3 Integrated Waste and Resource Management

3.1 Introduction

Material efficiency can be defined as achieving the minimum material input per unit output of a particular product, given existing technologies. Material efficiency can be improved either by reducing the amount of the material contained in the final product ("lightweighting") or by reducing the amount of material that enters the production process but ends up in the waste stream. Besides industrial waste, household and other municipal waste also contribute to solid waste.

Solid waste is a growing problem in all countries, and a critical problem in many cities of the developing world. Developed countries have in recent years reduced the environmental impact of solid waste through sanitary landfills and high-temperature incineration, as well as conserving natural resources and energy through increased recycling, but the volume of waste generated is steadily growing. In the developing world, few cities have adequate solid waste collection and disposal systems, and the accumulating waste threatens health, damages the environment, and detracts from the quality of life.

Waste management has been identified as a regional and international priority for the Marrakech Process. As yet, there is no Task Force established to address waste issues, although a number of countries have expressed interest. To support consideration of the issue, this paper will consider solid waste issues, including waste collection and disposal, and waste reduction and recycling. It will focus on industrial and household solid waste, with attention to air and water pollution and climate change as they relate to such waste. The paper does not address sewage, agricultural waste, mining waste or industrial waste prevention (cleaner production), some of which are addressed in other sections.

3.2 Current Status

Total material consumption

From an economy-wide perspective, material intensity is measured and monitored through material flow accounting (MFA), a concept developed by the World Resources Institute and elaborated in detail by Eurostat, including the development of a statistical database (Eurostat, 2001).

According to the Eurostat database, overall material consumption, including fossil fuels but excluding water, in the EU-15 amounted to 15.7 tonnes per capita in 2002. In broad categories, this includes, per capita, 7.0 tonnes of construction minerals (sand, gravel, crushed stone), 4.0 tonnes of biomass (food, fodder and wood), 3.7 tonnes of fossil fuels, and 1.0 tonnes of industrial ores and metals. Over the period 1970-2000, this broad measure of material consumption grew closely with economic growth in the lower-income countries of the EU-15, keeping material intensity fairly constant relative to GDP, while in

the richer countries, economic growth has been largely "de-coupled" from total material consumption, leading to a steady reduction in material intensity per unit of GDP.

There have been few if any policy efforts focusing on reducing aggregate material flows as such, in part because no single policy could address this broad aggregate, and in part because the different material flows have very different impacts on sustainability and the environment, and policies generally focus on more specific problems.

Lightweighting

The simplest and most direct form of improving material efficiency is reducing the amount of material that goes into a product, or "lightweighting". The average weight of aluminium cans in the United States has decreased from 20.6g in 1972 to 15.6g today, a reduction of 24 per cent. Glass bottles are now about 25 per cent lighter than they were in 1984. Plastic soft drink bottles made of polyethylene terephthalate (PET) had an average weight of 67g in 1984 and 48g in 2000. Plastic milk jugs made of high density polyethylene (HDPE) weighed 120g in the mid-1960s and 65g in 2000. The thickness of the most common plastic grocery bag has been reduced from 30 microns to 18 microns (Rathje and Murphy, 2001, p.101). This lightweighting has contributed substantially to improving material efficiency in the last few decades and to stabilizing, but not reducing, total material requirements.

Municipal waste management

In OECD countries, municipal waste generation averages about 540 kg per person per year, ranging from 354 kg per person in Norway to about 800 kg per person in the United States. Most of the solid waste in OECD countries goes to landfills, but incineration with energy recovery is increasing. Incineration, generally with energy generation, is dominant in the Netherlands, Denmark, Switzerland, Sweden, Belgium, Germany, Japan and Singapore, while landfill disposal is dominant in most of the other European countries, as well as in the United States, Canada and Australia.[22]

Modern sanitary landfills, with thick bottom liners and leachate (liquid run-off) collection systems to prevent water pollution, and daily coverage of waste to reduce smell, vermin and wind-blown debris, are costly and are most cost-effective when large. As a result, most small municipal or local "dumps" have been closed in recent years, with waste being transported longer distances to large sanitary landfills serving larger regions. Increasingly, methane gas generated within landfills by decomposition of organic material is being collected and used, mostly for generating electricity, thus reducing the release of this strong greenhouse gas.

