Overall Guidance Document on the Environmentally Sound Management of Household Waste

November 2019

This draft document has been developed by the Household Waste Partnership Working Group, taking into account the discussions at the fourteenth meeting of the Conference of the Parties to the Basel Convention, comments previously received from Parties and others, and taking into careful consideration the existing guidance under the Basel Convention, in particular on environmentally sound management.

Additional case studies are being developed by the Working Group and will be added to the guidance at the time of preparation of a second draft.

This document is presented as received from the Working Group and has not been formally edited.

Table of Contents

1. Introduction

One of the challenges faced by national governments and municipalities, particularly in developing countries, countries with economies in transition and small island developing states (SIDS), is the environmentally sound management (ESM) of household waste.

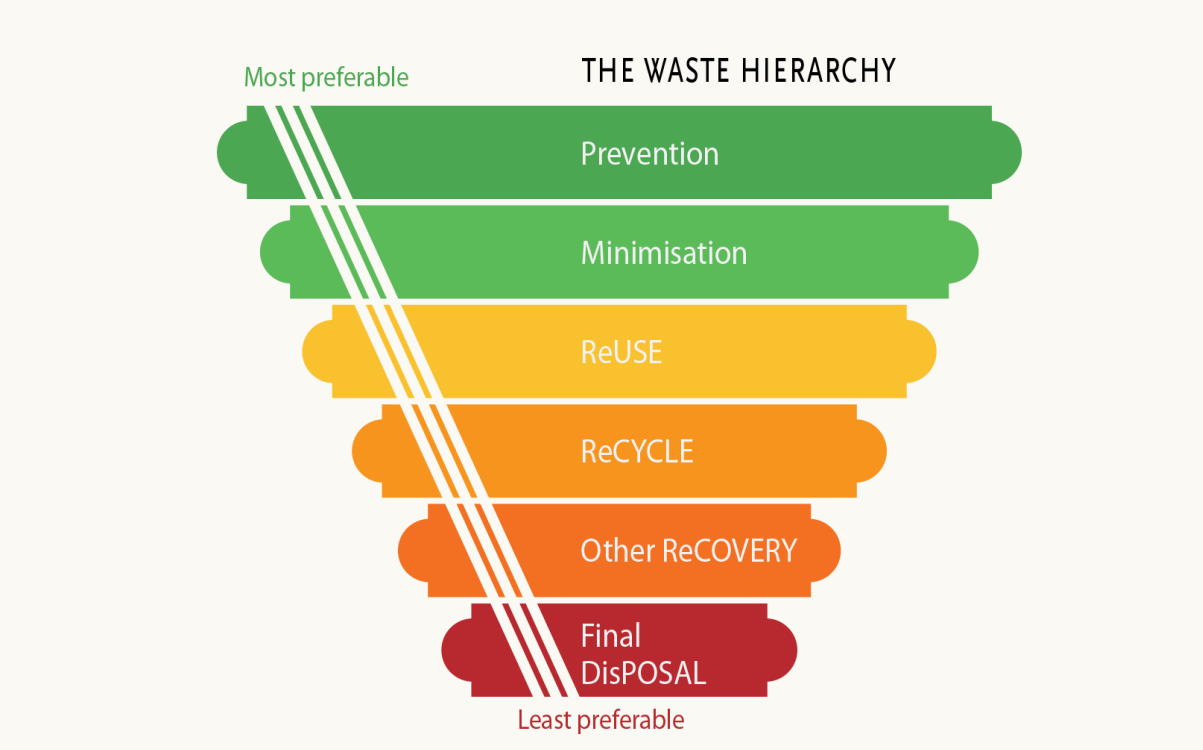
This document provides guidance on the environmentally sound management of household wastes, pursuant to decisions BC-13/14 and BC-14/19 of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (hereinafter referred to as "the Convention"). Household waste is classified under the Basel Convention as requiring special consideration (Basel Convention, Annex II, Y46 "Waste collected from households") because it may contain hazardous wastes such as unused cleaning products and even so, if not separated at source, it is a mixture of non-hazardous waste. While some stakeholders may define their respective waste management hierarchies in slightly different ways, this guidance references the general concept of a waste management hierarchy as follows: prevention, minimisation, reuse, recycling, other recovery including energy recovery, and final disposal.

