JOURNAL OF INDUSTRIAL ECOLOGY

中文摘要
《产业生态学报》
第17卷第3期

翻译
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Chinese Abstracts
Journal of Industrial Ecology
Volume 17, Number 3

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《产业生态学报》

2013 年，第 17 卷第 3 期，第 345–351 页

时间作为资源耗竭指标及其与大型石油勘探的深度与特征的关系

作者： L. Bruce Railsback

关键字： 石油，天然气，能源，资源流，钻探，产业生态学

摘要： 过去十五年间，大型含油带的勘探深度剧增，且探明油源多藏于盐下区带，开采难度更大。开发深层的石油储备更依赖技术进步；但如果地球上的浅层易开采石油储备仍如几十年前一般丰富，单纯的技术进步不足以推动深层石油的开发。开采埋层深、难开发的油井表明助推二十世纪全球经济的常规石油储备已经勘探殆尽。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 345–351

Depth and Nature of Giant Petroleum Discoveries Through Time as an Indicator of Resource Depletion

L. Bruce Railsback

Keywords:
oil, natural gas, energy, resource flows, drilling, industrial ecology

Summary:
A striking increase of the depth of giant petroleum discoveries in the past fifteen years coincides with a shift to discoveries in subsalt plays that require more challenging exploration and drilling. Technological advances have facilitated these changes, but technological advances alone could not have induced these changes in petroleum exploration on a planet in which shallow and less challenging targets remained in an abundance like that of previous decades. Instead, the trends toward greater discovery depths and more challenging plays suggest that most of the conventional petroleum accumulations of the kind that fueled the global economic system of the 1900s have already been found.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 352–362 页

生命周期评价中动态系统模拟之随机方法

作者： Shelie A. Miller, Stephen Moysey, Benjamin Sharp, Jose Alfaro

关键字： 贝叶斯定理，技术扩散，柳枝稷，个体为本模型，新兴系统，产业生态学

摘要： 本文提出了一个采用生命周期评价（LCA）法评估新兴系统的方法框架。现有 LCA 方法评估已建成系统时颇为有效；但评价未来的产品或过程时往往受到数据的限制，尽管未来产品或过程更需要生命周期信息。系统的生命周期清单（LCI）在许多情况下可随其发展路径而变。模拟新兴系统有助于更好地把握可能的趋势，深入理解 LCA 结果的未来情景与影响。本文提出的框架采用贝叶斯概率模拟技术应用，提出了一条分析系统进化的特别途径，既可单独使用，也可用于个体为本的模型（ABM）。此框架结合了情景模拟与生命周期数据，能够研究决策模式随时间推移而产生的影响，从而使 LCA 分析更为可靠与动态。该方法框架可用于研究城市发展带来的城市代谢变化，分析可再生能源技术的发展，辨识物料流的时空变迁，预测产品开发所需的工业网络。本文以柳枝稷生物质能为例验证了这一方法。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 352–362

A Stochastic Approach to Model Dynamic Systems in Life Cycle Assessment

Shelie A. Miller, Stephen Moysey, Benjamin Sharp, and Jose Alfaro

Keywords:
Bayes Theorem, technology diffusion, switchgrass, agent-based modeling, emerging systems, industrial ecology

Summary:
This paper presents a framework to evaluate emerging systems in life cycle assessment (LCA). Current LCA methods are effective for established systems; however, lack of data often inhibits robust analysis of future products or processes that may benefit the most from life cycle information. In many cases, the life cycle inventory (LCI) of a system can change depending on its development pathway. Modeling emerging systems allows insights into probable trends and a greater understanding of the effect of future scenarios on LCA results. The proposed framework uses Bayesian probabilities to model technology adoption. The method presents a unique approach to modeling system evolution and can be used independently or within the context of an agent-based model (ABM). LCA can be made more robust and dynamic by using this framework to couple scenario modeling with life cycle data, analyzing the effect of decision-making patterns over time. Potential uses include examining the changing urban metabolism of growing cities, understanding development of renewable energy technologies, identifying transformations in material flows over space and time, and forecasting industrial networks for developing products. A switchgrass-to-energy case demonstrates the approach.

