of eco-efficiency indicator(s)

g）生态效率指标的选择

— In this example, the eco-efficiency indicator is defined as the “product system value indicator divided by the environmental impact indicator”.

本示例中，生态效率指标定义为“产品系统价值指标与环境影响指标之比”。

— The eco-efficiency indicator is calculated with Formula (B.1) and the factor with Formula (B.2) as follows:

生态效率指标和因子分别由公式（B.1）和（B.2）计算得出，如下所示：

$$\text{Eco-efficiency} = \frac{\text{Product value}}{\text{Environmental impact}} \tag{B.1}$$

$$\text{生态效率} = \frac{\text{产品价值}}{\text{环境影响}} \tag{B.1}$$

$$\text{Factor} = \frac{\text{Eco−efficiency of the evaluated product}}{\text{Eco−efficiency of the base case product}} \tag{B.2}$$

$$\text{因子} = \frac{\text{被评价产品的生态效率}}{\text{基本情况产品的生态效率}} \tag{B.2}$$

8) Interpretation

h）解释说明

— In order to choose between options A and B, the eco-efficiency of these options needs to be compared to that of the current plant.

为了从方案 A 和方案 B 中做出选择，需将两种方案的生态效率与当前装置的生态效率进行比较。

9) Limitations

i）局限性

— In the environmental assessment, the calculations exclude:

在环境评价计算中排除了：

— construction, infrastructure and capital equipment;

——施工、基础设施和基本设备；

— human resources and labour.

——人力资源和劳动力。

— The calculations also exclude materials used in trace amounts and substances for which there was insufficient data.

计算中同时排除了微量使用的材料和数据不充分的物质。

10) Reporting and disclosure of results

j）结果报告和披露

— An internal report will be made.

需编写内部报告。

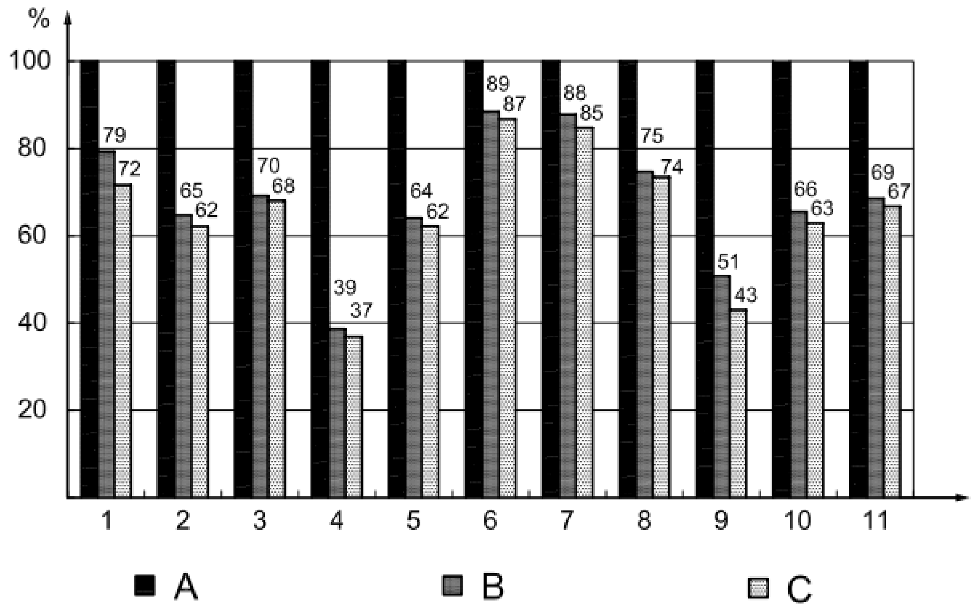
B.4.3 环境评价 Environmental assessment

— The environmental assessment was carried out using life cycle assessment in accordance with ISO 14040:2006 and ISO 14044:2006 and the Eco-indicator 99 (H) life cycle impact method.

根据 GB/T 24040、GB/T 24044 和生态指标 99(H)生命周期影响法，采用生命周期评价的方法进行环境评价。

— Figure B.3 shows the impact categories evaluated for options A and B, with respect to the current operation of the ethylene plant.