The waste hierarchy ranks waste management options according to sustainability[1] and what is best for the environment.[2] Top priority is accorded to preventing and reducing waste production. If waste is not produced, then there is no question of disposal. When waste is produced, the hierarchy gives precedence to preparing it for reuse/upcycling, followed by recycling/downcycling, then recovery, and last of all, disposal.

The aim of the hierarchy is to optimise the best use of discards so as to eliminate final disposal to the extent possible and conserve resources. If the ultimate goal is to achieve ESM of household waste, the hierarchy can be seen as stages with their own achievable targets, activities, deliverables and goals to achieve which relevant policy, infrastructure, financial mechanisms, awareness (behavioural change) and technological interventions would be needed.

[1] Hansen, W., Christopher, M., and Verbuecheln, M., "EU Waste Policies and Challenges for Local and Regional Authorities" (2002) available at http://www.arctic-transform.eu/files/projects/2013/1921-1922_background_paper_waste_en.PDF

[2] The proper application of the waste hierarchy can have several benefits. It can help prevent emissions of greenhouse gases, reduce pollutants, save energy, conserve resources, create jobs and stimulate the development of green technologies. (See, Waste-to-Energy Research and Technology Council (2009)).



The Environmentally Sound Management of Waste entails taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes. The Convention's Framework for the environmentally sound management of hazardous wastes and other wastes was developed to identify strategies that countries could implement at the national level and collectively, as parties to the Convention, to address the challenges of implementing ESM of wastes in a systematic and comprehensive manner. Intended as a practical guide for all stakeholders participating in the management of such wastes, the framework:

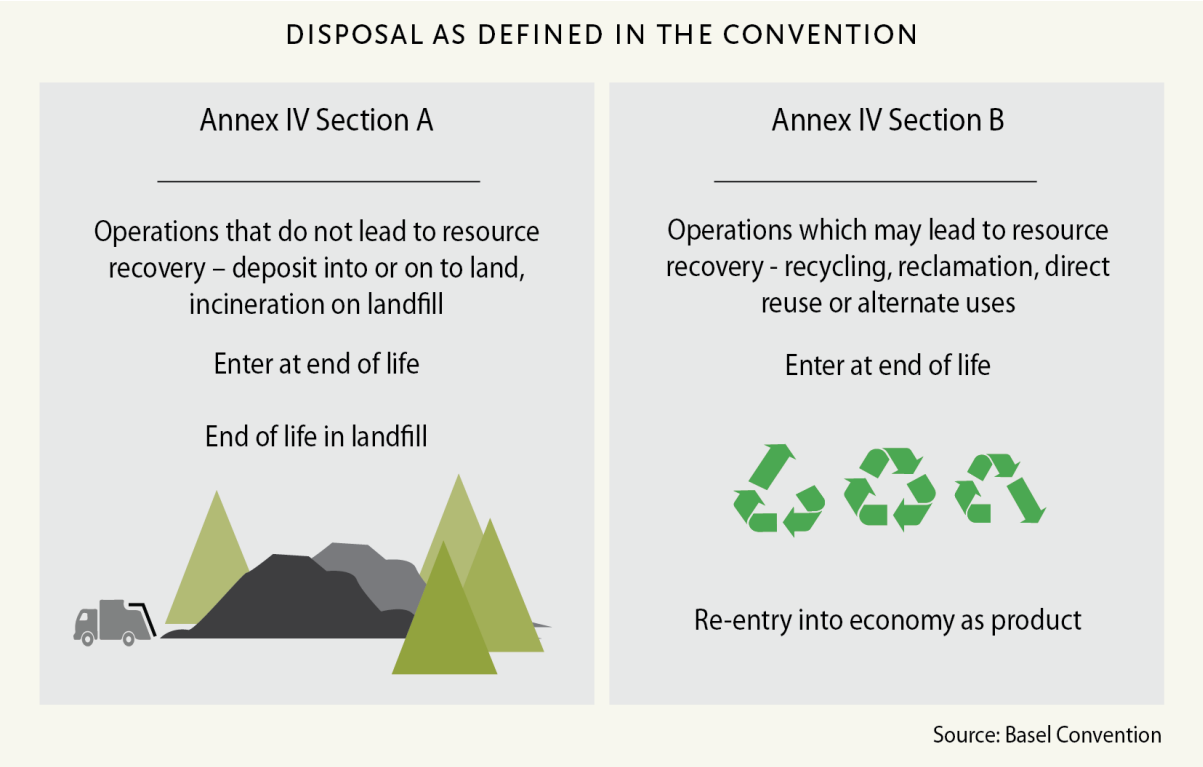
(a) Establishes a common understanding of what ESM encompasses;
(b) Identifies tools to support and promote the implementation of ESM;
(c) Identifies strategies to implement ESM.