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2013 年，第 17 卷第 3 期，第 363–374 页

采用替代资源炼铁的生命周期评价模型

作者：Carl O. Vadenbo, Michael E. Boesch, Stefanie Hellweg

关键字：高炉，产业生态学，生命周期评价（LCA），物质流动模型，可持续资源使用，废物管理

摘要：钢铁工业以废物为原料，同时生成有用的副产品，因此成为产业生态学的重要研究案例。为了支持涉及资源利用与废物管理的环境决策，我们开发了一个生命周期评价(LCA)工具。该工具结合了基于物质流动的过程模型与 LCA 数据库，考虑了多种过程配置，可评价炼铁过程的替代资源。本文对此工具作了描述，并通过一案例说明了其两个应用方向。案例的第一部分采用清单分析研究了回收废塑料作为炼铁的原料，以及这一过程对重金属排放的影响。研究展示了如何将原材料的重金属浓度与物质转移等不确定性引入模型，用以预测过程输出端的重金属含量。案例的第二部分评估了采用其它还原剂替代焦炭炼铁的气候变化与化石资源消耗的影响。在设定的焦炭替代率下，用可再生的木炭及来自废弃物的还原剂炼铁，有益于减少上述两方面的环境影响；但重油、焦炉煤气与粗焦油等副产品的变化可能引起其它种类影响的变化。废物资源化可避免废物处理的环境影响，此一效应亦不容忽视。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 363–374

Life Cycle Assessment Model for the Use of Alternative Resources in Ironmaking

Carl O. Vadenbo, Michael E. Boesch, and Stefanie Hellweg

Keywords:
blast furnace, industrial ecology, life cycle assessment (LCA), mass flow model, sustainable resource use, waste management

Summary:
The iron and steel industry represents an important case for industrial ecology due to its ability to accept waste-derived inputs and due to the generation of useful by-products. With the objective of supporting environmentally conscious decisions regarding resource use and waste management, a life cycle assessment (LCA) tool was developed. The tool combines mass flow-based process models with an LCA database to assess the use of alternative resources in ironmaking, considering various process configurations. The article contains a description of the tool and a case study illustrating two areas of application. In the first part of the case study, an inventory analysis focused on the effects of feedstock recycling of waste plastics in ironmaking on heavy metal distribution is presented. It is demonstrated how uncertainties in input heavy metal concentrations and mass transfer can be incorporated into the model to predict the heavy metal loads in the process outputs. In the second part, the substitution of coke with a range of alternative reducing agents are assessed with regard to climate change and fossil resource depletion. It was found that the use of sustainably sourced charcoal and waste-derived reducing agents is beneficial both with respect to the impact on climate change and fossil resource depletion at the respective calculated coke replacement ratio, whereas the results for heavy oil, coke oven gas, and raw tar indicate that trade-offs between impact categories occur. The results also highlight the importance of considering the avoided impacts of alternative treatments for waste-derived resources.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 375–384 页

经济均衡与生命周期评价模型相结合的基于政策的预测型生命周期评价

作者： J. Mason Earles, Anthony Halog, Peter Ince, Kenneth Skog

关键字： 生物燃料，预测型生命周期评价（CLCA），林业经济学，产业生态学，局部均衡模型

摘要： 产品系统发生改变且变化超出描述型生命周期评价（ALCA）所研究的实物型联系之外，其环境影响需要通过预测型生命周期评价（CLCA）加以分析。近来基于政策的 CLCA 分析开始采用更为复杂的经济模型，本研究即建立在有关工作的基础之上。研究结合一称为美国林业产品模块（USFPM）的局部市场均衡（PME）模型与 LCA 方法，分析了美国因生产乙醇导致木材用量增加 4 亿立方米时的能源需求情景。采用 USFPM-LCA 模型，本文厘清了若干间接的经济与环境影响。关键发现包括：如生产生物燃料所用的木材量大增，木制品厂采用天然气替代废木料供热供电，省下的废木料也用于生产生物燃料，那么使用天然气所导致的温室气体排放会抵消生物燃料替代汽油的减排量。尽管生物燃料需求大增，但相关林业产品部门的环境影响却不大。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 375–384

Integrated Economic Equilibrium and Life Cycle Assessment Modeling for Policy-based Consequential LCA

J. Mason Earles, Anthony Halog, Peter Ince, and Kenneth Skog

Keywords:
Biofuel, consequential life cycle assessment (CLCA), forest economics, industrial ecology, partial equilibrium modeling