图 B.3 显示了方案 A 和方案 B 对乙烯装置当前运行情况的影响类别评估。



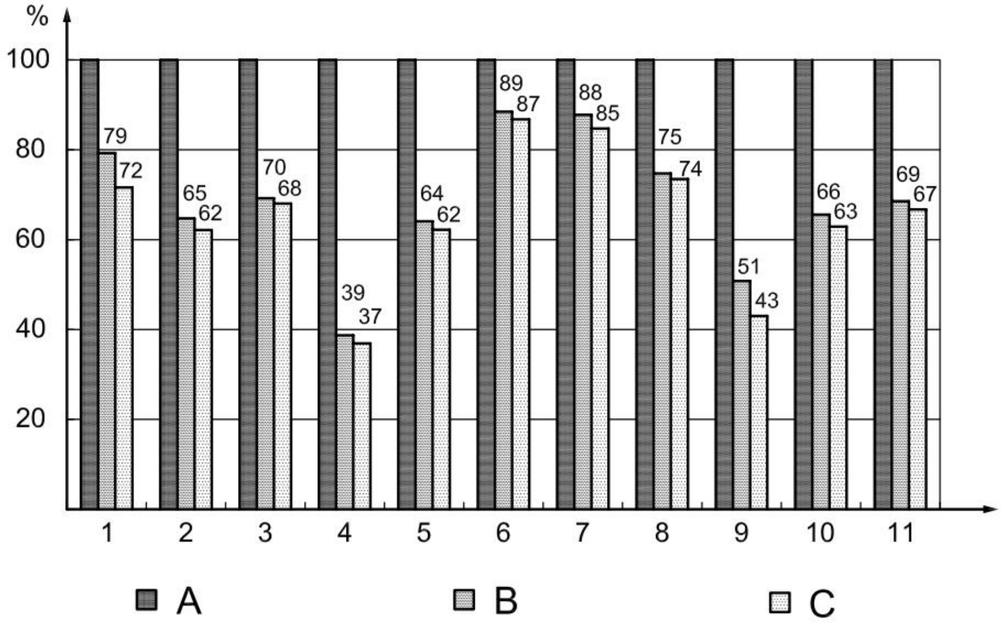
Key

A ethylene base 600

B ethylene expansion 900

C ethylene new burnes

Figure B.3 — Results by category of impact improvement



标引序号说明：

A　乙烯基本产量 600；

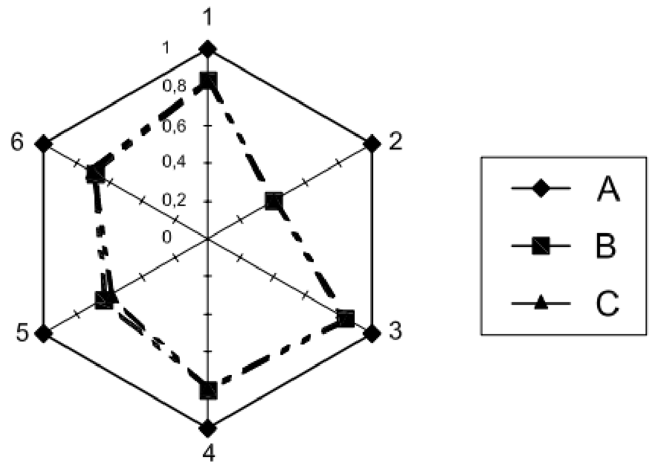
B　乙烯扩容 900；

C　新乙烯裂解炉。

图 B.3 按影响改善类别划分的结果

— Six impact categories were analysed to assess the advantages and disadvantages of the performance of the options examined. These categories were normalized. As shown in Figure B.4, the two options are assessed relative to the current impacts of ethylene plant.

对六个影响类别进行了分析以评估所考察方案的优缺点，并对这些类别进行了归一化处理。如图 B.4 所示，对两个方案相对于当前乙烯装置的影响进行了评价。



Key

1 carcinogens

2 climate change

3 ecotoxicity

4 acidification/eutrophication

5 minerals

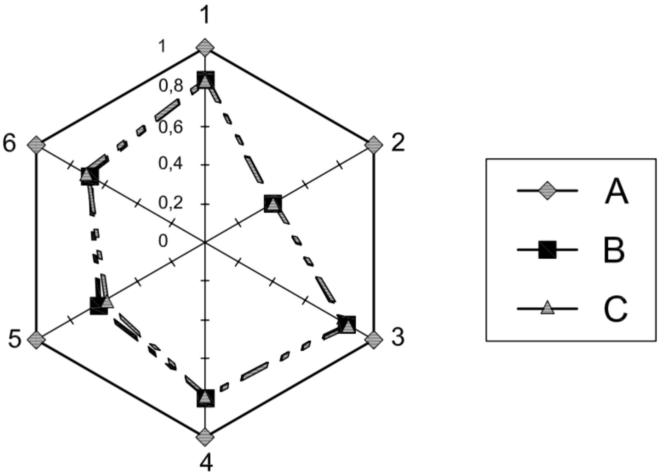
6 fossil fuels

A ethylene base 600

B ethylene expansion 900

C ethylene new furnaces

Figure B.4 — Six impact categories for the different options and normalized values



标引序号说明：

1——致癌物质；

2——气候变化；

3——生态毒性；

4——酸化/富营养化；

5——矿物质；

6——化石燃料；

A——乙烯基本产量 600；

B——乙烯扩容 900；

C——新乙烯裂解炉。

图 B.4 不同方案的六个影响类别和归一化值

— Table B.3 shows the improvement in the end-point categories. The three categories are reduced. These data are considered as the environmental impact of the project to calculate eco-efficiency.

终点类别的改进情况见表 B.3。三个类别均有所降低。将这些数据作为项目的环境影响以计算生态效率。

Table B.3 — Comparison of the three end-point categorie

	Human health (eco-points)	Ecosystem quality (eco- points)	Resources (eco- points)

Current plant	74,7	7,2	497,0
Ethylene expansion 900 (Option A)	41,8	5,4	341,4
Ethylene new furnaces (Option B)	40,6	5,3	332,0
Improvements (%)	<44 Option A <45 Option B	<25 (Option A) <26 (Option B)	<31 (Option A) <33 (Option B)

表 B.3 三个终点类别的比较

	人类健康 （生态分数）	生态系统质量 （生态分数）	资源 （生态分数）
当前装置	74.7	7.2	497.0
乙烯扩容 900（方案 A）	41.8	5.4	341.4
新乙烯裂解炉（方案 B）	40.6	5.3	332.0
改进（%）	<44（方案 A） <45（方案 B）	<25（方案 A） <26（方案 B）	<31（方案 A） <33（方案 B）

B.4.4 产品系统价值评价 Product system value assessment

— The product system value for the current plant is 1 800 t of ethylene per day (current capacity) and, for options A and B, 2 702 t of ethylene per day (planned capacity).

当前装置的产品系统价值是每天 1800 吨乙烯（当前产能），方案 A 和方案 B 产能为每天 2702 吨乙烯（计划产能）。

— All cases are calculated based on the same days of continuous operation per year.

所有情景均按每年连续运行相同天数进行计算。

B.4.5 生态效率结果的计算 Calculation of eco-efficiency results

The data used for the calculation of eco-efficiency results are shown in Table B.4.

计算生态效率结果所用的数据见表 B.4。

Table B.4 — Data used for the calculation of eco-efficiency results

	Current plant	**New expansion (Option A)**	**New furnaces (Option B)**
Capacity (t/d)	1 800	2 702	2 702
Ecopoints LCA[a]	437,9	288,6	280,5

[a] Ecopoints are calculated according to Reference [1].

