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《产业生态学报》

2006 年冬，第 10 卷第 4 期，15-36 页

题目：MEFASPACE：基于物料流的欧盟货运交通预测模型

作者：Marina Fischer-Kowalski, Veronika Gaube, Gerhard Rainer

关键字：非物质化，环境负担，采掘-生产-消费-处置链条，产业生态学，交通流量预测，重载系数

摘要：物料流分析(MFA)能够对国民经济的实物规模作出深度的综合。与之类似的是交通研究中对货运规模量化问题。本文从物流的角度建模并预测了货运流量。首先，对诸多物理变量间的因果关系通过一个线性的、静态的模型(白箱模型)作了概念化和规范化的描述，认为运输量(TV,以吨计)取决于直接物料投入(DMI)和重载系数这两个变量。从热力学的角度看重载系数的变化幅度有限。运输活动最常用的指标运输功(TW，以吨千米计)则取决于 TV 和单位托运距离。随后我们用过去四十年间欧盟国家的运输统计数据对这一模型进行了检验。模型的计算与公路和铁路运输的统计结果一致，但其它运输模式的统计不符。总体而言，这一成果是令人振奋的。四十年来，DMI 与 TV 密切相关，不同国家和不同时期的重载系数变化不大，处于一特定区间(1-3)。单位托运距离随国家不同而差异显著，且随时间的演进呈上升趋势。MFA 为货运交通的预测和情景分析开辟了一条新路。当然为了分析运输距离和交通活动的环境影响，其它领域的知识也不可或缺。

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MEFASPACE: A Model Predicting Freight Transport from Material Flows, and Transport Activity in Europe

Marina Fischer-Kowalski, Veronika Gaube, and Gerhard Rainer

KEYWORDS:
dematerialization, environmental pressure, extraction-production-consumption-disposal chain, industrial ecology, predicting transport volumes, reloading factor

SUMMARY:
Materials flow analysis (MFA) generates highly aggregated indicators for the material "scale" of national economies. Similarly, transport statistics operate with indicators for the scale of freight transport activity. This article presents a model that seeks to predict the scale of freight transport from material flows. In the first part, the model is developed conceptually and formally, as a linear and static ("mechanistic") model linking biophysical variables by defined causalities ("white box"). The key prediction is that transport volume (TV in metric tons) relates to direct material input (DMI) by a reloading factor, which, for thermodynamic reasons, varies very little. Transport work (TW in metric ton kilometers), the most common indicator for transport activity, depends on TV and distance per haul. In a second part, we probe this model with transport statistics from European countries for the past four decades. Whereas for road and rail transport statistical indicators exist for many countries and years and comply with our model's theoretical definitions, they are either lacking or not complying well for other modes. The results were encouraging, nevertheless. In the past four decades, DMI corresponded very closely to TV as predicted, with a reloading factor that is in the expected range (1–3) and fairly stable across countries and time. At the same time, distances per haul showed a much more dynamic pattern, with quite a bit of variation between countries and a clear tendency to increase over time. Thus, MFA opens a new path for projections and scenario building for freight transport, but needs to be coupled to knowledge from other fields to generate a full picture of transport distances and, finally, environmental pressure.

《产业生态学报》

2006 年冬，第 10 卷第 4 期，37-60 页

题目：基于国际互联网的集成环境评价系统 II：基于本体的语义搜索与代理人系统的知识发现

作者：Steven Kraines, Rafael Batres, Brian Kemper, Michihisa Koyama, Vincent Wolowski