Summary:
Consequential life cycle assessment (CLCA) has emerged as a tool for estimating environmental impacts of changes in product systems that go beyond physical relationships accounted for in attributional LCA (ALCA). This study builds on recent efforts to use more complex economic models for policy-based CLCA. A partial market equilibrium (PME) model, called the U.S. Forest Products Module (USFPM), is combined with LCA to analyze an energy demand scenario in which wood use increases 400 million cubic meters in the United States for ethanol production. Several types of indirect economic and environmental impacts are identified and estimated using USFPM-LCA. A key finding is that if wood use for biofuels increases to high levels and mill residue is used for biofuels and replaced by natural gas for heat and power in forest products mills, then the increased greenhouse gas emissions from natural gas could offset reductions obtained by substituting biofuels for gasoline. Such high levels of biofuel demand, however, appear to have relatively low environmental impacts across related forest product sectors.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 385–395 页

解释生命周期评价结果时归一化基准之重要性

作者：Junbeum Kim, Yi Yang, Junghan Bae, Sangwon Suh

关键字：玉米乙醇，环境影响，影响类型，产业生态学，生命周期评价（LCA），可持续性

摘要：生命周期评价（LCA）通过归一化这一步骤更好地理解各影响类别的相对重要性。进行归一化时，多以某一国家或区域经济等参考系统的特征化结果作为归一化的基准。归一化广泛用于基于 LCA 的决策支持与政策分析，实例包括城市固体废物的处理技术、可再生能源技术以及环境友好采购项目等。制定归一化基准需要长时间的工作以及对数据可得性和数据质量的深入理解。因此美国仅发布了一组归一化基准，目前已用于多项研究。本文评价了已有归一化基准的完备性，指出了其主要的数据缺口。毒物排放清单（TRI）显著低估了毒物排放对若干行业的潜在影响，这是产生数据缺口的一大原因。另外已有的归一化标准并未考虑土壤排放、氮磷元素的水体流失以及化学物质进入土壤的情况。如果将上述因素纳入归一化基准，则致癌性人体健康影响、非致癌性人体健康影响、生态毒性以及富营养化等环境影响类别的重要性将大为增加。这可能会改变甚至完全逆转生命周期评价的结果。我们采用旧有的及更新后的归一化标准对传统汽油和玉米乙醇作了生命周期评价。结果显示若生命周期评价研究包含归一化步骤，归一化基准对研究结果有决定性的影响。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 385–395

The Importance of Normalization References in Interpreting Life Cycle Assessment Results

Junbeum Kim, Yi Yang, Junghan Bae, and Sangwon Suh

Keywords:
Corn ethanol, environmental impact, impact category, industrial ecology, life cycle assessment (LCA), sustainability

Summary:
A normalization step is widely exercised in life cycle assessment (LCA) studies in order to better understand the relative significance of impact category results. In the normalization stage, normalization references (NRs) are the characterized results of a reference system, typically a national or regional economy. Normalization is widely practiced in LCA-based decision support and policy analysis (e.g., LCA cases in municipal solid waste treatment technologies, renewable energy technologies, and environmentally preferable purchasing programs, etc.). The compilation of NRs demands significant effort and time as well as an intimate knowledge of data availability and quality. Consequently only one set of published NRs is available for the United States, and has been adopted by various studies. In this study, the completeness of the previous NRs was evaluated and significant data gaps were identified. One of the reasons for the significant data gaps was that the toxic release inventory (TRI) data significantly underestimate the potential impact of toxic releases for some sectors. Also the previous NRs did not consider the soil emissions and nitrogen (N) and phosphorus (P) runoffs to water and chemical emissions to soils. Filling in these data gaps increased the magnitude of NRs for “human health cancer,” “human health noncancer,” “ecotoxicity,” and “eutrophication” significantly. Such significant changes can alter or even reverse the outcome of an LCA study. We applied the previous and updated NRs to conventional gasoline and corn ethanol LCAs. The results demonstrate that NRs play a decisive role in the interpretation of LCA results that use a normalization step.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 396–406 页