表 B.4 生态效率结果计算所用数据

	当前装置	新扩容 （方案 A）	新裂解炉 (方案 B)
产能（t/d）	1800	2702	2702

生命周期评价生态分数 [a]	437.9	288.6	280.5
[a] 生态分数根据参考文献计算得到。			

Eco-efficiency = Product value/Environmental impact

生态效率 = 产品价值/环境影响

$$\text{Current plant Eco-efficiency} = \frac{\text{Product value}}{\text{Environmental impact}} = \frac{1800\ \text{t/d}}{437{,}9\ \text{Pt}} = 4{,}11$$

$$\text{当前装置的生产效率} = \frac{\text{产品价值}}{\text{环境影响}} = \frac{1800\ \text{吨/天}}{437.9\ \text{Pt}} = 4.11$$

$$\text{Option A Eco-efficiency} = \frac{\text{Product value}}{\text{Environmental impact}} = \frac{2702\ \text{t/d}}{288{,}6\ \text{Pt}} = 9{,}36$$

$$\text{方案 A 的生态效率} = \frac{\text{产品价值}}{\text{环境影响}} = \frac{2702\ \text{吨/天}}{288.6\ \text{Pt}} = 9.36$$

$$\text{Option B Eco-efficiency} = \frac{\text{Product value}}{\text{Environmental impact}} = \frac{2702\ \text{t/d}}{280{,}5\ \text{Pt}} = 9{,}63$$

$$\text{方案 B 的生态效率} = \frac{\text{产品价值}}{\text{环境影响}} = \frac{2702\ \text{吨/天}}{280.5\ \text{Pt}} = 9.63$$

$$\text{Factor} = \frac{\text{Eco-efficiency of the evaluated product(Option B)}}{\text{Eco-efficiency of the base case product(Current plant)}} = \frac{9{,}63}{4{,}11} = 2{,}34$$

$$\text{因子} = \frac{\text{被评价产品的生态效率（方案 B）}}{\text{基本情况产品的生态效率（当前装置）}} = \frac{9.63}{4.11} = 2.34$$

B.4.6 敏感性和不确定性分析 Sensitivity and uncertainty analysis

— Sensitivity and uncertainty analysis was not carried out in this example.
该示例未进行敏感性和不确定性分析。

B.4.7 解释说明 Interpretation

— In comparing the two options with respect to the current plant, there is significant improvement in environmental performance.
两种方案相比当前装置情况来看，环境绩效有了显著提高。
— In summary, Option B has the highest eco-efficiency.
总体上，方案 B 的生态效率最高。

B.5 生态效率评价的应用——螯合剂 Application of eco-efficiency assessment — Chelating agents

B.5.1 概述 General

This eco-efficiency assessment was originally published by Borén *et al.* (2009), but is revised here to fit the format of this International Standard.
该生态效率评价最初由 Borén 等人（2009）发表，本文件中对其进行了修改以适应相应格式。

B.5.2 目的和范围界定 Goal and scope definition

B.5.2.1 目的界定 Goal definition

Purpose of the eco-efficiency assessment: 生态效率评价的目的	With the purpose of assessing different chelating agents from environmental and financial perspectives, an eco-efficiency assessment was carried out for European conditions. 为了从环境和财务角度评价不同的螯合剂，以欧洲条件进行了生态效率评价。
Intended audience: 目标受众	Primarily product developers, but also purchasers. 产品开发商为主，也包括购买者。
Intended use of the results: 结果的预期用途	The intended use is for product development and communication of product performance to business customers 用于产品开发以及向商业客户说明产品性能。

B.5.2.2 范围界定 Scope definition

1) Product system to be assessed

a）待评价产品系统

Name: 名称	Chelating agents made by four different processes; products A, B, C and D 由四种不同工艺制备的螯合剂；产品A、B、C和D
Scale of production: 生产规模	Industrial scale 工业规模
Location of life cycle stages: 生命周期各阶段的地理位置	Production: Europe; use and waste management: Europe 生产：欧洲 使用与废物管理：欧洲
Time of life cycle stages: 生命周期各阶段时间	Production: 2007; use: 2007; waste management: 2007 生产：2007年 使用：2007年 废物管理：2007年
Main stakeholders involved: 主要利益相关方	Product developer, purchasers 产品开发商、购买者

2) Function and functional unit

b）功能和功能单元

— Chelating agents are widely used in detergents and cleaners to improve the detergency power.

螯合剂广泛应用于洗涤剂和清洁剂中，以提高其去污能力。

— In this study, the chelating agents were compared on an equal-weight basis in order to make the study independent of the exact amounts used in the many detergent recipes. The functional unit is 1 t of chelating agent.

本研究中，对等重的螯合剂进行了比较，以便使研究独立于许多洗涤剂配方中使用的确切数量。功能单元为 1 吨螯合剂。

3) System boundary

c）系统边界

— The product system includes flows related to raw material extraction, processing of raw materials, manufacturing, use, maintenance, recycling/reuse, waste management, and transportation (Figure B.5). The product system excludes the function of different detergent recipes because it is assumed to be the same for alternative A, B, C and D.

产品系统包括与原料提取、原料加工、制造、使用、维护、回收/再利用、废物管理和运输相关的流程（图 B.5）。产品系统排除了不同洗涤剂配方的功能，假设备选产品 A、B、C 和 D 具有相同的功能。

— Cut-off criteria: 1 % rule

取舍准则：1%规则。

4) Allocation to external systems

d）外部系统的分配

— Made according to the economic value.

没有为相邻系统分配。

5) Environmental assessment method and types of impact

e）环境评价方法和影响类别

— Elementary flows present, as shown in Table B.5.

基本流如表 B.5 所示。

— The impact categories that were considered in the eco-efficiency assessment and applied for different chelating agents were: primary energy consumption, resource depletion, land use, emissions, human toxicity, and risk (referring to occupational health and accidents). The impact category “emissions” is further subdivided into other impact categories (see Table B.6).

在生态效率评价中考虑并应用于不同螯合剂的影响类别为：一次能源消耗、资源消耗、土地利用、排放、人类毒性和风险（指职业健康和事故）。影响类别“排放”进一步细分为其他影响类别（见表 B.6）。

— Impact assessment methods used are detailed in Saling *et al*. (2002)[11].

所用影响评价方法参考了 Saling 等人（2002）[11]的详细内容。

— In a further weighting process, the impact category results are aggregated into a single indication or statement of the total strain put on the environment. In the presented eco-efficiency assessment method, a weight that expresses the environmental importance of that impact category relative to the other impact categories for a specific region is assigned to each impact category. These weighting factors are a combination of impact category-specific “relevance factors” and “societal factors.” For the European relevance and societal factors, see Table B.6. To derive the relevance factor, the result of the alternative with the highest impact in that category is normalized against the total load of the same category in a specific region. This step yields the relative significance of the different impact category results. The societal factors express the importance of each category relative to the other impact categories as perceived by a group of people (see Table B.6). The societal factors are based on the opinion polls in the same region as were chosen for the relevance factors. The societal factors were derived through a public opinion poll (Kicherer, 2005). For more information regarding the weighting methodology and the subsequent integration of ecological and economic data, presented below, see Saling *et al.* (2002)[11] and Kicherer *et al.* (2007)[9].

