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《产业生态学报》

1998 年冬，第 2 卷第 1 期，13–22 页

题目：有关 X 倍跃进的争论：为生态效率设定目标

作者：Lucas Reijnders

关键字：非物质化，生态效率，环境定量指标，X 倍跃进，技术创新，技术促进

摘要：将生态效率（或者非物质化）提高 X 倍（X 倍跃进，X 在 4 到 50 之间）的观念正在被很多分析人员和政策提倡者所支持。从政治上讲，这种努力还主要局限在一些欧洲国家。他们体现了强烈的技术乐观主义。本文回顾了有关 X 倍跃进争论的一些主要问题。本案例介绍了如何采用因子 X 来定量描述非物质化和生态效率。本研究发现因子 X 还不能精确衡量，而且人们对于在一定技术约束下，各种经济活动能够实现的效率改进倍数 X 相差极大这一点并不感兴趣。人们对单纯依靠技术进步是否足以使整个经济活动的生态效率提高 X 倍还没有共识。然而，政府的技术促进对于实现 X 倍跃进，特别是当 X 倍非常大时，似乎是十分必要的。

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The Factor X Debate: Setting Targets for Eco-Efficiency

Lucas Reijnders

Keywords:
dematerialization, eco-efficiency, environmental metrics, factor X, technological innovation, technology forcing

Summary:
The quantification and achievement of eco-efficiency or dematerialization in the form of a factor X, with X varying between 4 and 50 is being espoused by a variety of analysts and advocates. Politically, these efforts are mainly confined to some European countries. They reflect a remarkable technological optimism. This article reviews some of the major issues pertinent to the factor X debate. The case is presented for quantifying dematerialization or eco-efficiency goals using a factor X. It is also found that the factor X lacks precision as yet, and that there is only limited interest in the possibility that achievable values for X may vary widely among economic activities given technological constraints. There is no agreement whether technological improvement alone will be sufficient to achieve a factor X in practice for economies as a whole. It seems likely, however, that government-driven technology forcing will be necessary to achieve a factor X in practical terms, especially when X is relatively large.

《产业生态学报》

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题目：关于“大目标”的评论：价值观在环境决策中的作用

作者：Paul Craig

关键字：环境目标，环境政策，环境价值观，生命周期评价，核政策，优先排序

摘要：Thomas Graedel（1997）在“大目标：在生命周期评价中开展环境问题优先分类的框架方法”一文中，提出了一个对环境问题进行优先排序的好方法。这个方法在三个层面上运用：大目标、环境问题和目标行动。我认为在第 1 个和第 3 个层面上更容易达成共识，但是在中间层面，即环境问题上却面临更多的困难。即使人们具有共同社会取向，但对于一些具体技术的看法也存在很大差异。我将 Graedel 系统中的第一个大目标（人类灭绝）运用到放射性物质上。我使用核废物的例子来说明价值观与环境问题之间的紧密联系。我的分析结果将有助于加强 Graedel 大目标框架的用途。

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Comments on 'The Grand Objectives': The Role of Values in Environmental Decision Making

Paul Craig

Keywords:
environmental objectives, environmental policy, environmental values, life-cycle assessment, nuclear policy, prioritization

Summary:
In "The Grand Objectives: A Framework for Prioritized Grouping of Environmental Concerns in Life-Cycle Assessment," Thomas Graedel (1997) proposed an elegant schema for prioritizing environmental concerns. It operates at three levels: grand objectives, environmental concerns, and targeted activities. I argue that consensus is most likely on the first and third levels, but that the middle level, environmental concerns, is more problematic. Even among individuals who agree on general societal directions, strong differences of views can occur regarding specific technologies. I illustrate by applying Graedel's system to his "radionuclide" category, under his first grand objective (human species extinction). I use the example of nuclear waste to illustrate how values are inextricably involved at the "environmental concerns" level. My analysis suggests ways to enhance the utility of Graedel's useful system.