建筑垃圾终端管理方案之生命周期评价

作者：Alberta Carpenter, Jenna R. Jambeck, Kevin Gardner, and Keith Weitz

关键字：能量补偿，产业生态学，生命周期评价，城市生活垃圾，决策支持工具，新罕布什尔州，从废物到能量

摘要：本文利用美国国家环保局的城市生活垃圾决策支持工具，对建筑垃圾的不同终端管理方案做了生命周期评价。研究以美国新罕布什尔州建筑垃圾的年产生量为功能单位，对比分析了七种管理情景的生命周期影响。每种情景都包括建筑垃圾的运输、处理、分离与循环利用过程，此外还对比了以下终端处理方案：包括对木质垃圾作燃烧发电亦或填埋处理，以及对非木质垃圾作循环利用亦或填埋处理等。我们还讨论了燃烧发电的能量补偿基准以燃煤电厂为准，以及取美国东北电网的均值等不同情景。通过改变木质建筑垃圾中的热值，并以不同化石能源作为发电的能量补偿基准，我们开展了灵敏度分析。研究结果涉及温室气体排放、指标性空气污染物、固体废弃物以及水体中的有机与无机排放物等多种环境影响类型。对非木质建筑垃圾进行循环利用，同时利用木质垃圾燃烧发电，这一组情景的环境影响较小。回收利用非木质垃圾、填埋木质垃圾比两类垃圾全填埋的环境影响要小。环境影响最小的情景则是循环利用非木质垃圾，而木质垃圾则就地作燃烧发电之用，如此每年可产生超过 7 万亿 BTU（英热单位）的净能量，并减少 13 万吨的温室气体排放。灵敏度分析发现能耗结果对木质垃圾中的热值很敏感，但对能量补偿的基准不敏感；温室气体排放结果则相反，对热值不敏感但对能量补偿基准敏感。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 396–406

Life Cycle Assessment of End-of-Life Management Options for Construction and Demolition Debris

Alberta Carpenter, Jenna R. Jambeck, Kevin Gardner, and Keith Weitz

Keywords:
energy offsets, industrial ecology, life cycle assessment (LCA), municipal solid waste, decision support tool, New Hampshire, waste to energy

Summary:
A life cycle assessment (LCA) of various end-of-life management options for construction and demolition (C&D) debris was conducted using the U.S. Environmental Protection Agency's Municipal Solid Waste Decision Support Tool. A comparative LCA evaluated seven different management scenarios using the annual production of C&D debris in New Hampshire as the functional unit. Each scenario encompassed C&D debris transport, processing, separation, and recycling, as well as varying end-of-life management options for the C&D debris (e.g., combustion to generate electricity versus landfilling for the wood debris stream and recycling versus landfilling for the nonwood debris stream) and different bases for the electricity generation offsets (e.g., the northeastern U.S. power grid versus coal-fired power generation). A sensitivity analysis was also conducted by varying the energy content of the C&D wood debris and by examining the impact of basing the energy offsets on electricity generated from various fossil fuels. The results include impacts for greenhouse gas (GHG) emissions, criteria air pollutants, ancillary solid waste production, and organic and inorganic constituents in water emissions. Scenarios with nonwood C&D debris recycling coupled with combustion of C&D wood debris to generate electricity had lower impacts than other scenarios. The nonwood C&D debris recycling scenarios where C&D wood debris was landfilled resulted in less overall impact than the scenarios where all C&D debris was landfilled. The lowest impact scenario included nonwood C&D debris recycling with local combustion of the C&D wood debris to generate electricity, providing a net gain in energy production of more than 7 trillion British thermal units (BTU) per year and a 130,000 tons per year reduction in GHG emissions. The sensitivity analysis revealed that for energy consumption, the model is sensitive to the energy content of the C&D wood debris but insensitive to the basis for the energy offset, and the opposite is true for GHG emissions.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 407–417 页