在进一步的加权处理过程中，将影响类别结果总结为对环境施加的总应变的单个指示或声明。在提出的生态效率评价方法中，为每种影响类别分配一个权重，用于表示该影响类别相对于特定区域其他影响类别的环境重要性。这些权重因子是特定影响类别的“相关性因子”和“社会因子”所组合。欧洲的相关性因子和社会因子见表 B.6。为了获得相关性因子，可将该类别中影响最大的备选方案结果根据特定区域中同一类别的总负荷进行归一化。该步骤可得出不同影响类别结果的相对重要性。社会因子表示一个人群所感知的每种类别相对于其他影响类别的重要性（见表 B.6）。

社会因子基于在相关性因子选择的同一区域中进行的民意调查。通过民意调查获得社会因子（Kicherer，2005）。有关权重方法以及后续对生态和经济数据进行整合的更多信息，请参考 Saling 等人（2002）[11]和 Kicherer 等人（2007）[9]。

6) The product system value

f）产品系统价值

— In this study, the product system value was assessed by using a Life Cycle Costing (LCC) method (Bengtsson, and Sjöborg, 2004[7]); costs associated with environmental impacts are not covered by the LCC since, by definition, external costs are borne by society and reflect environmental impacts of the system under study (Rudenauer *et al*., 2005[10]). These impacts are covered by the LCA in the environmental assessment.

本研究采用生命周期成本法（LCC）对产品系统价值进行评价（Bengtsson 和 Sjöborg，2004[7]）。与环境影响相关的成本并未包含在 LCC 的范围内。根据定义，外部成本由社会承担，并反映所研究系统的环境影响（Rudenauer 等人，2005[10]）。生命周期评价中的环境评价涵盖了这些影响。

— The product system value for the customer, based on an equal-weight basis, was the cost savings of the chelating agent for the detergent manufacturer.

对消费者而言，基于等重基础上的产品系统价值是螯合剂为洗涤剂制造商节省的成本。

— In the eco-efficiency assessment method applied, the total costs of the studied alternatives are normalized with respect to the gross domestic product of the same region that is used in the environmental assessment.

在采用的生态效率评价方法中，基于环境评价中所使用的同一区域的国内生产总值对所研究的备选方案的总成本进行归一化处理。

7) Choice of eco-efficiency indicators

g）生态效率指标的选择

— The eco-efficiency method includes a weighting of environmental impacts and costs, resulting in a two-dimensional diagram (see Figure B.6). The eco-efficiency method takes into account the contribution of the studied alternatives environmental impact to the total environmental impact within a certain region. In the same way, the costs of the studied alternatives are compared to the gross domestic product of the same region. Hence, this is a normalization step, which yields two ratios that communicate the significance of the environmental and financial impact. If the environmental impact is greater, for example, more weight will be put on the environmental performance of the studied alternatives. The axes in the diagram are inverted so that the alternative that has the lowest environmental impact and the best financial performance is found in the upper right corner. This alternative is termed the *most eco-efficient alternative* and is hence favoured from an eco-efficiency perspective.

生态效率方法为环境影响和成本的加权，从而得到一个二维图（见图 B.6）。生态效率方法考虑了所研究中备选方案的环境影响对某一区域内总环境影响的贡献。同样，将备选方案的成本与同一区域的国内生产总值进行比较。因此这是一个归一化步骤，可得到两个用于说明环境和财务影响重要性的比率。例如，如果环境影响更大，就为所研究备选方案的环境绩效分配更高权重。图中的轴线是倒置的，以便在右上角找到具有最低环境影响和最佳财务绩效的备选方案。这种备选方案为最具生态效率的方案，因此从生态效率的角度更受青睐。

8) Interpretation to be used

h）解释说明

— The two processes will be ranked and a sensitivity analysis will be made to assess the significance of the difference in environmental impact and life cycle cost.

需对这两个过程进行排名，并进行敏感性分析，以评估在环境影响和生命周期成本方面差异的显著性。

9) Reporting and disclosure of results

i）结果报告和披露

— An internal report will be made.