《产业生态学报》
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题目：产业生态学和竞争力：对公司的战略影响

作者：Daniel C. Esty，Michael Porter

关键字：闭路循环，竞争力，企业环境管理，生态效率，外部性，资源生产率

摘要：在产业生态学这门新兴学科中，一个尚待回答的问题是诸如面向环境的设计(DfE)、物质和能量闭环循环的实现等产业生态学概念在企业层面上的适用程度。我们在本文中重点分析产业生态学能否指导企业策略和行动来增强其竞争力，来讨论上述问题。

我们的结论是，对于那些寻求提高资源生产率和自身竞争力的企业来说，产业生态学思想往往十分有用。产业生态学所提倡的系统观点，可以帮助公司在其生产过程及其供应链的上下游找到提高增加值和降低成本的途径。但是，产业生态学并不能在各种情况下增强公司的竞争优势。在某些情况下，实现物质闭路循环的成本会超过其所带来的收益。在另一些情况下，环境法规并没有要求企业将其环境成本完全内部化，因此与努力消除所有污染排放的公司相比，污染企业可能取得短期甚至永久的成本优势。最后，由于产业生态学集中考察物质和能量流，因此无法用来优化公司内其他有利于增强其竞争力的因素。

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Industrial Ecology and Competitiveness: Strategic Implications for the Firm

Daniel C. Esty and Michael Porter

Keywords:
closed loop, competitiveness, corporate environmental management, eco-efficiency, externalities, resource productivity

Summary:
In the emerging field of industrial ecology one of the unsettled questions is the degree to which design for the environment, closing energy and materials loops, and other industrial ecology concepts apply at the firm level. In this article we examine this issue with a particular focus on whether industrial ecology can guide company strategy and efforts to enhance competitiveness.

We conclude that industrial ecology thinking will often be useful for firms seeking to improve their resource productivity and thus their competitiveness. The systems perspective that industrial ecology promotes can help companies find ways to add value or reduce costs both within their own production processes and up and down the supply chain. But industrial ecology cannot always be counted upon to yield competitive advantage at the firm level. In some cases, the cost of closing loops will exceed the benefits. In other cases, regulatory requirements do not fully internalize environmental costs, and thus polluting firms may gain temporary or permanent cost advantages relative to companies that attempt to eliminate all emissions. Finally, because industrial ecology focuses attention on materials and energy flows, it may not optimize other variables that contribute to competitiveness within the corporate setting.

《产业生态学报》
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题目：环境安全的产业生态学案例研究

作者：Brad Allenby

关键字：环境安全，环境战略，外部性，产业生态学，政策分析，贸易政策

摘要：环境安全是环境和国家安全考虑在国家政策层面上的结合点。虽然一些国家，例如美国，已经越来越多地将环境安全纳入传统的安全和外交机制，但是总体来讲，环境安全仍然是一个很新并富有争议的概念。下列几方面原因激发产业生态学家对环境安全的兴趣。首先，从方法论来看，环境安全问题往往十分复杂、具有跨学科特点，并在时间和空间上涉及多重尺度。因此，这是一个应用现有的产业生态学工具（比如产业代谢存量和流量分析）的好机会，并有助于发展产业生态学的新方法。其次，环境安全还为产业生态学的重要基本机制提供了一个很好的案例分析：环境在社会中由从属位置向战略地位转变。这个变化过程发生在多个层面上，从企业内部实施面向环境的设计(DfE)的方法，到世界贸易组织(WTO)的环境与贸易政策的整合；对于产业生态学家来说，认识它的内在规律非常重要。最后，国家安全是一个国家存在的先决条件。因此，使用产业生态学的方法和分析手段，将环境因素纳入国家安全政策和机制是产业生态学学科发展的一项重要任务。

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Environmental Security as a Case Study in Industrial Ecology

Brad Allenby

Keywords:
environmental security, environmental strategy, externalities, industrial ecology, policy analysis, trade policy

Summary:
Environmental security is the integration of environmental and national security considerations at a national policy level. It is a relatively new and still somewhat contentious concept, although in some countries, such as the United States, it is increasingly being embedded in traditional security and foreign policy institutions. It is of interest to the industrial ecologist for several reasons. First, from the methodological perspective, environmental security issues are frequently complex, multidisciplinary, and multiscalar in both temporal and geographic dimensions. They are thus good opportunities to apply existing industrial ecology tools such as industrial metabolism stock and flow studies, as well as to support the development of new industrial ecology methods. Second, environmental security offers an important case study of an important fundamental industrial ecology dynamic: the movement of environment from overhead to strategic for society. This process occurs at many different scales, from implementation of design for environment methodologies within firms to integration of environmental and trade considerations in the World Trade Organization; and it is important for the industrial ecologist to begin to understand its underlying dynamics. Finally, national security is the quintessential raison d'être of the national state. Accordingly, the integration of environmental considerations into national security policies and institutions, using industrial ecology methodologies and patterns of analysis, is a significant validation of the field.