关键字：代理人(agent)，产业生态学，模型，本体，搜索，语义学

摘要：对工艺和过程作出综合的环境评价需要集合众多领域的专家知识。本文因此提出了一个基于国际互联网的概念性评价平台，可通过互联网等先进通讯手段实现知识共享，数字化求解城市生态等大系统下的复杂问题。文中阐述了该软件平台共享并发现产业生态学相关领域专家知识的机理：各类知识以一定的计算机化语义模式公告于互联网上，在整合通用高级本体与特定领域级本体的基础上，软件通过一个语义层发出搜索请求，寻找相匹配的知识公告。实现分布式知识管理的关键在于一个多代理人(agent)系统：有的 agent 发布模型化的知识公告，有的 agent 代表用户提出知识请求，有的 agent 则对其它 agent 的地址和功能进行管理。本文还对上述概念模型作了验证：四位学者分处四方，却可通过这一系统互通有无、融会新知。

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Internet-Based Integrated Environmental Assessment, Part II: Semantic Searching Based on Ontologies and Agent Systems for Knowledge Discovery

Steven Kraines, Rafael Batres, Brian Kemper, Michihisa Koyama, and Vincent Wolowski

KEYWORDS:
agents, industrial ecology, models, ontologies, searching, semantics

SUMMARY:
Integrated environmental assessment of technologies and processes associated with industrial ecology requires the sharing of expert knowledge from a wide range of domains of research. A concept for an Internet-based platform that uses Internet and communication technologies to support knowledge sharing in the form of numerical model computational services for solving complex problems related to large-scale systems such as urban ecosystems has been proposed. Here, a software prototype that has been developed for sharing and discovery of expert knowledge from domains related to industrial ecology is described. The prototype uses the combination of a generic upper level ontology and a specific domain level ontology to provide a semantic layer for the process of searching and matching knowledge requests with knowledge advertisements. Knowledge advertisements are provided in the form of semantic descriptions of computational model service capabilities. The prototype uses a multiagent system to support the realization of a distributed knowledge-sharing marketplace on the Internet, populated by agents that advertise model services, agents that make requests on behalf of system users, agents that supply ontologies, agents that conduct searches on behalf of other agents, and agents that manage address and function repositories for other agents. A proof of concept demonstration of the prototype is provided, using a hypothetical scenario of four researchers around the world who have knowledge that could aid each other's research efforts.

《产业生态学报》

2006 年冬，第 10 卷第 4 期，61-76 页

题目：食品消费与营养流：瑞典 1870 年以来的氮循环

作 者： Tina-Simone Schmid Neset, Hans-Peter Bader, Ruth Scheidegger

关键字：动态建模，食品生产，产业生态学，物料流分析(MFA)，计量物料流分析(MMFA)，物质流分析(SFA)

摘要：食品消费及相关过程对环境中的氮元素流有重大影响。本文以瑞典 Linköping 市的常住人口为例，研究了 1870、1900、1950 和 2000 等时间节点上食品加工与消费、农业生产和有机废物处理方式的演变，进而分析了相应特征条件下氮元素在食品消费过程中的流动以及向水圈和大气圈的排放情况。有机废物处理时排向水圈的氮元素由每人每年 0.57 千克增至 3.1 千克，同时沉积堆放的废氮则几乎从零增长到每人每年 1.7 千克。整个过程最大的氮流来自饲料。化肥中的氮流量也逐渐升高到 2000 年的每人每年 15 千克。130 年来人均排向环境中的氮流减少了约 30%。

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Food Consumption and Nutrient Flows: Nitrogen in Sweden since the 1870s

Tina-Simone Schmid Neset, Hans-Peter Bader, and Ruth Scheidegger

KEYWORDS:
dynamic modeling, food production, industrial ecology, materials flow analysis (MFA), mathematical materials flow analysis (MMFA), substance flow analysis (SFA)

SUMMARY:
Changes in food consumption and related processes have a significant impact on the flow of nitrogen in the environment. This study identifies both flows within the system and emissions to the hydrosphere and atmosphere. A case study of an average inhabitant of the city of Linköping, Sweden, covers the years 1870, 1900, 1950, and 2000 and includes changes in food consumption and processing, agricultural production, and organic waste handling practices. Emissions to the hydrosphere from organic waste handling increased from 0.57 kilograms of nitrogen per capita per year (kg N/cap per year) to 3.1 kg N/cap per year, whereas the total flow of nitrogen to waste deposits grew from a negligible amount to 1.7 kg N/cap per year. The largest flow of nitrogen during the entire period came from fodder. The input of chemical fertilizer rose gradually to a high level of 15 kg N/cap per year in the year 2000. The total load per capita disposed of to the environment decreased during these 130 years by about 30%.