Environmentally sound management of household waste contributes to resource efficiency and also provides a mechanism for decoupling waste generation from economic growth and progressing towards a circular economy. However, in many countries, authorities are struggling to make the changes necessary to cope with both the increasing volume and changing composition of household waste (e.g. Kumar et al. 2017). To achieve affordable and effective ESM requires significant planning with integrated strategies relating to waste prevention and minimization, separation at source, collection, transportation, treatment, recycling, and disposal (Al Sabbagh et al. 2012).

Definition of waste

The Convention defines Waste in Art.2(1) as: –

"Disposal" is then defined in Art. 2(4) as meaning any operation specified in Annex IV to the Convention. Annex IV, entitled 'Disposal Operations' has two Sections:



Hazardous waste

Hazardous wastes are a special category and are those wastes that:

- belong to any category contained in Annex I of the Convention, unless they do not possess any of the characteristics contained in Annex III of the Convention and
- wastes defined as, or considered to be, hazardous wastes by national legislation.

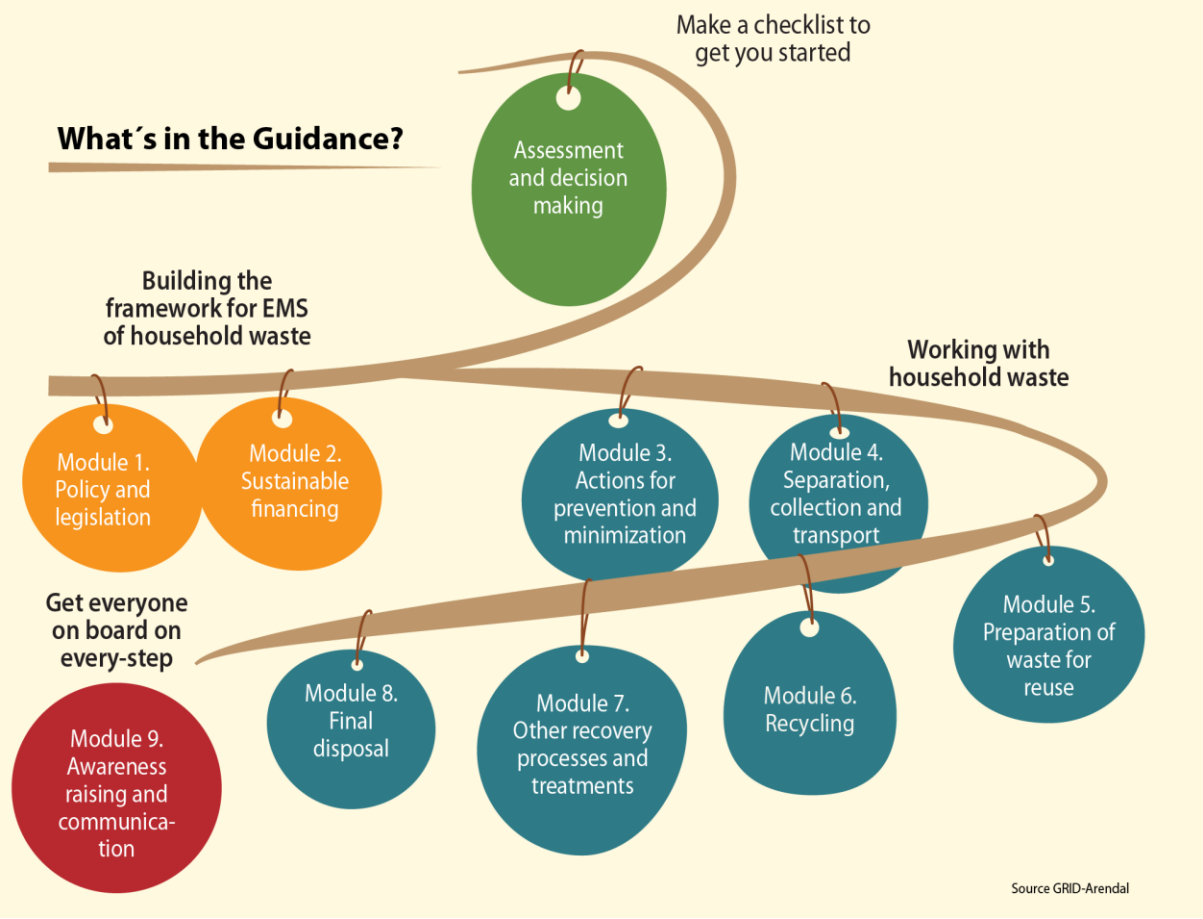
ANNEX I CATEGORIES OF WASTES TO BE CONTROLLED WASTE STREAMS Y3 Waste pharmaceuticals, drugs and medicines Y4 Wastes from the production, formulation and use of biocides and phytopharmaceuticals Y5 Wastes from the manufacture, formulation and use of wood preserving chemicals Y6 Wastes from the production, formulation and use of organic solvents Y8 Waste mineral oils unfit for their originally intended use Y9 Waste oils/water, hydrocarbons/water mixtures, emulsions Y12 Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish	**unless they do not possess any of**	ANNEX III LIST OF HAZARDOUS CHARACTERISTICS H1 Explosive H3 Flammable liquids H4.1 Flammable solids H4.2 Substances or wastes liable to spontaneous combustion H4.3 Substances or wastes which, in contact with water emit flammable gases H5.1 Oxidizing H5.2 Organic Peroxides H6.1 Poisonous (Acute) H6.2 Infectious substances H8 Corrosives H10 Liberation of toxic gases in contact with air or water H11 Toxic (Delayed or chronic) H12 Ecotoxic H13 Capable, by any means, after disposal, of yielding another material, e.g., leachate, which possesses any of the characteristics listed above.