《产业生态学报》
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题目：社会代谢：材料流分析的理论发展

作者：Marina Fisher-Kowalski

关键字：产业代谢，知识演化历史，材料流分析，物质经济，社会生态学，社会理论

摘要：我们在本文中探寻将生物学中的“新陈代谢”概念应用到社会系统的知识演化历史——我们并不是简单地进行类比，而是分析经济社会中，以及与各种自然系统之间的物质和能量流动过程。本文回顾了对这种方法的形成做出贡献的一些科学传统，包括生物学和生态学、社会理论、人类学和社会地理学。文章广泛收集了自 1860 年以来的各种方法和尝试，并介绍了他们是如何为 20 世纪 60 年代后期以来的“产业代谢理论”发展奠定基础的。随着政治观点的变化，代谢理论逐渐发展成为一个跨学科的重要概念。估计再经过 25 年的时间，代谢方法可能会成为对社会－自然交互作用、开展实证研究的重要的跨学科方法。有关后一阶段，我们将在本文献综述的第 2 部分讨论。

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Society's Metabolism: The Intellectual History of Material Flow Analysis.

Marina Fisher-Kowalski

Keywords:
industrial metabolism, intellectual history, material flow analysis, physical economy, social ecology, social theory

Summary:
In this article, we inquire into the intellectual history of the application of the biological concept of metabolism to social systems--not as a metaphor, but as a material and energetic process within the economy and society, vis-à-vis various natural systems. The paper reviews several scientific traditions that may contribute to such a view, including biology and ecology, social theory, cultural anthropology, and social geography. It assembles widely scattered approaches dating from the 1860s onward and shows how they prepare the ground for the pioneers of "industrial metabolism" in the late 1960s. In connection to varying political perspectives, metabolism gradually takes shape as a powerful interdisciplinary concept. It will take another 25 years before this approach becomes one of the most important paradigms for the empirical analysis of the society-nature-interaction across various disciplines. This later period will be the subject of part II of this literature review.

《产业生态学报》
1998 年冬，第 2 卷第 1 期，79–92 页

题目：面向环境的产品和生产过程设计的利弊权衡模型

作者：James Carnahan, Deborah Thurston

关键字：并行工程，对环境负责的生产，地板砖生产，质量屋（HOQ），多变量效用分析，污染预防

摘要：本文介绍了一个如何将污染预防与并行工程（同时设计产品及其生产过程）相结合的方法。关键问题是如何对污染、生产成本和产品质量等因素之间进行必需的利弊权衡。我们将生产过程的概率特征作为污染预防的一个机会来研究。我们提出了一个基于数学模型的决策工具，供工程技术人员和其他参与权衡比较谈判的人员使用。具体来讲，该方法将概率生产过程控制整合到一个多目标设计优化模型中。首先，我们开发了一个多变量效用函数框架用来决定哪个目标既相关，又可以谈判。然后，我们进行一个统计生产过程控制的试验，来确定那些制约所有目标最大化的因素。与此同时，我们利用在试验中获得的信息来调整效用函数的上下限。我们在文章提供了一个从生产者角度出发的地板砖生产案例分析。根据产品质量（用边角料产生率来衡量）、大气污染和生产成本等冲突目标的最佳组合，作出了材料选择和生产过程设计。研究发现，为减少固体废物而增加生产废料的综合利用，却导致大气污染的加剧。

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Tradeoff Modeling for Product and Manufacturing Process Design for the Environment