B2C 图书零售业两类送货系统环境影响之比较研究

作者：Liyi Zhang, Yi Zhang

关键字：二氧化碳排放，分配，能耗，环境影响评价，产业生态学，可持续网络式运送（SND）

摘要：中国已经成为世界上二氧化碳（CO_2）排放量最高的国家。其物流系统的总能耗与二氧化碳排放在 B2C（企业对消费者）零售业中所占的比例很大。本研究着重分析了中国图书零售业 B2C 送货阶段的环境影响。根据现实的“电子商务网络式运送”（END）系统与“可持续网络式运送”（SND）系统，我们建立数学模型计算了两种系统送递每本书的能耗与二氧化碳排放；另外，我们还比较了其它国家类似的研究结果，并解释了本研究结果与之存在差异的原因。结果显示:（1）总体而言中国 SND 系统的环境表现比 END 系统更好；（2）中国 END 系统相较美国与英国相同系统的环境影响要小，但中国 SND 系统比美国 SND 系统的环境影响大；（3）广泛使用电动自行车等低能耗运输车辆是中国得以降低 SND 与 END 系统单位环境影响的主要原因。我们还讨论了本研究的局限之处及未来的研究方向。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 407–417

A Comparative Study of Environmental Impacts of Two Delivery Systems in the Business-to-Customer Book Retail Sector

Liyi Zhang and Yi Zhang

Keywords:
CO_2 emissions; distribution; energy consumption; environmental impact assessment; industrial ecology; sustainable networked delivery (SND)

Summary:
China has the highest carbon dioxide (CO_2) emissions in the world. In China, logistics accounts for a significant portion of the total energy use and CO_2 emissions in business-to-customer (B2C) retailing. This study focuses on the environmental impacts of B2C delivery in China, focusing on the book retail industry. Mathematical models are proposed based on the practical operations of the “e-commerce networked delivery” (END) system and the “sustainable networked delivery” (SND) system. The energy consumption and CO_2 emissions per book are then determined and compared for the two systems. Furthermore, we contrast the findings with those of similar studies conducted for other countries and provide explanations for the differences. The results show that (1) in general, in China, the SND system is better than the END system in terms of environmental impacts; (2) the END system in China generates fewer environmental impacts than those in the United States and the United Kingdom, while the SND system in China has greater environmental impacts than that in the United States; and (3) the wide use of vehicles such as electric bicycles that have low energy consumption rates contributes to the reduction of environmental impacts per book in both the END and SND systems in China. The limitations of the study and suggestions for future research are also discussed.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 418–431 页

内置的透明性：增材制造之能耗与成本评估

作者： Martin Baumers, Chris Tuck, Ricky Wildman, Ian Ashcroft, Emma Rosamond, Richard Hague

关键字： 数字化供应链，能耗，产业生态学，制造过程，快速制造，快速原型开发

摘要： 现代制造的供应链往往长且复杂，由此导致的不透明性妨碍了能耗的测算与节约，并进而影响了可持续制造的开展。本文研究了采用增材制造可否提高制造过程的能耗与经济成本的透明性。

增材制造是采用电力驱动组合材料的技术，它通过单步的数控过程生产复杂几何形状的产品，无需模具等工具。其单步制造的特性有助于全面评测过程的能源消耗与生产成本。但增材制造具有并行性，可同时生产多个零件，这为估算制造过程的资源消耗提出了新的挑战。

本研究探讨了直接金属激光烧结（一类增材制造）技术的能量流与成本的一种估算方法。结果显示，该方法可准确估算多种零件样品的生产。不同于传统过程，所产零件的数量与种类以及与此相关的机器产能的利用率等因素也会影响过程效率。此外，增材制造的成本最小化与过程能耗最小化正相关，这有助于改进制造过程的可持续性。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 418–431

Transparency Built-in: Energy Consumption and Cost Estimation for Additive Manufacturing

Martin Baumers, Chris Tuck, Ricky Wildman, Ian Ashcroft, Emma Rosamond, and Richard Hague

Keywords:
Digital supply chain, energy consumption, industrial ecology, manufacturing process, rapid manufacturing, rapid prototyping

Summary:
The supply chains found in modern manufacturing are often complex and long. The resulting opacity poses a significant barrier to the measurement and minimization of energy consumption and therefore to the implementation of sustainable manufacturing. The current article investigates whether the adoption of additive manufacturing (AM) technology can be used to reach transparency in terms of energy and financial inputs to manufacturing operations.

AM refers to the use of a group of electricity-driven technologies capable of combining materials to manufacture geometrically complex products in a single digitally controlled process step, entirely without molds, dies, or other tooling. The single-step nature affords full measurability with respect to process energy inputs and production costs. However, the parallel character of AM (allowing the contemporaneous production of multiple parts) poses previously unconsidered problems in the estimation of manufacturing resource consumption.