需编写内部报告。

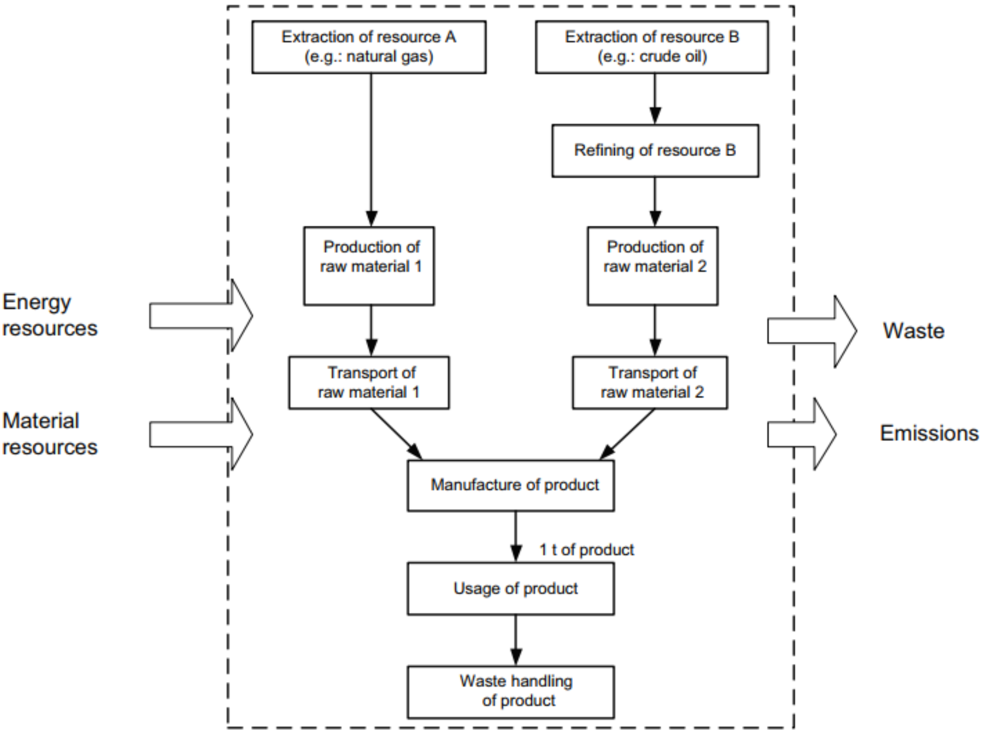


Figure B.5 — System boundary

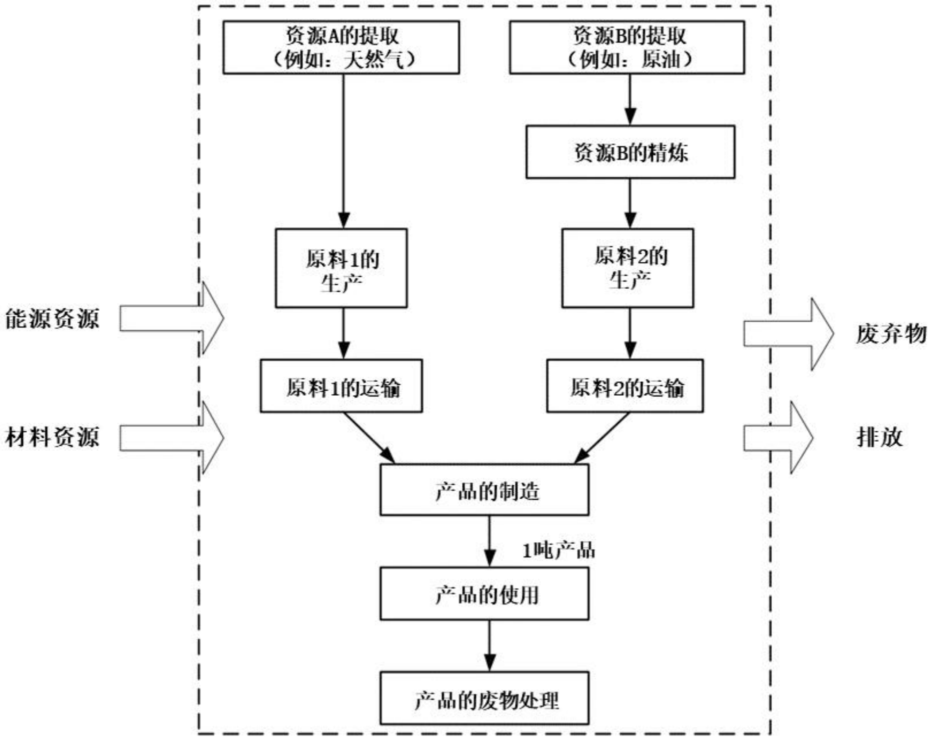


图 B.5 系统边界

Table B.5 — Elementary flows assessed

Energy (MJ/FU)	Coal Oil Gas Waterpower Nuclear Lignite Recovered/other Biomass	Emissions to water (mg/FU)	COD BOD N-tot NH_4- N P-tot AOX HM HC SO_4^{2-} Cl^-
Resources (kg/FU)	Stone coal Oil Natural gas Brown coal Sodium Chloride Sulfur Phosphorous Iron Lime Bauxite Sand	Waste (kg/FU)	Municipal waste Chemical waste Construction waste Mining waste
Emissions to air (mg/FU)	CO_2 SO_x NO_x CH_4 NM-VOC CFCs NH_3 N_2O HCl	Land use (m^2/FU)	Forest Pasture, fallow, bio-agric. Conv. agriculture Sealed Roads, tracks, canals

表 B.5 评价的基本流

能源（MJ/FU）	煤炭 石油 气 水电 核能 褐煤 回收的/其他 生物质能	**向水中排放（mg/FU）**	COD（化学需氧量） BOD（生化需氧量） 总碳 NH_4-N 总磷 AOX HM HC SO_4^{2-} Cl^-

资源（kg/FU）	石煤 石油 天然气 褐煤 氯化钠 硫 磷 铁 石灰 矾土 砂	**废物（kg/FU）**	城市废弃物 化学废弃物 建筑废弃物 采矿废弃物
向空气排放（mg/FU）	CO_2 SO_x NO_x CH_4 NM-VOC CFCs NH_3 N_2O HCI	**土地利用（m^2/FU）**	森林 牧场、休耕地、生态农业 传统农业 密封 道路、轨道、运河

Table B.6 — Impact categories and weighting factors

Impact category	**Societal factor** S %	**Relevance factor** R %	**Total weighting Factor** **μ[a]** **%**
Resource use	20	4	11
Primary energy use	20	5	13
Area use	10	0,3	2
Toxicity potential	20	20	20
Risk potential	10	10	10
Emissions	20	61	44
Water emissions[b]	35	95	78
Solid waste	15	—	—
Air	50	5	22
Global warming potential (GWP)	50	69	68
Photochemical ozone creation potential (POCP)	20	8	15
Ozone depletion potential (ODP)	20	—	—
Acidification potential (AP)	10	23	17

[a] Geometric mean of *S* and *R*.

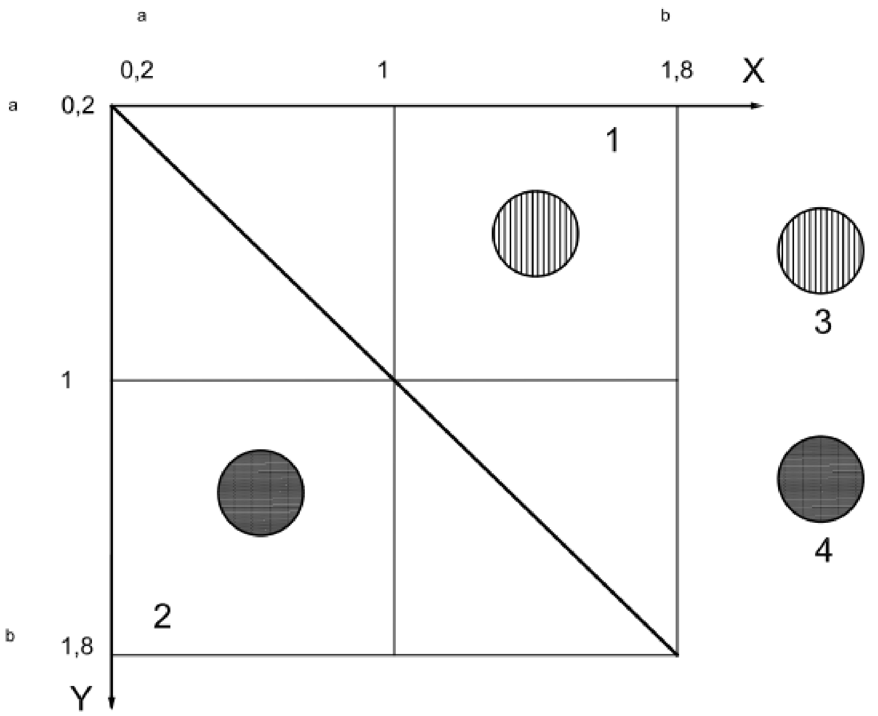
[b] This impact category includes the eutrophication potential of substances emitted to the water recipient.