《产业生态学报》
2006 年冬，第 10 卷第 4 期，77-94 页

题目：欧盟报废车辆回收利用目标的实现策略

作者：Paulo Ferrão, Pedro Nazareth, Jośe Amaral

关键字：车辆破碎残渣(ASR)，报废车辆(ELV)，欧盟，生产者延伸责任制(EPR)，产业生态学，再生

摘要：报废车辆的处置是欧盟环境政策的一个新热点。为此欧盟推出了车辆报废法令，对汽车设计和报废汽车最低回收利用率做出了技术规定，在经济可行的前提下，仅可能地对报废汽车处理系统实行优化。

本文评述了既有与新兴的报废车辆再循环技术，制定相应策略时可加以参考。相对旧车拆卸而言，破碎工艺的劳动密集程度较低，研究重点关注了车辆破碎残渣(ASR)的回收技术，指明了其未来发展的方向。

研究采用实比例实验所得破碎数据，模拟了报废车辆处理系统。结果表明 ASR 机械分离与回收技术可大幅提高回收率，并满足报废汽车法令的要求。这一技术比其它重在节能的技术更有发展前景。

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Strategies for Meeting EU End-of-Life Vehicle Reuse/Recovery Targets

Paulo Ferrão, Pedro Nazareth, and Jośe Amaral

KEYWORDS:
automobile shredder residue (ASR), end-of-life vehicles (ELV), European Union, extended producer responsibility (EPR), industrial ecology, recycling

SUMMARY:
Disposal of end-of-life vehicles (ELVs) is a relatively new focus of the European policy community. Technical requirements for car design and minimum reuse and recovery rates for end-of-life vehicles are the subject of a recent European Union directive on ELVs. This directive is expected to induce changes in the infrastructure required for ELV processing, and presents a substantial challenge to maintaining such an infrastructure as economically viable.

This paper assesses current and emerging ELV recycling technologies, in order to provide guidelines for the development of future ELV recycling strategies. Emphasis is given to technologies dedicated to automobile shredder residue (ASR) recovery, as an alternative/complement to more labor-intensive dismantling activities. The ultimate goal is to develop a vision of the type of ASR processing technology that could emerge in the future.

The analysis is based on a model developed to simulate ELV processing infrastructures, and shredding data are taken from full-scale experiments. The results obtained show that ASR mechanical separation and recycling technologies may enable more extensive recycling and contribute to achieving European Union recycling targets, and can thus be considered as far more promising than technologies based on energy recovery.

《产业生态学报》
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题目：英国汽车产业环境法规的战略性应对：关于欧盟车辆报废法令与波特假设

作者：Jo Crotty, Mark Smith

关键字：汽车，面向环境的设计(DfE)，环境法规，生产者延伸责任制(EPR)，产业生态学，供应链

摘要：2006 年 1 月 1 日起欧盟的所有汽车代工商(OEM)及零件制造商都必须遵守欧盟车辆报废法令。该法令要求 OEM 厂商回收并拆卸欧盟内所有的报废车辆。回收的零件视情况再利用或再循环。欧盟车辆重复利用和循环的部分应达 85%，2015 年更应提高到 95%以上。责任为此落实到 OEM 厂商与零件制造商的身上，迫使它们必须采取面向拆卸的设计。这是检验波特假设的一个好案例。波特认为严格有效的环境法规有助于企业改进产品设计、减少污染排放，从而抵消了法规所导致的成本，使企业最终获益。车辆报废法令旨在促使企业改进设计、实现创新，这方面的收益是可以衡量的。本文采用 Rugman 与 Verbeke1998 年提出的环境法规应对策略矩阵，对英国汽车零件制造商及 OEM 厂商的应对策略作了评价，并分析了由之而来的收益。但结果有悖于波特假设，这可能因为 Rugman-Verbeke 模型中的前提设定有误。