Other wastes

Other wastes are listed in Annex II (as Y46 and Y48) and include the wastes collected from households that require special consideration. These "other wastes" include certain plastics that are technically and economically difficult to recycle or cannot be recycled.
*National definitions of waste may diverge from that of the Convention.

1.1 Guidance to improve waste management

This guidance has been compiled for decision makers. Local authorities generally have responsibility for waste management within a local area, but a range of industries, businesses, communities and individuals are all involved in waste management. An objective of the guidance is to promote and share existing practical and concrete solutions in order to assist stakeholders on the ESM of household waste.



The guidance aims to:

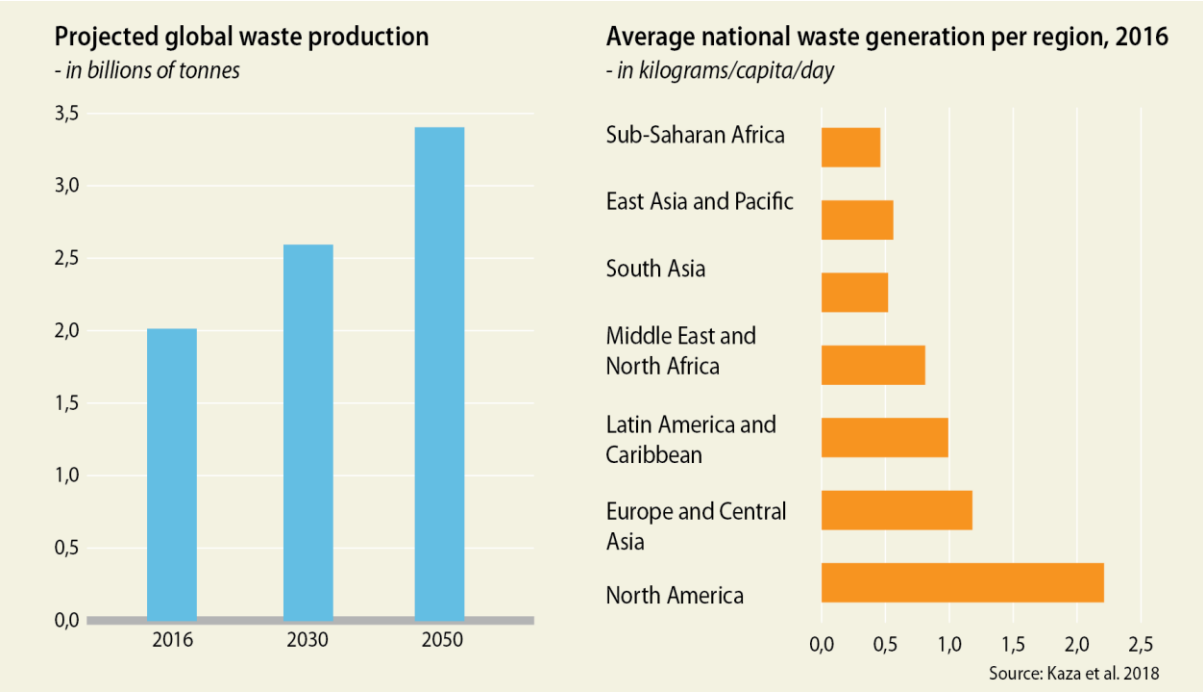
- Inform planning, investment and management decisions for ESM of household waste by setting priorities in ESM of household waste;
- Improve knowledge of environmentally sound waste management approaches