表 B.6 影响类别和权重因子

影响类别	社会因子 *S* %	相关性因子 *R* %	总权重因子 *μ*[a] %
资源利用	20	4	11
一次能源利用	20	5	13
场地利用	10	0.3	2
潜在毒性	20	20	20
潜在风险	10	10	10
排放	20	61	44
水排放[b]	35	95	78
固体废弃物	15	—	—
空气	50	5	22
全球变暖潜势（GWP）	50	69	68
光化学臭氧生成潜势（POCP）	20	8	15
臭氧消耗潜势（ODP）	20	—	—
酸化潜势（AP）	10	23	17

[a] *S* 和 *R* 的几何平均数；

[b] 该影响类别包括排放到水体接受者中物质的富营养化潜势。



Key

X product system value

Y environmental impact (norm.)

1 high eco-efficiency

2 low eco-efficiency

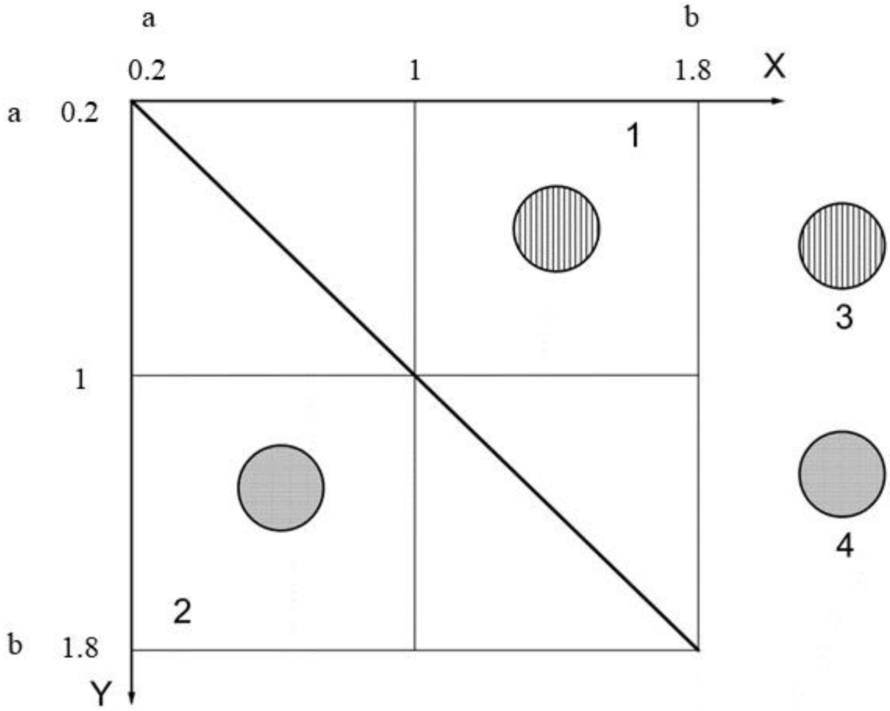
3 product/Process 1

4 product/Process 2

a Low.

b High.

Figure B.6 — The eco-efficiency portfolio



标引序号说明：

X——产品系统价值；

Y——环境影响（归一化）；

1——高生态效率；

2——低生态效率；

3——产品/过程 1；

4——产品/过程 2；

[a] 低；

[b] 高。

图 B.6 生态效率组合

B.5.3 环境评价 Environmental assessment

— The results of the impact assessment are shown in Table B.7.
影响评价的结果见表 B.7。

Table B.7 — Characterization/impact category results for 1 t of the studied chelating agents[a]

Impact categories	Alternatives			
	A	B	C	D
Primary energy use [GJ]	71	83	77	20
Resource use [ton crude oil equivalent]	1,2	1,4	1,3	1,3
Area use [m^2·yr]	358	3	3	1

Toxicity potential [dimensionless]	0,09	0,34	1	0,11
Risk potential [dimensionless]	0,58	1	0,89	0,18
Global warming potential [ton CO_2 equivalent]	5,1	5,7	5,5	2,7
Photochemical ozone creation potential [kg C_2H_4 equivalent]	1,0	1,1	1,0	0,4
Ozone depletion potential [kg CFC11 equivalent]	—	—	—	—
Acidification potential [kg SO_2 equivalent]	17	15	12	15
Waste [kg]	—	—	—	—
Water emissions [1 000 m^3]	0,6	6	0,2	27

[a] Grey-shaded items constitute emissions.

表 B.7 1 吨所研究螯合剂的表征/影响类别结果 [a]

影响类别	备选方案			
	A	B	C	D
一次能源利用（GJ）	71	83	77	20
资源利用（t 原油当量）	1.2	1.4	1.3	1.3
场地利用（m^2·y）	358	3	3	1
潜在毒性（无量纲）	0.09	0.34	1	0.11
潜在风险（无量纲）	0.58	1	0.89	0.18
全球变暖潜势（t CO_2 当量）	5.1	5.7	5.5	2.7
光化学臭氧生成潜势（kg C_2H_4 当量）	1.0	1.1	1.0	0.4
臭氧消耗潜势（kg CFC11 当量）	—	—	—	—
酸化潜势（kg SO_2 当量）	17	15	12	15
废弃物（kg）	—	—	—	—
水排放（1000 m^3）	0.6	6	0.2	27

[a] 灰色阴影的项目构成排放。

B.5.4 产品系统价值评价 Product system value assessment

— The normalized costs savings that were obtained are shown in Figure B.8.
归一化后的成本节约见图 B.8。