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Strategic Responses to Environmental Regulation in the UK Automotive Sector: The European Union End-of-Life Vehicle Directive and the Porter Hypothesis

Jo Crotty and Mark Smith

KEYWORDS:
automobile, design for environment (DfE), environmental regulation, extended producer responsibility (EPR), industrial ecology, supply chain

SUMMARY:
As of 1 January 2006 all automotive OEMs (original equipment manufacturers) and component manufacturers operating within the European Union will need to comply with the End-of-Life Vehicle Directive (referred to hereafter as the EU ELV Directive). The EU ELV Directive compels all OEMs to take back and dismantle all motor vehicles for domestic use at the end of their useful lives. Each component part will then be either reused or recycled. To this end, the ultimate goal of the EU ELV Directive is that all motor vehicles for domestic use will have a reuse or recyclable content of 85% at the end of their useful lives, moving toward 95% by 2015. The burden of the EU ELV Directive falls on both the OEMs and their component manufacturers, forcing them to innovate and "design for disassembly." This being the case, it offers a unique real world example with which to test the Porter Hypothesis. Porter asserts that strict, correctly formulated environmental regulation can offer a firm secondary benefits through improved product design and the reduction of waste. This in turn allows the firm to offset the cost of compliance. Because the EU ELV Directive has been fashioned to force firms into a process of innovation and redesign, the magnitude of these so-called offsets can be judged. This article employs Rugman and Verbeke's 1998 strategic matrix of firm response to environmental regulation to examine qualitative details of the strategic response of automotive component manufacturers and OEMs in the United Kingdom to the demands of the directive to judge the volume of offsets generated. This analysis shows no support for the Porter Hypothesis and challenges the assumptions of Rugman and Verbeke's model.

《产业生态学报》
2006 年冬，第 10 卷第 4 期，113-132 页

题目：服务型企业环境表现管理的多情景分析

作者：Seppo Junnila

关键字：生命周期评价(LCA)，情景分析，服务类企业，环境影响，产业生态学，环境管理

摘要：本文基于六个企业案例，建立了服务类企业的生命周期情景模型，进而分析了 32 个不同情景下的环境影响。模型模拟了企业可能采取的各种环境管理手段，并对其可能造成的总体环境影响进行了生命周期评价。研究发现一些特定的管理情景会决定性的影响企业的环境表现。主要的影响因素包括电力获取、建筑能耗、交通工具选择、空间使用率以及建筑的维修周期。上述任一因素都可能导致企业总体环境影响发生 10%以上的变化

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Alternative Scenarios for Managing the Environmental Performance of a Service Sector Company

Seppo Junnila

KEYWORDS:
life-cycle assessment (LCA), scenario analysis, service company, environmental impact, industrial ecology, environmental management

SUMMARY:
This article presents a scenario analysis for a life-cycle model of service sector companies. The model is based on six case companies and it is applied to test the influence of 32 management scenarios. The scenarios simulate feasible options for environmental management measures in companies, and the life-cycle assessment method is used to model their relevance in terms of the total environmental impact of the company. The study found that the bulk of tested scenarios had only a minor influence on the total environmental impact of the company. Some individual management scenarios, though, turned out to have a major influence on the organization's environmental performance. The scenarios with greatest influence were those related to the procurement of electricity, building energy consumption, commuting vehicle mix, space usage efficiency, and refurbishment periods of the building. All of these management scenarios had an influence of more than 10% on the environmental impact of the model organization.