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[22] UK Department for Environment, Food and Rural Affairs (DEFRA) (November 2006, e-Digest Statistics About: Waste and Recycling, www.defra.gov.uk/environment/statistics/index.htm; See also Soizick de Tilly, "Waste Generation and Related Policies", in The Economics of Waste, OECD 2004; and WorldWatch Institute, State of the World 2004, p. 16.

Incinerators that burn municipal solid waste substantially reduce the volume of waste (by about 90%) and can generate electricity and/or heat, while allowing metal recovery from the ash. Modern incinerators use high-temperature combustion to destroy toxic organic substances and emissions control systems to minimize hazardous emissions from others. Incinerator ash may contain heavy metals and other toxic materials that require special disposal procedures.[23]

Solid waste generation is increasing rapidly in many developing countries, driven by population growth, urbanization, industrialization, and rising living standards. Industrial, electronic and medical waste, some of which is hazardous, is increasing rapidly in many countries. Most cities in developing countries do not have the financial resources to provide full-coverage municipal waste collection services, in particular in informal settlements and other low-income neighbourhoods, where limited access for large vehicles poses a problem.

Scavenging and informal recycling have long been the norm in developing countries, and governments have begun to consider how to make such systems work more effectively and safely, recognizing their importance not only to waste collection and recycling of useful materials, but also to employment of the unskilled. The World Bank estimated that, in 1995, scavenging – sometimes including door-to-door household waste collection with handcarts – employed 7000 workers in Manila, 8000 in Jakarta, and 10,000 in Mexico City. Support measures to promote informal recycling while improving safety include legalizing and regulating scavenging activities, encouraging formation of scavenger cooperatives, awarding contracts for collection of mixed wastes and recyclables to organizations of scavengers, and establishing public-private partnerships between local authorities, businesses and scavengers.[24]

Waste reduction and recycling

Recycling of waste reduces the amount going to landfill or incineration, generates revenue to cover some of the cost of waste collection, conserves natural resources and energy, and contributes to reducing greenhouse gas emissions. Recycling of metals is generally most cost-effective, particularly with the sharp rise in prices since 2004. Recycling scrap metal requires much less energy than refining metal from ore – up to 95% less for aluminium and 75% less for iron and steel – as well as avoiding the pollution and resource depletion associated with mining and smelting. Recycling of good quality paper and some plastics is also economic, particularly where disposal costs are high, in addition to conserving energy and natural resources. Sorting and composting of organic material, including yard and food waste and paper, produces compost for local farming and gardening, as well as reducing methane emis-

[23] OECD, Towards Sustainable Household Consumption: Trends and Policies in OECD Countries, 2002.

[24] Thomas Kinnaman and Don Fullerton, "The Economics of Residential Solid Waste Management", NBER Working Paper 7326 (1999), p. 19, www.nber.org/papers/w7326, and Soizick de Tilly, "Waste generation and related policies: Broad trends over the last ten years", in The Economics of Waste, OECD 2004.

sions from landfill. In the UK, increases in recycling since 2000 have more than offset increases in waste generation, reducing the volume of municipal waste for disposal by 15%.[25]

Recycling is most cost-effective when large quantities of uniform waste material can be collected. Industrial and commercial wastes are therefore more economic to collect and process than household waste consisting of small volumes of mixed waste. In the United Kingdom, industrial and commercial recycling amounted to 30.7 million tonnes (45% of total industrial and commercial waste) in 2003, while recycling of household waste amounted to 6.3 million tonnes (22% of household waste).[26] Recycling is more economic when materials can be separated at the source, whether industry, offices or households, although complicated sorting requirements can reduce separation.

Most developed countries have been promoting recycling by both industry and households. In OECD countries, overall recycling rates are increasing and now average over 80% for metals, 40-55% for paper and cardboard, and 35-40% for glass.[27] Scrap metal recycling is increasingly important as a source of raw material for industry, driven by the high prices for metals resulting in large part from strong demand from emerging economies.

Household recycling has expanded dramatically in OECD countries. In the United States, some 9000 municipalities have introduced public collection of separated household waste for recycling since the 1970s, with some achieving municipal waste recovery rates of 50 per cent.[28] In the UK, household recycling increased from about 1.7 million tonnes in 1997 to almost 7 million tonnes in 2006, with paper and cardboard, and compost being the largest components. Among EU-15 countries, recycling of municipal solid waste varies from 4 per cent in Portugal to 64 per cent in the Netherlands.[29]

Apart from metals, demand, and therefore prices, for many recycled materials have been low, in part because industries have been reluctant to invest in systems to process recycled material, which often differ from systems for virgin raw materials (e.g. recycled paper vs virgin wood pulp). Economic analyses of household waste recycling indicate that it usually does not pay for itself, particularly where inexpensive land is available for landfill disposal, although this does not take account of some of the social costs of resource depletion and environmental degradation.