As mentioned, the guidance follows the principles of the waste hierarchy – reduce the

quantity of waste generated, maximise the amount that can be reused or recycled, recover energy and dispose. It references other relevant guidance documents produced under the Basel Convention, including the practical manuals on the promotion of the environmentally sound management of wastes and guidance on the prevention and minimisation of waste, as well as the large number of technical guidelines (see latest technical guidelines). The guidance provided in this document is general in nature and elements will be relevant to both urban and rural settings or can be adapted for different scales and locations.

1.2 About household waste

The amount of waste the world produces is growing and without serious intervention is expected to reach nearly 3.5 billion tonnes a year in 2050. Increasing urbanisation and population growth have put enormous pressure on traditional waste disposal methods such as landfill (Table 1). There is an increased awareness that poorly designed and maintained landfills are a significant health hazard, produce large quantities of greenhouse gases and odours, and leach toxic substances into the environment. Addressing these problems provides opportunities for continued development in waste prevention, reuse, recycling and energy recovery markets.



IMPACT OF IMPROPERLY DISPOSED HOUSEHOLD WASTE

WASTE DISPOSAL	CONSEQUENCES	NEGATIVE EFFECT	ECONOMIC IMPACT
UNSINTARY LANDFILL	Contaminated leachate into soil and groundwater	May contaminate drinking water; run-off can contaminate streams and lakes	Loses from reduction in productivity due to ill-health; absence from work; increase in health care costs; may be necessary to drill new drinking water wells
	Requires land that could be better used for food production, housing or public amenity	Removal of habitats; loss of productive land (farm and forest); reduction in human well-being when changing from healthy land to waste fields	Higher food prices; lower land price; increased traffic on roads
	Landscape changes	May impact surface and groundwater flow	Losses from flooding and ecosystem damage
	Degassing	Greenhouse gasses directly into the air; odours from the waste	Contribute to climate change impacts; reduction in land value due to odours; fire hazard
	Wind	Spreading the waste outside the waste area	Potential loss due to spread of disease-causing pathogens
UNCONTAINED RUBBISH	Blocks drains and clogs waterways	Potential for increased flooding; ecosystem damage	Damage to infrastructure and potential loss of life
OPEN BURNING	Atmospheric pollution which may contain toxic chemicals	Potential to impact a large area	Increased health costs due to respiratory health problems
	Fallout of contaminated soot may pollute waterways and drinking water	Potential human and environmental impacts	Potential loss of income due to spread of toxins and pathogens

Table 1. Impact of improperly disposed household waste

1.3 Assessment and Decision-Making

While most developed countries have introduced complex household waste management practices, many developing, and transition countries are still struggling with sound management of the ever-increasing volume of household waste (UNEP Basel Convention).

Municipalities and other relevant bodies involved in improving household waste management need to understand and assess current practices in order to identify and address the key challenges in moving towards ESM. **An assessment checklist** has been developed to help facilitate the policies and strategies required to deal effectively with household waste within an ESM framework (see Appendix 1).

Who should use the Checklist?