《产业生态学报》
2006 年冬，第 10 卷第 4 期，133-148 页

题目：全球资源开采的区域模式

作者：Heinz Schandl, Nina Eisenmenger

关键字：物料流分析(MFA)，资源开采，可持续的资源利用，自然资源，产业生态学，消费

摘要：本文利用物料流分析方法，对 1999 年的世界资源开采情况作了分原料类比、分地理区域和分发展阶段的评价，评价结果可作为可持续资源管理的决策依据。目前全球的资源采掘总量约为每年 500 亿吨，平均每人可分摊到 8 吨。随着中国、印度等发展中国家工业化步伐的迈进，这一数量还会翻番。本文在结合经济指标的基础上，提出了一些资源利用指标，以资制定可持续的资源利用政策。

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Regional Patterns in Global Resource Extraction

Heinz Schandl and Nina Eisenmenger

KEYWORDS:
materials flow analysis (MFA), resource extraction, sustainable resource use, natural resources, industrial ecology, consumption

SUMMARY:
This article presents an account of global resource extraction for the year 1999 by material groups, world regions, and development status. The account is based on materials flow analysis methodology and provides benchmark information for political strategies toward sustainable resource management. It shows that currently around 50 thousand megatons of resources are extracted yearly on a global scale, which results in a yearly global average resource use of around 8 tonnes per capita. Assuming further growth in world regions not yet close to the levels of resource use in the industrial cores—such as India or China—numbers could easily double once these parts of the world come to fully incorporate the industrial mode of production and consumption. This article contributes to information on resource use indicators, complementing and enriching information from economic accounting in order to facilitate political measures toward a sustainable use of resources.

《产业生态学报》
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题目：以生物质为重点的关于欧盟与美国十年期能量代谢的时间序列分析

作者：Helmut Haberl, Helga Weisz, Christof Amann, Alberte Bondeau, Nina Eisenmenger, Karl-Heinz Erb, Marina Fischer-Kowalski, Fridolin Krausmann

关键字：生物质，能量会计，能量流分析(EFA)，人类占用的净初级生产力(HANPP)，物料流分析(MFA)，实物经济

摘要：本文论述了欧盟(仅含 2004 年欧盟扩大前的 15 个成员国，简称 EU-15)1970-2001 年间及美国 1980-2000 年间的能量输入情况。研究所基于的能量流分析(EFA)方法与针对社会经济系统所采用的物料流分析(MFA)方法在概念上有异曲同工之处。EFA 能够评价国民经济的生物物理特征，从而量化该经济系统的总能量需求。有别于单纯统计产业技术能费的传统能量平衡表，EFA 还包括了投入社会经济系统的生物质如食品、饲料、木材和其它生物有机原料的数量，不过本文省略了上述生物质所内含的化学能。能量流分析可对比不同的社会模式(如农业与工业社会)，并研究能量消费与土地使用之间的关系。EU-15 的内部能量消费(DEC=内部生产+进口-出口，即表观能量消费)由 1970 年的 60EJ/年(1EJ=10^{18} 焦耳)增至 2001 年的 79EJ/年，已经超过了该地区的初级能量生产(NPP，为生态系统能量产出的一个量度)。美国的 DEC 则由 1980 年的 102EJ/年升至 2000 年的 125EJ/年，仅略小于其 NPP。20 世纪 90 年代初期，EU-15 与美国仅占世界陆地 NPP 的 10%和人口总量的 11%，却合计占有了世界产业能耗的 38%及总能量代谢的 31%。此外，美国的人均 DEC 超过欧盟一倍有余。EU-15 与美国能量输入的 EFA 计算值与传统能量平衡表相比要大五分之一到三分之一。本文最后论述了以上结果的对世界可持续发展的意义以及未来的研究方向。

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The Energetic Metabolism of the European Union and the United States: Decadal Energy Input Time-Series with an Emphasis on Biomass

Helmut Haberl, Helga Weisz, Christof Amann, Alberte Bondeau, Nina Eisenmenger, Karl-Heinz Erb, Marina Fischer-Kowalski, and Fridolin Krausmann

