

國立臺北大學自然資源與環境管理研究所

112 學年度第二學期『清潔生產與工業生態學』

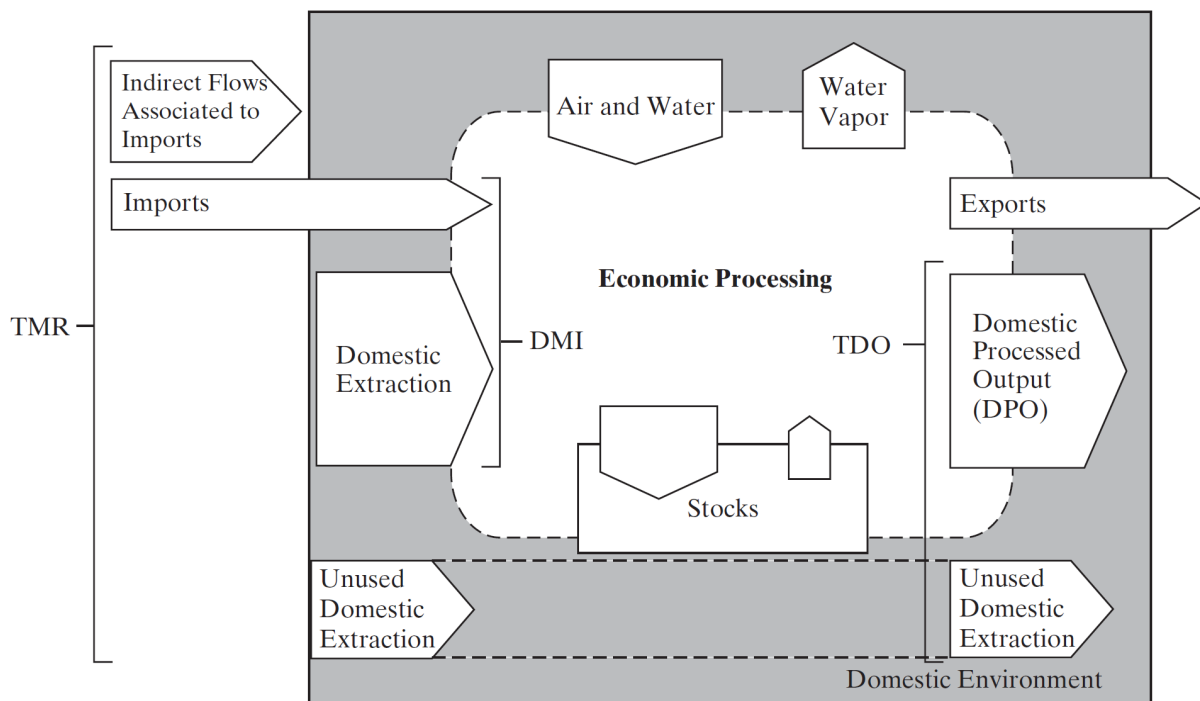
課程進度(07)：物質流分析、物質流成本會計與生態效率
Material Flow Analysis, Material Flow Cost Accounting and Eco-Efficiency

● MATERIAL FLOW ANALYSIS

- Budgets and Cycles: Conservation of Mass (G&A, Chp.17, pp.240-244)
 - ⇒ Level, Sources, and Sinks => Final sinks of resources or materials
 - ⇒ Residence time and Age
 - ⇒ Connecting waste management with production and fabrication...
- Resource Analyses in Industrial Ecology
 - ⇒ Elemental Substance Analysis and Molecular Analysis (G&A, Chp.17, pp.244-249)
- The Balance between Natural and Anthropogenic Mobilization of Resources