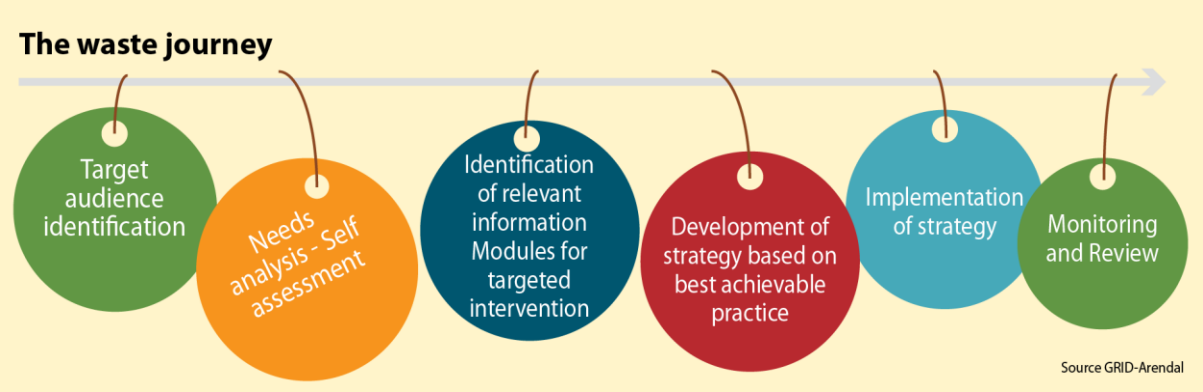
The checklist is aimed at assisting:

- Government Institutions;

- Municipalities;
- Practitioners (e.g. official or unofficial, licensed or unlicensed collectors, transporters, disposal operators, scavenger groups etc.).

Why use the checklist?

The checklist aims to assist users to identify their requirements and determine the current status or their waste management system and plan the future actions that may be required to develop and implement an environmentally sound waste management system.



Module 1 – Policy, legislation and institutional framework for ESM of household waste

1. Introduction

This Module examines the policy and regulation framework required for ESM of household waste. Local authorities generally have responsibility for waste management within their local areas in accordance with a regulatory framework. Local governments play an important role in providing household waste collection and recycling services, managing and operating landfill sites, delivering education and awareness programs, and providing and maintaining litter infrastructure. The choice of policy and regulatory framework will depend on many factors including political, institutional, social, environmental, and economic aspects (McAllister 2015).

Legislation creates a framework for proper management of waste, including the protection of human health and the environment, and provides a platform for an effective waste industry. Laws pertaining to waste are many and varied and are dealt with under numerous state, federal and international laws, regulations and codes of conduct, depending upon the type of waste and its lifecycle stage.

As the development of waste management progresses, legislation generally changes focus, from public health and environmental protection, to the minimization of waste and reuse and recycling. Modern frameworks emphasise waste avoidance, minimisation, resource recovery and use a risk-based approach to manage safety and environmental concerns. This change has been in line with a growing shift in community attitudes and expectations. Developing ESM of household waste is integral to achieving many of the United Nations Sustainable Development Goals, such as SDG 3 (good health and wellbeing), SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production) and SDG 14 (sustainable use of the ocean).

1.1 Strategic waste management planning

To achieve sustainable and effective waste management, strategies must go beyond purely technical considerations to include the development of appropriate policies that address the political, institutional, social, financial, economic and technical aspects of household waste management. Developing a policy framework is the first strategic response to the challenges of household waste. The formulation of policy begins with agenda-setting, followed by decision making and finally implementation.

Effective strategies should enable policy makers to foster and enhance the implementation of the ESM of household wastes at the national, local and facility levels. These strategies should respect the waste management hierarchy and be reviewed on a periodic basis. A strategy should provide a road map for waste management planners and decision makers that is appropriate for the national contexts and the availability of resources. The strategy has to clearly define the goals and objectives of each of the strategic areas and the identification of these strategic areas needs to be undertaken in consultation with stakeholders.

Strategies to support the ESM of household waste should integrate the interests of communities, business and governments. They should build on existing initiatives to develop cost effective priority actions. In developing appropriate strategies, the Basel Convention guidance on the prevention and minimisation of hazardous and other waste (ref) suggests steps that are also relevant to household waste. These include:

- Determine the scope and timeframe of the strategy;
- Define the objectives driving the strategy (e.g. to minimize residues for landfilling or to increase community recycling rates);
- Determine the priority areas for achieving the objectives.

The current state of waste management should be analysed in terms of what and how much waste is being generate, the adequacy of the existing infrastructure and legal and financing mechanisms This situation analysis can be used to identify gaps and thus help to determine priority areas for action.