This research discusses the implementation of a tool for the estimation of process energy flows and costs occurring in the AM technology variant direct metal laser sintering. It is demonstrated that accurate predictions can be made for the production of a basket of sample parts. Further, it is shown that, unlike conventional processes, the quantity and variety of parts demanded and the resulting ability to fully utilize the available machine capacity have an impact on process efficiency. It is also demonstrated that cost minimization in additive manufacturing may lead to the minimization of process energy consumption, thereby motivating sustainability improvements.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 432–439 页

探究环境、实物与混合投入产出模型结果差异之原因

作者：Sai Liang，Tianzhu Zhang

关键字：中国，产业生态学，产业代谢，投入产出分析，物料流分析（MFA），社会经济代谢

摘要：找出环境投入产出（EIO）、实物投入产出（PIO）与混合投入产出（HIO）模型结果存在差异的原因，对产业与环境政策分析至关重要。本研究采用 EIO、PIO 与 HIO 模型计算了中国的产业代谢，发现不同模型结果的差异有四大原因：即模型对居民消费、服务行业与废物回收利用的处理方式不同，另外部门的价格假设也各有特异。HIO 模型将居民消费作为中间传递矩阵的一个产业部门，相较 EIO 与 PIO 模型，其更适于分析产业与环境政策。另外在 HIO 模型中，以下五类产业部门的废物回收问题应全面统筹考虑，包括农业，纸制品、印刷、文化、教育和体育用品制造业，非金属矿物制品业，金属冶炼和压延加工业以及建筑业。本文还讨论了 EIO、PIO 及 HIO 模型的改进与未来研究。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 432–439

Investigating Reasons for Differences in the Results of Environmental, Physical, and Hybrid Input-Output Models

Sai Liang and Tianzhu Zhang

Keywords:
China; industrial ecology; industrial metabolism; input-output analysis; material flow analysis (MFA) ; socioeconomic metabolism

Summary:
It is vital to find reasons for differences in the results of environmental input-output (EIO), physical input-output (PIO), and hybrid input-output (HIO) models for industrial and environmental policy analysis. Using EIO, PIO, and HIO models, China's industrial metabolism is calculated. Four reasons were found to account for differences in the results of analysis using EIO, PIO, and HIO models: the manner in which they deal with residential consumption, service sectors, and waste recycling, and the assumption of unique sector prices. The HIO model, which treats residential consumption as sectors of the intermediate delivery matrix, is preferred to the EIO and PIO models for analyzing industrial and environmental policies. Moreover, waste recycling in five sectors—agriculture; the manufacture of paper, printing, and articles for culture, education, and sports activities; the manufacture of nonmetallic mineral products; smelting and pressing of metals; and construction—should be comprehensively considered when using the HIO model to study problems related to these five sectors. Improvements in the EIO, PIO, and HIO models and future work are also discussed.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 440–451 页

如何看待资源生产率：社会经济因素与资源生产率之关系

作者：Yu Gan, Tianzhu Zhang, Sai Liang, Zhongnan Zhao, and Nan Li

关键字：经济结构，经济系统物料流分析，收入水平，产业生态学，国际贸易，人口密度

摘要：提高资源生产率是解决环境污染与资源稀缺问题的核心手段之一。设立并改进资源管理政策则应首先认清影响资源生产率的重要社会经济因素。本研究通过对比分析多国数据建立了一个资源生产率模型，进而深入讨论了各类社会经济因素及其影响特征。研究发现影响资源生产率的主要因素包括收入水平、人口密度、经济结构、能源结构以及原材料贸易。其中收入水平、人口密度与经济结构的影响最为显著。主要结论如下：（1）资源生产率随着收入水平的增加而提高；（2）在人口密度较高的国家，资源生产率往往更高；（3）经济结构对资源生产率的影响具有两阶段性：即在工业化时期，农业活动减少、工业活动增加会提高资源生产率；而工业化完成后，工业活动减少、服务部门扩张则成为改进资源生产率的新的主要驱动；（4）原材料出口对资源生产率具有负面影响，严重依赖原料出口的国家表现出独特的资源生产率演化模式。这些国家在收入较低时资源生产率相对较高，而收入提高后资源生产率相对变低，总体而言经济增长对资源效率的改进效果有限。最后根据本文的研究成果，作者提出了若干促进可持续资源管理与提高资源生产率的政策建议。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 440–451