● NATIONAL MATERIAL ACCOUNTS

- National-Level Accounting: National Material Accounts (G&A, Chp.18, pp.254-255)
- Country-Level Metabolism (G&A, Chp.18, pp.255-260)
 - ⇒ Total Material Requirement (TMR):
Domestic Material Input (DMI) and Domestic Material Consumption (DMC)
 - ⇒ Domestic Processed Output (DPO)
- Embodiments in Trade (G&A, Chp.18, pp.260-261)
 - ⇒ Embodied GHG Emission, Carbon Leakage, and Carbon Border Adjustment Mechanism
- Resource Productivity (G&A, Chp.18, pp.261-262)
- Input-Output Tables (G&A, Chp.18, pp.262-266)
- Eurostat [Economy-wide Material Flow Accounts Handbook](#)



● TYPES OF MATERIAL FLOW ANALYSIS (Ayres, Chp.8 -- Bringezu and Moriguchi)

- Industrial / Societal Metabolism
 - ⇒ Material flow analysis (MFA) refers to the analysis of the throughput of process chains comprising extraction or harvest, chemical transformation, manufacturing, consumption, recycling and disposal of materials.
- Specific environmental problems related to certain impacts per unit flow of:
 - ⇒ Ia. Substances: Substance Flow Analysis
 - ⇒ Ib. Materials: Bulk Material Analysis
 - ⇒ Ic. Products: Life Cycle Assessment
- Problems of environmental concern related to the throughput of:
 - ⇒ Iia. Firms: Material Flow Costing Accounting / Eco-Efficiency
 - ⇒ Iib. Sectors: Physical Input-Output Analysis / Critical Flux
 - ⇒ Iic. Regions: Economy-wide Material Flow Analysis / Final Sinks
- The term ‘MFA’ has usually referred to analyses of types Ia, Ib, Iib and Iic. Studies of type Ic are generally considered to fall under the heading of LCA. Accounting of type Iia is mainly related to environmental management.

Table 8.1 Types of material flow-related analysis

Type of analysis	I		
	a	b	c
Objects of primary interest	Specific environmental problems related to certain impacts per unit flow of:		
	substances e.g. Cd, Cl, Pb, Zn, Hg, N, P, C, CO ₂ , CFC	materials e.g. wooden products, energy carriers, excavation, biomass, plastics	products e.g. diapers, batteries, cars
	within certain firms, sectors, regions		
	II		
	a	b	c
	Problems of environmental concern related to the throughput of:		
	firms e.g. single plants, medium and large companies	sectors e.g. production sectors, chemical industry, construction	regions e.g. total or main throughput, mass flow balance, total material requirement
	associated with substances, materials, products		

● MATERIAL FLOW COST ACCOUNTING

- Environmental Management Accounting
 - ⇒ Environmental Management; Management Accounting
 - ⇒ Traditional cost accounting vs. Material Flow Cost Accounting
- MFCA has been developed in Germany in the late 1990s. After 2000, MFCA was tremendously supported by the Japanese Ministry of Trade and Industry (METI).
- MFCA is ISO-standardized to 14051:2011 (General framework), 14052:2017 (Guidance for practical implementation in a supply chain) and 14053:2021 (Guidance for phased implementation in organizations).
- [製造業產品環境足跡與資源永續資訊專區-MFCA 簡介](#)

物質流分析主要評估資源或物質由開採到棄置等各生命週期階段的工業代謝過程。依據本計畫彙整相關文獻 (Steurer, 1996; Tjahjadi et al., 1999; Palm, 2002; Bringezu, 2004)，物質流分析依其探討對象可分為三類：經濟體的總物質需求分析 (TMR)；大宗物質流分析 (Bulk-MFA)，例如石油、塑膠、木材等大宗物質之流動分析；以及針對特定元素進行之工業代謝分析 (Substance Flow Analysis, SFA)，例如重金屬、氮化合物等元素或化合物之流動分析。經濟體總物質需求分析 (TMR) 主要用以評估資源生產力與去物質化政策發展方向；塊材物質流分析 (Bulk-MFA) 則可用以分析塊材物質之工業代謝循環概況，進而探討資源善用程度，亦或研擬合適之回收政策；特定物質工業代謝分析 (SFA) 則可用以探討若干毒性較強或環境累積性較高之元素或物質，其於環境中代謝消長之循環關係。依據 Steuer (1996) 及 Tjahjadi et al. (1999) 之研究建議，物質流分析所關切之對象、決策管理議題類別與其對應之尺度範圍如圖 1 所示。此外，Bringezu and Moriguchi (2002) 則嘗試從工業生態角度出發，探討各類物質於工業系統中之代謝循環機制，該研究並提具物質工業代謝分析之對象可為：特定物質 (substance)、塊材物質 (material) 及產品 (product) 等三類，涵蓋之尺度則可為廠商 (firm)、產業部門 (sector) 或經濟體 (economy) 等三項。