B.5.5 解释说明 Interpretation

B.5.5.1 概述 General

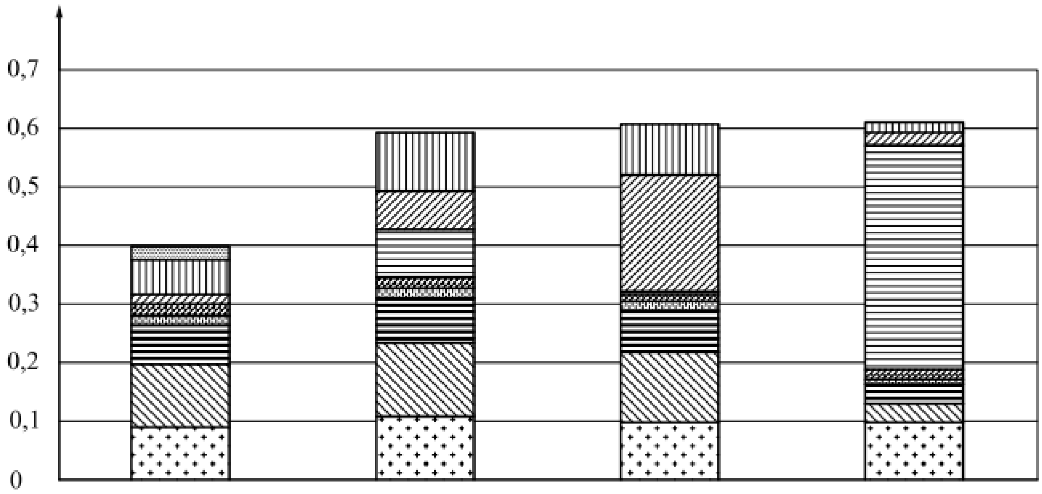
Results of eco-efficiency assessment of different chelating agents:
不同螯合剂的生态效率评价结果：
— The impact category results for 1 t of chelating agent are presented for the different alternatives in Table B.7.
——表 B.7 列出了不同备选方案的 11 种螯合剂的影响类别结果。
— From these results, it is clear that a trade-off between the different kinds of environmental impacts is needed in order to generate a priority list of the different chelating agents from a holistic environmental perspective. This trade-off is done via the weighting step. The weighting factors that were used to aggregate the impact category results in a single score, denoting the total environmental pressure of the different alternatives,

are presented in Table B.6 and represent European conditions.

——从结果看出不同类型的环境影响之间需要进行权衡，以便从环境整体的角度生成不同螯合剂的优先顺序清单。通过加权步骤实现权衡。表 B.6 列出了用于集成影响类别结果的权重因子，这些权重因子表示不同备选方案的总环境压力，同时代表了欧洲条件。

— The result of the weighting is illustrated in the bar chart and table in Figure B.7. They show the weighted values for each impact category and chelating agent; the top of the bars denotes the total and final environmental results that were integrated with the economic data in the complete eco-efficiency assessment.

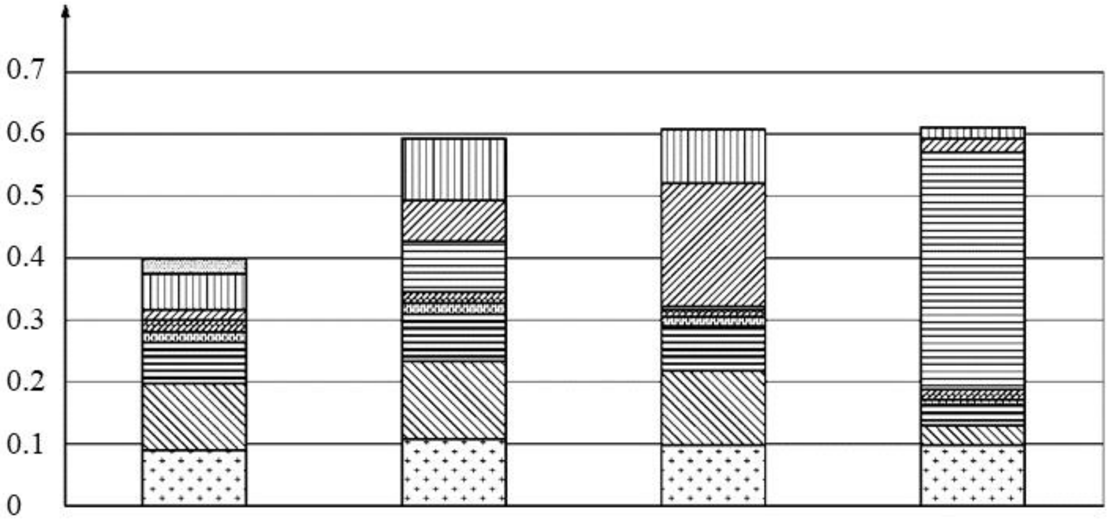
——图 B.7 的条形图和表格中显示了加权结果，其中显示了每种影响类别和螯合剂的加权值，条形图顶部表示完整生态效率评价中与经济数据相结合的总体和最终环境结果。



		A	B	C	D
	Area use	0,02	0,000 2	0,000 2	0,000 1
	Risk potential	0,06	0,10	0,09	0,02
	Toxicity potential	0,02	0,07	0,20	0,02
	Water emissions	0,000 9	0,08	0,003	0,38
	AP	0,02	0,02	0,01	0,02
	POCP	0,01	0,02	0,02	0,006
	GWP	0,07	0,08	0,07	0,04

	Energy use	0,11	0,13	0,12	0,03
	Resources use	0,09	0,11	0,10	0,10

Figure B.7 — Weighted values for the different impact categories and chelating agents



		A	B	C	D
	场地利用	0.02	0.0002	0.0002	0.0001
	潜在风险	0.06	0.10	0.09	0.02
	潜在毒性	0.02	0.07	0.20	0.02
	在水中的排放量	0.0009	0.08	0.003	0.38
	酸化潜势	0.02	0.02	0.01	0.02
	光化学臭氧潜势生成	0.01	0.02	0.02	0.006
	全球变暖潜势	0.07	0.08	0.07	0.04
	能源利用	0.11	0.13	0.12	0.03
	资源利用	0.09	0.11	0.10	0.10

图 B.7 不同影响类别和螯合剂的加权值

B.5.5.2 加权环境影响 Weighted environmental impact

— The result of this study indicates that the product system for chelating agent A has the lowest total environmental impact. A performs well in all important aspects compared with the other alternatives, mainly because it is based on renewable raw materials and is readily biodegradable. Another advantage of A and C is that (unlike D and B) they do not give rise to any phosphorus emissions to water and hence the eutrophication potential of A is minor. The most significant impact of chelating agents is their water emissions, according to the applied weighting methodology. This is due to the fact that a lot of the eutrophication is caused by the use of phosphorous in detergents. More than 60 % of the environmental impact of chelating agent D is due to eutrophication, which is the single impact category that gives this chelating agent a higher environmental impact than agent A.

