3R Policy Indicators
Factsheets Series

Reference and background reading material

Antonio, L.C., Kojima, M., Phechpakdee, P. 2009, *Synthesis on Industrial Waste Information Exchange Program (Chapter 11)*. 3R Policies for Southeast and East Asia. Kojima, M., Damanhuri, E. (eds). ERIA Research Project Report 2008 No.6-1

Aquatech Environment, Economics, and Information, 1997, *A Benchmark of Current Cleaner Production Practices*. Prepared for Cleaner Industries Section, Environment Protection Group Environment Australia

Aschner, A. 2004, *Planning for Sustainability through Cleaner Production*. PhD Thesis-The University of New South Wales School of Mechanical and Manufacturing Engineering.

Ashton, W., Luque, A., Ehrenfeld, J.R., 2002, *Best Practices in Cleaner Production Promotion and Implementation for Smaller Enterprises*. Prepared for Multilateral Investment Fund (MIF), Interamerican Development Bank (IADB), Washington D.C: USA

Department of Environmental Affairs and Tourism South Africa, and DANIDA, 2005, National Waste Management *Strategy Implementation South Africa-Review of Industrial Waste Exchange*. Report Number: 12/9/6 Annexure G.

Institute for Global Environmental Strategies (IGES), 2007, *Eco-Industrial Clusters in Urban-Rural Fringe Areas- A Strategic Approach for Integrated Environmental and Economic Planning*. IGES- Kansai Research Centre, Japan.

Kane, G. Industrial Symbiosis. CLEMANCE (01642) 342504

Kotelnikov, V. *Measuring Cleaner Production (CP)* - Harnessing Business Benefits. Ten³ BUSINESS e-COACH – Innovation Unlimited. Available at: http://www.1000ventures.com/environment/cp_measuring.html

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Ministry of the Environment

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Measuring Waste Reduction, Reuse and Recycling through Industrial Symbiosis

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01 Outline of indicator

Most industrial operations are linear processes in which raw materials are processed into products, with waste as a by-product. However, waste is also generated at the time of raw material extraction, during processing, and ultimately at the end-of-life stage of a product. To minimise, reutilise or recycle waste at each stage, industrial operations can be reconfigured though ***industrial symbiosis (IS)***, in which waste produced from one industry is reutilised by another as a raw material. Industrial symbiosis supports resource efficiency in two ways: Cleaner Production (application of techniques and technologies, and management strategies that reduce the waste generated from industrial operations) and Waste Exchange Programmes (exchange of one waste with another resource or raw material). Thus, the benefits of industrial symbiosis are twofold; economic, by lowering the cost of operations and waste disposal, and environmental, via pollution (waste) abatement. There are many concepts involved in IS; however, basic indicators of a successful IS are: 1) reduction in the waste generated from industrial operations, 2) Ratio of recycled materials used in raw material through waste exchanges, 3) Reduction in the amount of industrial waste landfilled, and 4) Reduction in the cost of waste treatment and disposal borne by industry.

02 Policy goals to be monitored by this indicator

Industrial symbiotic activities lead to upstream resource efficiency by reconfiguring the linear flow of materials and resources into a cyclical pattern by recovering and recycling waste into the production chain. The major policy goals to be measured by this indicator are to achieve waste minimisation, reduce virgin material use by using recyclable materials as raw materials, and divert

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waste from landfills into the production chain. Other policy goals are collaboration of industries into an eco-industrial cluster, green manufacturing and green purchasing, and even linkage with the Environment Management System (EMS) (e.g., ISO 14001).

03 Definition and Scope

Industrial symbiosis (IS)

Industrial symbiosis is basically "engaging several traditionally separate firms and industries in a collective approach to competitive advantage involving physical exchange of ***materials***, energy, water, and by-products" (Chertow, 2000)*[1]. Industrial symbiosis is a subset of industrial ecology with a particular focus on material and energy exchange. It offers upstream resource efficiency by lowering material in-flow in the production system by careful design of production processes and products (*Cleaner Production*), as well as reutilising waste as resources and raw materials in secondary industries (Waste/by-product Exchange).

Industrial symbiosis and cleaner production (CP) indicators

Cleaner production is a preventive measure to achieve upstream resource efficiency by reducing the use of energy, water and material resources, and minimise waste in the production process. It involves rethinking the entire life cycle of products, including resource extraction, selection of raw materials, product design, production and assembly of the final product, consumer use, and managing all end-of-life products.