James Carnahan and Deborah Thurston

Keywords:
concurrent engineering, environmentally conscious manufacturing, floor tile manufacturing, house of quality (HOQ), multiattribute utility analysis, pollution prevention

Summary:
This article presents a method for integrating pollution prevention and concurrent engineering (simultaneous design of products and the manufacturing processes used to produce them). The central issue is unavoidable trade-offs, such as those among pollution, manufacturing cost, and quality. The probabilistic nature of the manufacturing process is exploited as an opportunity for pollution prevention. A decision tool in the form of a mathematical model is presented, which can be used by engineers and others with whom these trade-offs must be negotiated. Specifically, the method integrates statistical manufacturing process control into a multiobjective design optimization formulation. First, the framework of a multiattribute utility function is developed to determine which objectives are both relevant and negotiable. Then, a statistical manufacturing process control experiment is conducted to formulate some of the constraints that prevent all objectives from being maximized. Simultaneously, information obtained from the experiment is also used to fine-tune the upper and lower bounds in the utility functions. The results of an industrial case study of a floor tile manufacturer are presented, from the manufacturer's viewpoint. The material choice and manufacturing process settings that result in the best combination of the conflicting objectives of product quality (measured in terms of scrap rate), air pollution, and manufacturing cost are determined. The analysis also reveals the irony that for this manufacturer, efforts to reduce solid waste through greater use of scrap materials increase air pollution levels.

《产业生态学报》
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题目：氯的生命周期——第 3 部分：最终使用核算

作者：Robert Ayres

关键字：CFCs，化工生产，氯，产业代谢，材料核算，物质流分析

摘要：在本系列的前面两篇文章中，我们回顾了氯的主要生产过程（第 1 部分）以及氯作为生产其他化学品过程的中间体以及由此产生的废物（第 2 部分）。在本文中，我考虑了氯的一些最终应用（例如水处理和纸浆漂白）和氯化物在工业活动中的最重要应用（例如溶剂、CFCs 和塑料）。我还总结了有关它们环境命运的已知证据。关于持久性有毒化合物（如杀虫剂）的案例将会在后续文章中讨论。

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Life-cycle of chlorine Part III: Accounting for Final Use

Robert Ayres

Keywords:
CFCs, chemical manufacturing, chlorine, industrial metabolism, materials accounting, substance flow analysis

Summary:
In the two previous articles in this series we reviewed the major processes of chlorine production (Part I) and its intermediate uses and waste products in the production of other chemicals (Part II). In this article I consider some of the final applications of chlorine (e.g., for water treatment and pulp bleaching) and the uses of the most important chlorinated compounds such as solvents, chlorofluorocarbons, and the plastic polyvinyl chloride in the industrial economy. I summarize known evidence regarding their environmental fates. The special case of persistent long-lived toxic compounds (e.g., pesticides) will be discussed in a subsequent article.

《产业生态学报》
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题目：回收使用后的尼龙地毯：关于回收消费废品的经济学和工程学案例研究

作者：Lester Lave, Noellette Conway-Schempf, James Harvey, Deanna Hart, Timothy Bee, Christopher MacCracken

关键字：地毯回收，垃圾填埋覆盖，材料性质，尼龙再循环，再生地毯塑料（RCP），再循环经济学

摘要：在美国，每年有 30－40 亿磅尼龙地毯被丢弃到垃圾填埋场。作为一个案例研究，我们分析了对这种废弃塑料进行再循环的技术和经济可行性。地毯可以：(1) 被切碎作为填埋场的覆盖物或者作为混凝土的强化材料；(2) 经过剪切和化学处理的尼龙可以作为再生尼龙或者纯尼龙的原料；(3) 或者用来生产其他塑料。我们在估算在宾夕法尼亚州匹兹堡市建设一个每月处理 450,000 磅废弃尼龙再循环设施的成本后发现，在现有技术、法规和市场条件下，只有在很少情况下对商业场所的地毯进行切削和化学处理在经济上才是可行的。我们通过这个案例研究得到四点启示：首先，收集成本的高低决定了再循环是否经济可行。其次，给予一定的经济激励，可以降低收集成本。再次，如果试图再循环那些在设计阶段没有考虑再循环因素的产品，会产生很多问题。通过只使用单一原材料和易去除的黏合剂等措施来重新设计地毯，可以大大简化地毯再循环过程。最后，再循环过程应该尽可能设计成生产目前已经使用的材料，因为新材料会带来市场销售的问题。