1.1.1 Stakeholders

Government Waste Authorities – Authorities often have waste management high on their political agenda as the cost of inaction is high. Their commitment can be expressed in a Charter or action plan for the ESM of household waste for the country or the local region. These documents clearly demonstrate political will and may detail ways to enhance and promote ESM.

Householders – Householder behaviour plays a huge role in minimizing waste and maximising the recovery of resources for recycling. Separating recyclables such as organic waste, glass, plastic, paper and metal at the source ensures more efficient and cost-effective recycling. But recycling is only one part of the story – a shift towards more sustainable consumption is also required. Purchasing decisions can be based on product durability, recycled content and recyclability.

Waste businesses – There are increasing opportunities to create value from waste as recycling and energy recovery technologies advance. However, governments need to set recycling

targets and provide incentives. Recycling is only possible if it is economically viable, which means that the market has to function properly.

Product manufacturers and retailers – Environmentally green products often come at a premium to other products. There is a need for shared responsibility to ensure affordability of green products, reduce packaging, and to make sure products are recyclable. Policy approaches that make manufacturers take some responsibility for the treatment or disposal of post-consumer products (extended producer responsibility) are required. This provides manufactures with incentives to prevent waste at the source, promote product design for the environment and support the achievement of public recycling and materials management goals (OECD 2018).

1.1.2 Characterization of waste

The importance of understanding the nature of waste generated in the relevant jurisdiction of a waste authority cannot be overemphasised. Waste characterisation and quantification exercises are the essential building blocks for the development of waste management strategy and plan. There can be several ways of carrying out such studies and they are best developed and executed in a collaborative manner with the relevant stakeholders.

Waste characterization and the development of waste inventories allow waste authorities to understand the nature and types of discards being generated in their jurisdiction. This provides assistance in planning post collection infrastructure, logistics etc. The success of waste management decisions relies on the accurate assessment of waste. The exercise can be carried out in several ways - either at source, at the secondary sorting locations or at the final disposal site. It is important to develop a robust methodology to capture the diversity of streams and materials that flow through the system. Categorisation and value of such materials can be determined later based on markets.

Waste Characterization Methodologies

The European Commission SWA-Tool is an example of a comprehensive waste analysis methodology that can be used at a local and regional level to develop characterization and quantification of waste. The methodology describes an approach for the representative sampling of mixed residential and commercial waste. The Basel Convention has developed the Methodological Guide for the Development of Inventories of Hazardous Wastes which provides a guide for understanding this waste stream.

When categorizing waste, the number and nature of the fractions can be highly variable. The degree of complexity chosen, may be influenced by a number of socio-economic factors, such as household income and expenditure, geography and climate, and available management options.

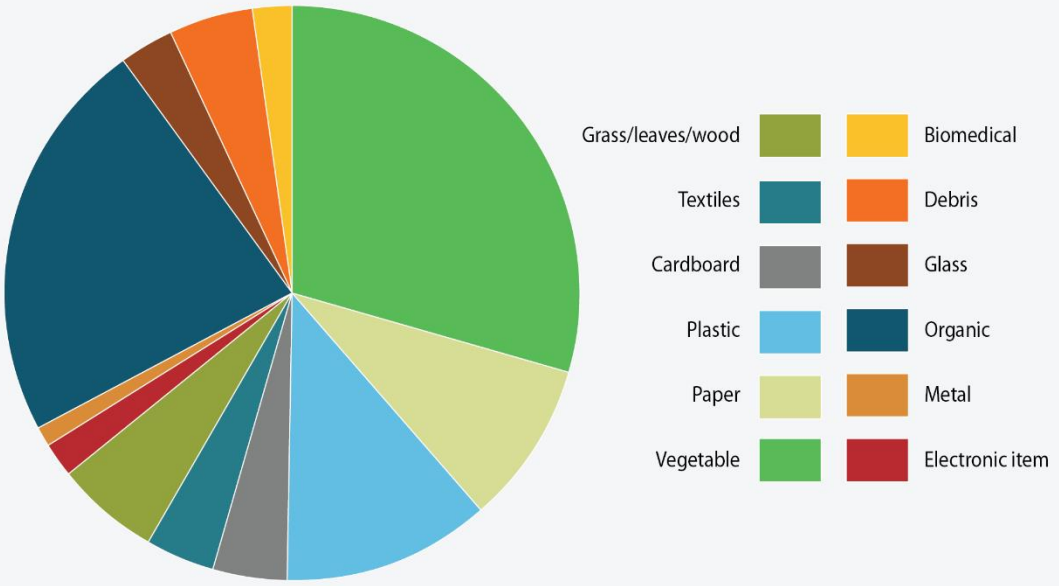
The table below lists the waste categories used by SWACH, an informal sector group in Pune India, to assess the value of waste for recycling.