Resource efficiency by using CP can be measured by quantifying any changes in cleaner production as measured by resource use, waste generation, etc. The basic CP indicators are*[2]:

- Gross turnover of the (industrial) waste management industry: This could reflect both the adoption of cleaner production practices, due to awareness of cleaner production and thus more involvement (industrial) of the waste management industry, or the opposite; greater adoption of cleaner production practices, resulting in less pollution, and lowered need for services of the (industrial) waste management industry.
- Expenditure on waste disposal: Since lowered waste disposal costs mean lowered waste generation, it can be indicative of CP practices. However, expenditure on waste disposal may decrease due to a range of other factors, such as lower industrial output, inappropriate or illegal disposal, or the use of more cost-effective waste disposal technologies.

CP indicator measurement is basically an ***input-output ratio***. On the input side, indicators of cleaner production could include:

- Measurement of energy used per unit of output produced
- Measurement of water used per unit of output produced
- Measurement of environmentally harmful inputs per unit of output produced

On the output side, indicators at the aggregate level of cleaner production could include measurement of:

- Discharges to atmosphere (tonnes per unit of output)
- Discharges to water (megalitres or kilograms of biochemical oxygen demand (BOD) or kilograms of chemical oxygen demand (COD) or kilograms of suspended solids (SS) per unit of output)
- Discharges to land (tonnes of solid waste per unit of output)
- Transfers of waste to storage (tonnes of waste per unit of output)

04 Policy instruments useful for improving recycling through industrial symbiosis

There are many interrelated and connected policy instruments that can assist recycling through industrial symbiosis:

- National Industrial Policy: Policies favouring eco-industrial clusters, cleaner production, design for environment and waste exchange programmes
- Volume-based landfill tax for industrial waste landfills
- Product stewardship and Extended Producer Responsibility (EPR)
- Green purchasing of goods manufactured with recycled products/waste reuse
- Financial support for industrial waste recycling

05 Challenges and concerns

Indicators measuring cleaner production are complex and involve the entire life cycle of products. The industrial waste exchange indictor is simpler, as the amount or weight of exchanged can be quantified for both the industry selling or giving away the waste and the industry buying or taking-in such waste. However, identifying actual fractions of waste used in products is complex. Not all the waste exchanged can be used in a production system, thus some loss may occur in the post-treatment of waste before re-use as a raw material. A waste exchange database is an integral part of IWE, as it provides a central location for individuals and organisations to either check on, or add to, waste materials in the list, then make contact with the relevant parties concerned. Such database needs to be coherent, consistent and continually updated.

06 Best practices

Industrial Waste Information Exchange Programme (IWIEP) in Asia

Among Asian regions, Japan, the Philippines and Thailand have conducted IWIEPs. IWIEP links suppliers and users of industrial waste to enhance utilisation of waste. A third party collects information on the kinds of wastes generated by waste generators and which wastes can be utilised by users. This information is then provided to waste generators and users to facilitate matching between them.

Material Exchange Centre - Thailand

Thailand's Environment Institute initiated a web-based information exchange project in 2005. In this system, companies match their waste disposal and raw material needs through a computerised database, and subsequently exchange waste. For waste suppliers, these types of transactions avoid disposal costs, while for users raw materials can be purchased at lower prices than new materials, which reduces the energy needed during manufacturing processes.

Thailand Centre for Transfer of Clean Technology

The Technology Promotion Department of Thailand's Ministry of Science, Technology and Environment (MOSTE), founded in 1992, is responsible for developing and transferring technologies as well as enhancing and strengthening capabilities to acquire and transfer technologies from both foreign and domestic sources to Small and Medium Enterprises (SMEs), and rural people. Its main technology focus has been rural and agriculture based enterprises. This Department is to be transformed into the **Centre for Transfer of Clean Technology (CTCT)** and will become Thailand's national data and web networking centre for clean technologies and Cleaner Production (CP).

Measuring the CP requires complex indicators using the entire Life Cycle Assessment (LCA) and Total Cost Assessment (TCA) methods. CP indicators measure both the process performance and environmental performance.