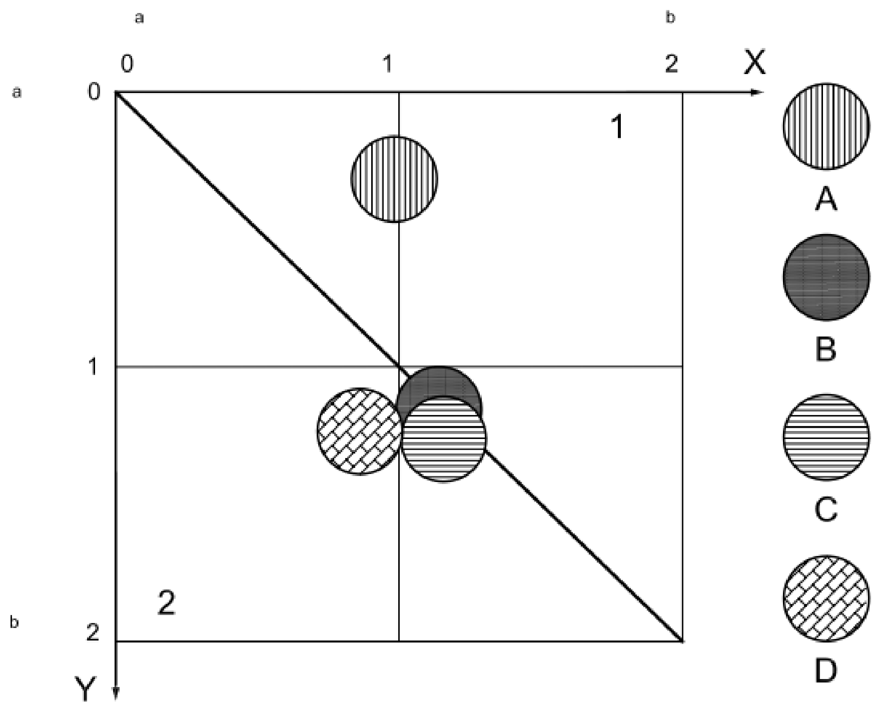
本研究的结果表明，螯合剂 A 产品系统的总环境影响最小。与其他备选方案相比，螯合剂 A 在所有重要方面都表现良好，主要因为它基于可再生原料并易生物降解。螯合剂 A 和 C 的另一个优点（与螯合剂 D 和 B 不同）是它们不会向水中排放任何磷，因此螯合剂 A 的富营养化潜势很小。根据所用的加权方法，螯合剂最显著的影响是其水排放，因为洗涤剂中使用的磷会引起严重的富营养化。螯合剂 D 有超过 60%的环境影响是因富营养化所引起，而富营养化这种单一影响类别使螯合剂 D 的环境影响高于螯合剂 A。

— With respect to the toxicity potential, A scores much better than C especially; for C, there is limited evidence of carcinogenic effects from exposure. For these reasons, it can be concluded that on an equal mass basis, A is the most environmentally preferred product system. A sensitivity analysis also showed that this result is robust with regard to the region (continent) that is chosen for the weighting.

在潜在毒性方面，螯合剂 A 明显优于螯合剂 C，有限的证据表明接触螯合剂 C 会引起致癌效应。基于这些原因，在同等权重的基础上，螯合剂 A 是最环保的产品系统。敏感性分析还表明，该结果对于选择用于加权的区域（大陆）是可靠的。

— The total result, including financial aspects, is presented in Figure B.8.

包括财务方面在内的总体结果见图 B.8。



Key

X product system value

Y environmental impact (norm.)

A Product A

B Product B

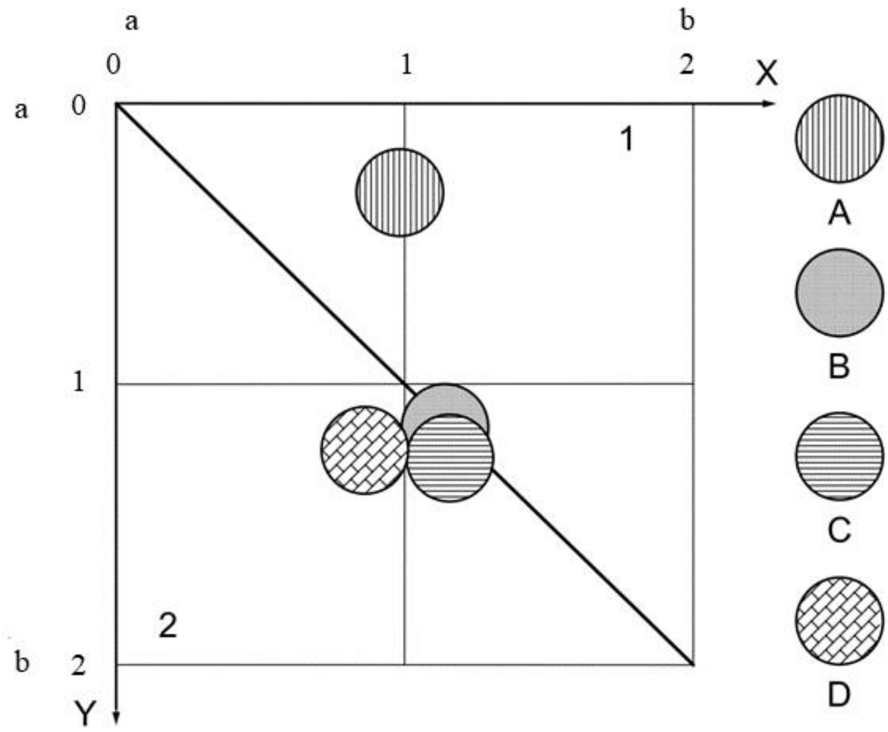
C Product C

D Product D

a Low.

b High.

Figure B.8 — Eco-efficiency diagram



标引序号说明：

X——产品系统价值；

Y——环境影响（归一化）；

A——产品 A；

B——产品 B；

C——产品 C；

D——产品 D；

[a] 低；

[b] 高。

图 B.8 生态效率图

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