The growth of recycling has been accompanied by an increase in international trade in recycled material (often called scrap or secondary material), particularly from developed countries to China and other rapidly industrializing Asian countries. This trade has been estimated at 135 million tonnes annually, includ-

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[25] UK Department of Environment, Food and Rural Affairs, "Municipal Waste Management Statistics" at www.defra.gov.uk/environment/statistics/wastats/archive/mwb200611.xls

[26] UK Department for Environment, Food and Rural Affairs (DEFRA) (November 2006), Key Facts About Waste and Recycling. www.defra.gov.uk/environment/statistics/waste/kf/wrkf03.htm

[27] Soizick de Tilly, "Waste Generation and related policies: Broad Trends over the last ten years", in The Economics of Waste, OECD 2004.

[28] USEnvironmental Protection Agency (November 2006), Municipal Solid Waste: Recycling. www.epa.gov/msw/recycle.htm. See also Elizabeth Royte, *Garbage Land: On the Secret Trail of Trash.* Little Brown & Co., New York, 2005, p.264.

[29] UK Department for Environment, Food and Rural Affairs (DEFRA) (May 2007), Key Facts About Waste and Recycling. www.defra.gov.uk/environment/statistics/waste/kf/wrkf08.htm, and wrkf15.htm.

ing 78 million tonnes of iron and steel scrap, 35 million tonnes of paper and cardboard, 15 million tonnes of aluminium and other non-ferrous metals, and 4 million tonnes of plastics.[30]

In developing countries, low labour costs can make recycling more economic, resulting in increasing imports of scrap material, higher international prices for those materials, and increased cost recovery for recycling programmes. In some cases, however, hazardous waste is exported as recyclable material to developing countries without the capability for ensuring that waste handling and recycling are performed under safe conditions. Efforts are being made under the Basel Convention to address these issues.

Computers and other electronic equipment, which contain lead, mercury, chromium, cadmium, barium, beryllium, PVCs, brominated flame retardants and other toxic materials as well as plastic, glass, copper, silver and gold, are of growing concern with respect to disposal. In the United States, electronic waste is estimated to amount to about 2.5 million tons per year, of which only about 10 per cent is recycled. It is estimated that about 70 per cent of the heavy metals in landfills come from electronic waste. A large quantity of discarded computers and other electronic products from the United States, Japan and the Republic of Korea is exported to China and other developing countries in Asia for recycling, often under unsafe conditions.[31]

To reduce electronic waste going to landfills and incinerators, the European Union in 2003 adopted a Waste Electrical and Electronic Equipment (WEEE) Directive requiring producers, starting in 2005, to take responsibility for recovering and recycling electronic waste without charge to consumers. This is intended not only to promote recycling and reduce landfill disposal and incineration, but also as an incentive to producers to design products so as to reduce waste and facilitate recycling.[32]

The EU also adopted in 2003 a Directive on Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment (ROHS), banning, from 2006, the use of lead, mercury, cadmium, hexavalent chromium and two brominated flame retardants used in plastics. China has also adopted regulations banning the same six substances, beginning in 2006, thus ensuring that Chinese products meet EU requirements.

The building sector accounts for a large amount of waste (mostly concrete and bricks from demolition, but also wood and steel), accounting for 10-44% of total solid waste in various OECD countries. As it is difficult to reduce substantially the amount of material in buildings without reducing performance, the potential for waste reduction is mainly from recycling materials following demolition. Currently the estimated recycling rate ranges from 5-90% in various OECD countries, with much of the waste going to engineering fill or road foundation, where the quality of the material is less important than in the case of building materials.

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[30] Veolia Environmental Services, "From Waste to Resource: An Abstract of 2006 World Waste Survey", www.veoliaenvironmentalservices.com/documents/From_waste_to_ressource_abstract_XP.pdf

[31] WorldWatch Institute (2004), State of the World 2004, pp. 44-45. See also US Environmental Protection Agency (November 2006), eCycling. www.epa.gov/epaoswer/hazwaste/recycle/ecycling.