Process performance indictors:

- Actual % reduction in material use per annum
- Target % reduction for year XXXX
- Actual reduction in material expenditure per annum
- Target reduction for year XXXX

Environmental performance indicators:

- Tonnes of raw material used per tonne of production
- Tonnes of waste produced per tonne of production
- Chemical composition of waste
- Amount of waste; discharge of waste to land/atmosphere
- Quantity of recycled material within the production process (in-site)
- Quantity of off-site waste recycling
- Cost of waste disposal pre- and post-CP
- Investments in performance improvements (techniques, strategies and technologies)
- Occupation health issues within production units

These CP indicators not only estimate the CP of a product or process, but also enable comparisons with other equivalents, improvement of existing processes or products and development of new products.

CP Index is the ratio of the productivity of a given system to its environmental impact. Productivity is measured in terms of economic efficiency using Total Cost Assessment (TCA), and the environmental impact is calculated using standard LCA methodology. But, making a ratio simply from the two CP indices (existing and alternative systems) will fail to adequately reflect the concept of time value of money, therefore the "productivity ratio" as a ratio of the productivity elements of the current process and alternative process, expressed as economic efficiency over time, should also be measured. Similarly, the "environmental ratio" as the ratio of reciprocals of the environmental impact elements between the current process and alternative process should also be measured. These two ratios are multiplied together to generate the **CP Ratio**. If the CP ratio is higher than 1 it means that the alternative is better than the current one, from the perspective of CP.

CP Index = productivity / environmental impact
CP Ratio = productivity ratio × environmental ratio*3

*1 Chertow, M. R. 2000, Industrial symbiosis: Literature and taxonomy. Annual Review of Energy and Environment 25:313–337.
*2 Aquatech Environment, Economics, and Information, 1997, A Benchmark of Current Cleaner Production Practices. Prepared for Cleaner Industries Section, Environment Protection Group Environment Australia.
*3 Kotelnikov, V. Measuring Cleaner Production (CP) - Harnessing Business Benefits. Ten³ BUSINESS e-COACH – Innovation Unlimited. Available at: http://www.1000ventures.com/environment/cp_measuring.html

Industrial symbiosis and industrial waste exchange (IWE) indicators

Industrial symbiosis is based on the exchange and collaboration between or among firms, where one facility's waste (energy, water or materials) becomes another facility's feedstock. Such waste or by-product exchanges can be useful when an industrial plant reaches the limits of cleaner production but still generates some waste. Industrial waste exchange, involving reuse and recycling of industrial waste, is a widely recognised concept, and typically involves one-way exchanges (transactions) of waste at the end-of-life stage. IWE occurs in a) collaboration between industries that generate waste and industries that can use the waste as raw material; b) linking industrial waste generators with waste recycling companies; and c) linking municipalities (as facilitators) with waste generating industries and recyclers. The following could be used as indicators in industrial waste exchange:

1. Input/Output ratio and amount of waste exchanged in/from an industry
2. Volume of waste diverted from landfill and tonnes of GHG emissions avoided
3. Reduced cost of waste disposal (for waste-generating industries)
4. Cost saving in raw material input (due to lower raw material inputs of reused/recycled waste)

One of the basic requirements of waste exchange is an up-to-date ***database*** of waste generating industries and potential recyclers and reusers, which should include the following information:

- Company contact information
- Company waste streams and inputs
- Material description
- Quality
- Quantity: weight or volume
- Exchange logistics
- Pick-up or drop-off information
- Material sorting
- Warehouse space or outdoor bins
- Results of exchanges (measurable impacts)
- Commodity exchanged
- Companies involved
- Material weight
- Market value of material (which can fluctuate) or landfill tipping rate
- Commodity-associated CO_2 equivalence for material (varies with reuse or recycling)

IWE Performance Indicator Selection

- Number of businesses participating
- Type of participating businesses
- Number of business partnerships formed
- Number of material exchanges resulting from partnerships (e.g., continuous or one-off)
- Tonnage of waste diverted from material exchanges
- Total financial savings to businesses (e.g., waste suppliers, recipients) from material exchanges in landfill tipping fees, waste bin pick-ups, reduced cost of raw materials and market value of commodities
- Greenhouse gas savings from material exchanges
- Website traffic statistics are used to determine site activity*4

*4 Department of Environmental Affairs and Tourism South Africa, and DANIDA, 2005. National Waste Management Strategy Implementation South Africa-Review of Industrial Waste Exchange. Report Number: 12/9/6 Annexure G