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Recycling Post-Consumer Nylon Carpet: A Case Study of the Economics and Engineering Issues Associated with Recycling Post-Consumer Goods

Lester Lave, Noellette Conway-Schempf, James Harvey, Deanna Hart, Timothy Bee and Christopher MacCracken

Keywords:
carpet recycling, landfill cover, materials properties, nylon recycling, recycled carpet plastic (RCP), recycling economics

Summary:
Each year 3-4 billion pounds of nylon carpet are discarded into landfills in the United States. As a case study, we examine the technical and economic feasibility of recycling a portion of this source of discarded plastic. The carpet could be (1) shredded for use as daily cover at landfills or as a strengthening component of concrete, (2) sheared or chemically processed for reuse as recycled nylon or as pure nylon feedstock, or (3) made into a new type of plastic. We estimate the costs of a recycling facility to handle 450,000 lb. of discarded nylon carpet each month in Pittsburgh, Pennsylvania. We found that with current technology, regulations, and markets, only the recycling of carpet from commercial settings using shearing or chemical processing is economical and only under very narrow circumstances. We learned four lessons from this study. First, collection costs are high and can dominate the economics of recycling. Second, given time and incentives, collection costs can be reduced. Third, trying to recycle products not designed to be recycled leads to many problems. Carpet could be redesigned to make recycling easier by making the carpet out of a single material and using an adhesive that can be removed easily. Fourth, recycling processes should be designed to produce an existing material if at all possible, because new materials present marketing problems.

《产业生态学报》
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题目：一个基于简化生命周期评价和废物风险成本评价的考虑环境因素的决策支持系统

作者：Gautam Biswas, Kazuhiko Kawamura, David Hunkeler, Rajive Dhingra, Lochlin Caffey, Ellen Huang

关键字：考虑环境因素的设计和生产，生命周期评价软件，生命周期管理，油漆，风险评价，简化生命周期评价

摘要：我们开发了一个基于因特网并考虑环境因素的决策支持工具（EcoDS）进行生命周期管理。EcoDS 引入了一个纵向简化过程：在这个过程中，重要的生命周期阶段、环境压力和影响因素被筛选出来并相互关联起来。因为简化在清单分析前进行，所以大大加快了数据收集过程。对备选产品设计或者生产过程的比较采用两个定量指标：财务风险（或者成本）和废物风险。为方便评价，这两个指标分别根据特定用户或者机构的价值评估体系进行综合评定。EcoDS 的一个重要特点是，评价结果可以被归纳到同一个综合矩阵，类似混合财务和环境资产负债表。对每一种备选方案的优缺点的清晰描述，方便了高层管理的决策。文章还通过一个油漆选择案例来说明这种方法的应用。

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An Environmentally Conscious Decision Support System Based on a Streamlined Life Cycle Assessment and a Cost Residual Risk Based Evaluation

Gautam Biswas, Kazuhiko Kawamura, David Hunkeler, Rajive Dhingra, Lochlin Caffey and Ellen Huang

Keywords:
environmentally conscious design and manufacturing, LCA software, life-cycle management, painting, risk assessment, streamlined life-cycle assessment

Summary:
An Internet-based environmentally conscious decision support tool (EcoDS) has been developed for life-cycle management. EcoDS involves an initial vertical streamlining step, where the significant life-cycle stages, stressors, and impact categories are selected and cross-correlated. Because the streamlining is performed prior to the inventory, the approach expedites data collection. Comparisons among alternative product designs or manufacturing processes are based on two metrics: financial risk (or cost) and "residual" risk. For purposes of evaluation these two indicators are individually aggregated using a user- or organization-specified value system. A salient feature of EcoDS is that this output can be condensed into a single summary matrix akin to a hybrid pro forma income statement and environmental balance sheet. The clear delineating between the trade-offs involved in each alternative facilitates decision making by upper management. A case study on painting alternatives is presented to illustrate the methodology.