How to Deal with Resource Productivity: Relationships between Socioeconomic Factors and Resource Productivity

Yu Gan, Tianzhu Zhang, Sai Liang, Zhongnan Zhao, and Nan Li

Keywords:
Economic structure, economy-wide material flow analysis (EW-MFA), income level, industrial ecology, international trade, population density

Summary:
Resource productivity enhancement stands at the center of tackling issues on environmental pollution and resource scarcity. Identifying influential socioeconomic factors should be the first step in establishing and improving resource management policy. This study compares and analyzes data from multiple countries to construct a resource productivity simulation model. The socioeconomic factors and their characteristic patterns are discussed in detail. The results demonstrate that the major factors influencing resource productivity include income level, population density, economic structure, energy structure, and raw material trade. Among these factors, the three most important are income level, population density, and economic structure. The influencing patterns can be summarized as follows: (1) Resource productivity increases with increasing income levels. (2) Countries with high population density are inclined to demonstrate high resource productivity. (3) The economic structure shows a biphase influence on resource productivity, that is, during industrialization, decreased agricultural activity and increased industrial activity lead to higher resource productivity. On the other hand, after industrialization, decreasing industrial activity and an expanding service sector become the major impetus of resource productivity enhancement. (4) Raw material export demonstrates a negative effect on resource productivity. Countries that depend heavily on raw material export show a unique resource productivity evolution pattern. For these countries, relatively high resource productivity in low income phases and relatively low resource productivity in high income phases show only small increases in resource efficiency and economic growth. Finally, insights from the study are transformed into suggestions for sustainable resource management and resource productivity enhancement.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 452–460 页

中国县级社会经济系统中磷流通的定量分析

作者：Jun Bi, Qinqin Chen, Ling Zhang, Zengwei Yuan

关键字：县，环境管理，产业生态学，磷，物质流分析（SFA）

摘要：磷在水体富营养化问题中是一个关键的因素，磷污染也成为全球普遍存在的问题。许多发展中国家，包括中国，都在防控磷污染方面做出了很大的努力。本文主要采用静态物质流分析讨论了无为县的磷流通，该县的污水处理水平低，属于典型的中国县城。本文显示对在县城水平上分析磷代谢途径的特征可以给磷污染防控提供有用的信息。通过复杂的计算，研究表明无为县在 2008 年想当地水环境排放 3552 吨磷素，其磷负荷高达 3.35 千克/人/年，或 19.43 千克/公顷/年，超过临近两个县城和巢湖市平均水平的总和。农业系统对排磷最多（2572 吨），而其生产转化效率（32%）和磷回收率（36%）则相对偏低。农村居民和小型牲畜培育系统也排放了大量磷素。因此磷污染的防控工作应将重点放在上述三个方面。根据研究的结果，本文还讨论了减少磷污染的潜在工作的可行性。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 452–460

Quantifying Phosphorus Flow Pathways through Socioeconomic Systems at the County Level in China

Jun Bi, Qinqin Chen, Ling Zhang, and Zengwei Yuan

Keywords:
County, environmental management, industrial ecology, industrial metabolism, Phosphorus, substance flow analysis (SFA)

Summary:
Phosphorus (P) is a key factor in aquatic eutrophication, and P contamination has become a common issue worldwide. Many developing countries, including China, have made great efforts in the anti-P contamination battle. In this article we mainly discuss the P flow in Wuwei, a typical county in China with insufficient wastewater treatment, using the method of static substance flow analysis. We show that characterizing P metabolic pathways and flows at the county level can provide useful information about P pollution. Through complex calculations, we found that Wuwei County released 3,552 metric tons (t) of P into the local aquatic environment in 2008 and that its P load (3.35 kilograms P per capita per year [kg P/cap/yr] or 19.43 kilograms P per hectare per year [kg-P/ha/yr]) was greater than both the adjoining counties' and Chaohu City's average levels combined. The agricultural subsystem discharged the largest quantity of P (2,572 t) and had a relatively low production conversion efficiency (32%) and P waste recycling rate (36%). The rural residential and small-scale livestock breeding systems also accounted for substantial portions of P discharge. Anti-P contamination efforts should consequently focus on those three subsystems. Based on the results of this case study, we also discuss the feasibility of potential efforts to reduce P contamination.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 461–471 页