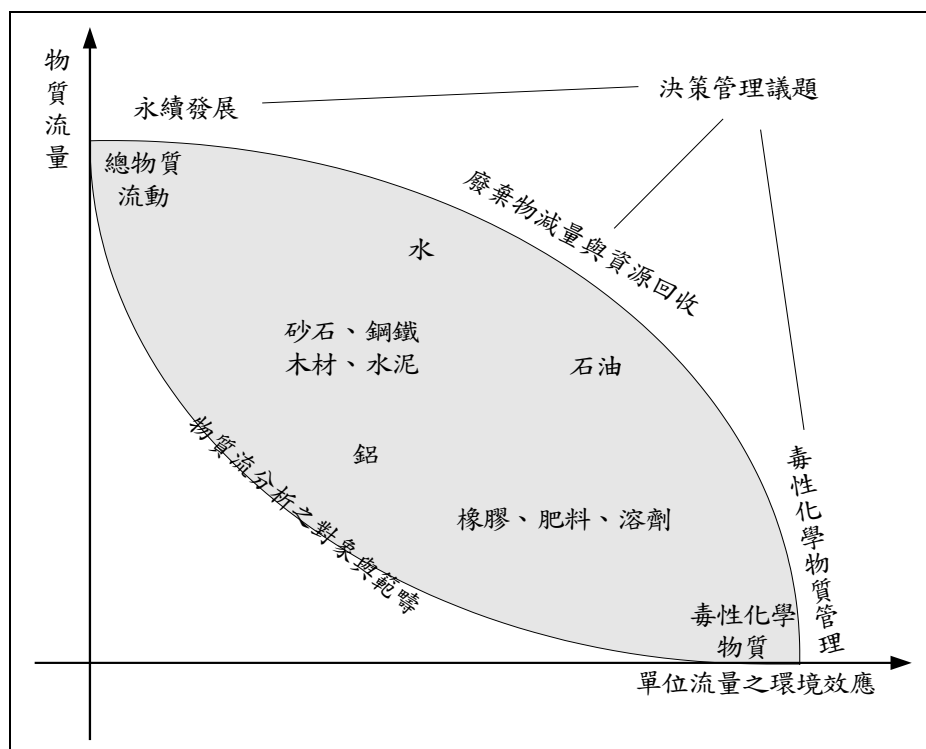


圖 1 物質流分析之尺度與管理議題 (修改自 Steurer, 1996; Tjahjadi et al., 1999)

一般而言，物質流分析有四個步驟：(1) 目標與範疇界定、(2) 投入與產出量之盤查、(3) 物質平衡計算、(4) 建立模型與預測評估 (Bringezu, 2004)。第一步驟先行選定欲分析的特定物質，並確認分析目標及系統因子項目，以界定分析範疇；另外，時間和空間的不同也會影響物質流分析的分類項目與作用範圍。第二步驟則是進行細部的物質流動分析，包括投入和產出的過程及其流動數量的說明和調查。第三步驟須和第二步驟配合進行，其基本原則是將系統中的投入與產出質量維持平衡，同時檢查遺漏的數據資料，以協助建構數學模型與進行電腦模擬。最後一個步驟是將所得之分析數據建立動態模型，並以最終的結果評估建模的假設與目的之合適性。