KEYWORDS:
biomass, energy accounting, energy flow analysis (EFA), human appropriation of net primary productivity (HANPP), materials flow analysis (MFA), physical economy

SUMMARY:
This article presents an assessment of energy inputs of the European Union (the 15 countries before the 2004 enlargement, abbreviated EU-15) for the period 1970–2001 and the United States for 1980–2000. The data are based on an energy flow analysis (EFA) that evaluates socioeconomic energy flows in a way that is conceptually consistent with current materials flow analysis (MFA) methods. EFA allows assessment of the total amount of energy required by a national economy; it yields measures of the size of economic systems in biophysical units. In contrast to conventional energy balances, which only include technically used energy, EFA also accounts for socioeconomic inputs of biomass; that is, it also considers food, feed, wood and other materials of biological origin. The energy flow accounts presented in this article do not include embodied energy. Energy flow analyses are relevant for comparisons across modes of subsistence (e.g., agrarian and industrial society) and also to detect interrelations between energy utilization and land use. In the EU-15, domestic energy consumption (DEC = apparent consumption = domestic extraction plus import minus export) grew from 60 exajoules per year (1 EJ = 10^{18} J) in 1970 to 79 EJ/yr in 2001, thus exceeding its territory's net primary production (NPP, a measure of the energy throughput of ecosystems). In the United States, DEC increased from 102 EJ/yr in 1980 to 125 EJ/yr in 2000 and was thus slightly smaller than its NPP. Taken together, the EU-15 and the United States accounted for about 38% of global technical energy use, 31% of humanity's energetic metabolism, but only 10% of global terrestrial NPP and 11% of world population in the early 1990s. Per capita DEC of the United States is more than twice that of the EU-15. Calculated according to EFA methods, energy input in the EU and the United States was between one-fifth and one-third above the corresponding value reported in conventional energy balances. The article discusses implications of these results for sustainability, as well as future research needs.

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题目：对 Haberl 能量代谢一文的述评：传统能量分析方法的理论与现实意义

作者：Mario Giampietro

关键字：生物质，能量分析，能量会计，化石燃料，产业生态学，代谢

摘要：本文是对 Haberl 及其同事发表于本期的欧盟及美国能量代谢一文的回复。Haberl 等人的文章采用了大量数据，对从资源流与社会-自然关系角度探讨经济过程的可持续性颇有助益。但作者将各类不同性质、不等价的能量输入，通过一些简单的转换(如热当量转换)，归纳为“全社会每年能量输入”这一单一指标。用这种归纳主义的方法分析社会能量代谢问题，不免有些过时且引起争议。

本文认为对各类不同性质的能量进行综合时必须在简便与实用之间寻求平衡。过度的指标简化可能削弱数据的多样性，从而影响分析的实用效果。文章简述了主要的数据集成策略，对进一步理解 Haberl 等人的分析方法不无裨益。

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Comments on “The Energetic Metabolism of the European Union and the United States” by Haberl and Colleagues: Theoretical and Practical Considerations on the Meaning and Usefulness of Traditional Energy Analysis

Mario Giampietro

KEYWORDS:
biomass, energy analysis, energy accounting, fossil fuels, industrial ecology, metabolism

SUMMARY:
This commentary responds the study “The Energetic Metabolism of the European Union and the United States: Decadal Energy Input Time-Series with an Emphasis on Biomass” by Haberl and colleagues, published in this issue. Their article provides an analysis based on a set of data that could be very useful for discussing the sustainability of economic processes in terms of resource flows and societal relations to nature. The authors’ choice to adopt a reductionist analysis of the metabolism of societies in energetic terms—that is, an analysis based on a single-scale and single-variable indicator such as “joules of energy input metabolized per year for the whole society” — is a controversial one. Such a choice implies the aggregation of different types of data—referring to nonequivalent categories of energy inputs—into a single overall assessment. That is, in their study the authors are adopting an old and controversial solution for aggregating different types of energy forms: applying a set of flat conversion factors (calorimetric equivalent) to the different types of energy inputs considered.