1991 至 2008 年间美国三制造业部门有毒化学物管理之分解分析

作者：Hidemichi Fujii, Shunsuke Managi

关键字：清洁生产，分解分析，过程末端，产业生态学，对数平均迪氏指数，有毒物质

摘要：本研究分析了 1991 至 2008 年间美国三个制造业部门的有毒化学物管理。我们采用基于对数平均迪氏指数的分解分析法，研究了影响有毒化学物质排放变化的五项因素，包括清洁生产、末端治理、转移并深度治理、中间物料混合以及生产规模。结果显示化学品制造业主要通过末端治理减少有毒化学物的排放。金属加工业的减排则主要采取转移及深度治理的方式，因为 20 世纪 90 年代中美国的环保产业大为扩张，回收金属和其它废弃物的基础设施也更为高效。电子产品制造业中清洁生产对有毒化学物质减排的贡献最大，说明该产业部门在环保型产品设计与生产流程开发方面取得了成功。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 461–471

Decomposition of Toxic Chemical Substance Management in Three U.S. Manufacturing Sectors from 1991 to 2008

Hidemichi Fujii and Shunsuke Managi

Keywords:
cleaner production, decomposition analysis, end-of-pipe, industrial ecology, logarithmic mean Divisia index, toxic substances

Summary:
This study analyzes toxic chemical substance management in three U.S. manufacturing sectors from 1991 to 2008. Decomposition analysis applying the logarithmic mean Divisia index is used to analyze changes in toxic chemical substance emissions by the following five factors: cleaner production, end-of-pipe treatment, transfer for further management, mixing of intermediate materials, and production scale. Based on our results, the chemical manufacturing sector reduced toxic chemical substance emissions mainly via end-of-pipe treatment. In the meantime, transfer for further management contributed to the reduction of toxic chemical substance emissions in the metal fabrication industry. This occurred because the environmental business market expanded in the 1990s, and the infrastructure for the recycling of metal and other wastes became more efficient. Cleaner production is the main contributor to toxic chemical reduction in the electrical product industry. This implies that the electrical product industry is successful in developing a more environmentally friendly product design and production process.

《产业生态学报》

2013 年，第 17 卷第 3 期，第 472–481 页

印度家庭用水之存量与流量分析

作者：G. Venkatesh

关键字：电，能耗，环境影响，产业生态学，物料流分析（MFA），肥皂

摘要：城市水系统代谢研究之焦点多放在水处理与供应以及废水收集、处理与排放等城市水设施。为家庭提供净化水需要大量的物料与能量，这一水需求的子系统同样不容忽视。本文研究了印度家庭用水所需的关键物料与能量流，以及相关的环境影响。洗衣机与热水装置的电耗对几乎所有 13 项环境影响类别的贡献都最大，这与印度化石燃料发电所占的比例（60%）较高有关。肥皂的使用对陆地生态毒性及空气恶臭的贡献最大。对印度全国，所有各类环境影响都值得关注。未来若干年，电力、肥皂与清洁剂的绝对消费量以及家电的需求量都将持续增长。

Journal of Industrial Ecology

2013, Vol. 17, Issue 3, pp. 472–481

An Analysis of Stocks and Flows Associated with Water Consumption in Indian Households

G. Venkatesh

Keywords:
Electricity, energy use, environmental impact, industrial ecology, material flow analysis (MFA), soaps

Summary:

The focus of urban water system metabolism studies has, by and large, been restricted to what comes under the domain of the urban water utilities: water treatment and supply, and wastewater collection, treatment, and disposal. The material and energy flows both necessitated and facilitated by the supply of treated water to households—the water demand subsystem—are by no means negligible. This article studies the key flows into households associated with water consumption and the environmental impacts related to the same for India as a whole. Electricity consumption in washing machines and water heaters contributes the most to almost all the 13 environmental impact categories considered. This is easily explained by the fossil fuel heaviness of the Indian mix (>60%). Soaps contribute the most to terrestrial eco-toxicity and malodorous air. In India, on a national scale, all the environmental impact categories deserve attention. The absolute consumption of electricity, soaps, and detergents, and the demand for home appliances will increase in the years to come.