[32] Europa, "Waste Electrical and Electronic Equipment", at europa.eu.int/scadplus/leg/en/lvb/l21210.htm

To reduce the volume of demolition waste going to landfill or incineration, some OECD countries require separation of demolition waste and restrict the disposal of recyclable construction material to landfills. In some countries, demolition contractors must get disposal plans approved before demolition can begin, which also helps protect against illegal dumping. These measures are often in addition to general landfill taxes and virgin material taxes (e.g. construction aggregate taxes), which increase the economic incentive for recycling. In Denmark and the Netherlands, 90% of demolition waste is recycled as a result of strict limitations on the disposal of recyclable demolition waste in landfills, landfill taxes, permission requirements for demolition, and other incentives for recycling.[33]

To promote recycling, exchange networks for recycled material have been developed in a number of countries, including the Netherlands, Japan, the Philippines, the United States and the United Kingdom, as well as a regional Waste Exchange of Africa.[34] Businesses with waste of potential usefulness can advertise the material on an internet network for interested businesses. Such exchanges can eliminate or reduce the cost of disposal to the source company, while providing low-cost materials to the acquiring business, as well as reducing environmental damage from virgin material extraction and processing, and problems arising from landfill disposal or incineration. In some cases, as pioneered in Kalundborg, Denmark, businesses that can use the waste material of other businesses have been located near them in "eco-industrial parks", making waste exchange more economical, an approach known as "industrial ecology".[35]

3.3 Challenges

- In order to enhance material efficiency of products and reduce the amount of waste that is not reused or recycled, extensive training and outreach are needed to further dsseminate eco-design principles and life-cycle analysis methods. This is particularly true for small and medium-size enterprises that make up the large majority of manufacturers globally. Efforts are required to develop policies that can promote and provide incentives for eco-design and product innovation.

- Most developing countries need more financial and technical resources to provide adequate municipal solid waste collection and disposal services. As informal waste collectors are at the heart of municipal waste collection in many developing countries, improved systems should as far as possible seek to build on this foundation, while protecting workers, especially children, from hazardous working conditions. A variety of ways to finance waste management need to be explored, including general tax revenues, property taxes, fee-for-service collection, extended producer responsibility, deposit-return schemes, product taxes or charges that reflect waste-related externalities, public-private partnerships, partnerships with community organizations and other NGOs, the Clean Development Mechanism, and others.

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[33] Japan Ministry of the Environment (November 2006), www.env.go.jp/en/.

[34] Waste Exchange of Africa, at www.worldwaste.org (May 2007)

[35] For Asia, see Eco-lindustrial Park Handbook for Asian Developing Countries, Asian Development Bank, 2001, http://indigodev.com/ADBHBdownloads.html

- To build markets and increase prices for recycled material, and to encourage the development of production systems that use recycled material, governments can pass laws requiring public agencies, and perhaps private entities, to buy products made from recycled material. Businesses and households can also be encouraged to purchase such products. National regulations and standards, in addition to collection programmes at the municipal level, can help build national markets for recycled material.

- Reducing the large amount of waste from construction and demolition requires separation and recycling of material within the sector. Regulation of debris disposal, landfill charges, and taxes on construction material extraction can promote this recycling.

- Governments and industry can promote and support networks for industrial waste exchange, including through use of the internet and establishment of eco-industrial parks, to allow suppliers with unwanted materials or wastes to find others who can use them.

- Further international efforts are needed to regulate international trade in recycled materials, particularly hazardous waste through the Basel Convention, in order to ensure safety and environmental protection, and to prevent recycling being used as a cover for hazardous waste disposal in developing countries without adequate technical capabilities or regulation.

3.4 Key Questions

Some key questions to be discussed among the participants in the working group on integrated resource and waste management (on 27 June, Group 3) are suggested below:

1. What are the priority issues relating to resource efficiency, waste management and recycling at the national and regional level that should be incorporated in the 10YFP on SCP?
2. How can financial and technical resources be mobilized to improve waste collection and disposal and recycling, particularly in the large cities of developing countries?
3. What measures can increase demand for recycled materials in order to make recycling more economic?
4. What measures can encourage manufacturers to adopt eco-design principles for new product development to prevent and reduce waste as well as improve recyclability?
5. How can the Marrakech Process build more partnerships and cooperation in the promotion of integrated resource and waste management, is there a need for a new task force or possibility for new partnerships with existing organisations or networks working in these areas?