This commentary discusses the trade-off entailed by any method of aggregation of energy forms of different quality: (i) compression—reducing the number of indices used—versus (ii) relevance—maintaining a diversity of categories needed for the usefulness of the analysis. A brief history of the main strategies adopted so far for dealing with the problem of aggregation suggests implications for the approach adopted by Haberl and colleagues.

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题目：面向下一代的设计：Herman Miller 家具产品从摇篮到摇篮的设计理念

作者：Mark Rossi, Scott Charon, Gabe Wing, James Ewell

关键字：化学毒性与危害，面向环境的设计(DfE)，拆卸，产业生态学，办公订做家具产业，可回收性

摘要：20 世纪 90 年代末，办公家具制造商 Herman Miller 公司与建筑师 William McDonough 合作开发了一套基于从摇篮到摇篮理念的产品设计系统以及产品面向环境设计(DfE)的评价工具，用以评价产品的设计进展。Herman Miller 的第一种 DfE 设计产品是 Mirra 座椅。在座椅开发过程中，通过 DfE 对其进行了很多修改，包括完全更换椅背用料、增加座椅的可回收部分、限制聚氯乙烯(PVC)部件的使用、实现座椅的便捷拆卸等。

Mirra 座椅面向环境设计的最大亮点在于可回收材料的使用和可拆卸性的提高，但距完全使用绿色的、可再生的化学材料还有一定的距离。金属回收产业日趋完备，座椅使用金属材料增强了其可回收性。对产品组装过程的高度重视与控制同样有助于产品的未来拆卸。但座椅使用了塑料，与金属的完全可再生不同，多数塑料还是由一次性高分子材料制成的。此外，绿色材料和绿色化学品的种类和市场都有限，限制了座椅用材的进一步改进。

Mirra 座椅是产品设计与环境理念相结合的一项示范，设计过程须通过有效的评价工具加以评测，真正创造出从摇篮到摇篮的产品也仍然面临诸多挑战。Herman Miller 将不断改进其产品设计，向从摇篮到摇篮的目标迈进。

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Design for the Next Generation: Incorporating Cradle-to-Cradle Design into Herman Miller Products

Mark Rossi, Scott Charon, Gabe Wing, and James Ewell

KEYWORDS:
chemical hazards and toxicity , design for environment (DfE), disassembly, industrial ecology, office contract furniture industry, recyclability

SUMMARY:
In the late 1990s, office furniture manufacturer Herman Miller, Inc., entered into a collaboration with architect William McDonough to create a system for designing cradle-to-cradle products. This collaboration led to the creation of a tool—the Design for Environment (DfE) product assessment tool—that evaluates progress towards cradle-to-cradle products. The first product Herman Miller designed using the DfE product assessment tool was the Mirra chair. Over the course of the chair's development, the DfE process generated a number of design changes, including selecting a completely different material for the chair's spine, increasing recycled content in chair components, eliminating all PVC (polyvinyl chloride) components, and designing the chair for rapid disassembly using common tools.

The areas of greatest success in designing the Mirra chair for the environment were the increased use of recyclable parts and increased ease of disassembly, whereas the areas of greatest challenge were increasing recycled content and using materials with a green chemistry composition. The success in recyclability reflects the use of metals materials that have a well-established recycling infrastructure. The success in disassembly reflects the high degree of control that Herman Miller has over product assembly. The challenge to increasing recycled content is the use of plastics in chairs. Unlike the metals, which all contain some recycled content, most plastics are made from virgin polymers. The challenge to improving materials chemistry is the limited range of green chemicals and materials on the market.

The Mirra chair exemplifies the value of incorporating the environment into design and the need for tools to benchmark progress, as well as the challenges of creating a truly cradle-to-cradle product. Herman Miller recognizes that working toward cradle-to-cradle products is a journey that will involve continuous improvement of its products.