Categories as per informal sector valuation

Items likely to be ReCYCLED	Items less likely to be ReCYCLED	Items not likely to be ReCYCLED
Metals	Glass (from bulbs, mirrors etc.)	Nylon and polyester cloth
Iron	Paper	Thin plastic (Main)
Copper	Cardboard	Road Scrap (mixed road sweeping)
Aluminium	Newspaper	Multilayered plastic pouches and wrappers
Plastics (above 50 micron thickness)		Nylon, polyester and rubber shoes, sandals
Notebooks		
Books		
PET		
Glass Bottles		
Saline Bottles		
Tetrapaks		

Source: Swach, Pune a waste picker led cooperative.

Categories as per Bruhat Bangalore Mahanagar Palike
- Physical composition of MSW (%)



1.2 Regulatory frameworks

Legislation creates a framework for proper management of waste including the protection of human health and the environment and provides a platform for an effective waste industry. Laws pertaining to waste are many and varied and are dealt with under numerous state, federal and international laws, regulations, and codes of conduct, depending upon the type of waste and the stage it is at in its lifecycle.

The Guidelines for Framework Legislation for Integrated Waste Management, (UNEP February 2016) provides a framework and examples from a range of existing legislation,

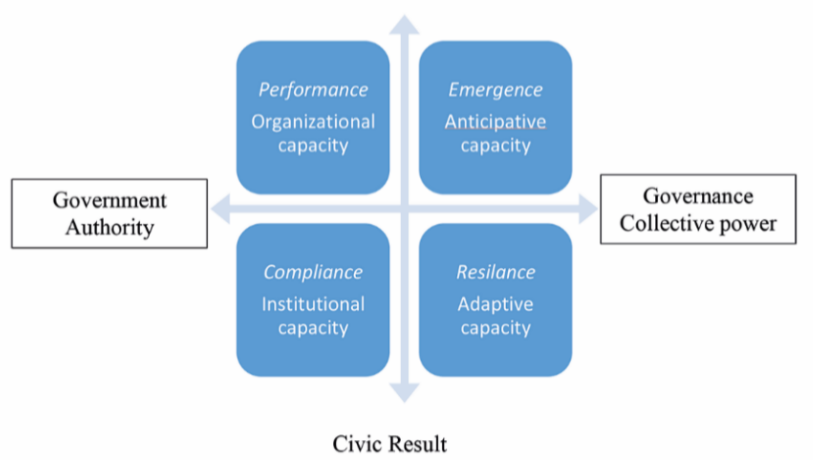
which are used to demonstrate how different countries have approached the legislative aspects of waste management. The table below illustrates a development pathway for waste legislation.

Table 1: Legislation Development

Disposal	
General Provisions	**Use of Economic Instruments**
Waste Strategy Infrastructure Planning Waste Management Plan Treatment Disposal Household Waste Waste Collection Landfills Sewage Hazardous Waste Litter	Levies Grants
Environmental Aspects of Waste	**Responsibilities in Waste Management**
Adverse Effects Discharge of Contaminants Environmental Emergencies and Disasters Environmental Impact Assessment Import/Export/Transboundary Waste	National Government Advisory Committee Local Government Non-Government Organisations Citizens Private Sector
Auditing and Reporting	**Compliance and Enforcement**
Audit Data/Information Monitoring Reporting	Licensing Liability Enforcement Offences and Penalties
Single Medium Integration	
General Provisions	**Circular Economy**
Waste Management Hierarchy Prevention Reduction Reuse Recycling Recovery Disposal Ban Separation Biowaste Burning Mining/Mineral Waste Tyres	Best Available Technology Procurement
Environmental Aspects of Waste	**Extended Producer Responsibility/ Product**
Contaminated Land	**Stewardship** Extended Producer Responsibility Product Stewardship Drop-off Systems Deposit Scheme
Multimedia Integration	
General Provisions	**Environmental Aspects of Waste**
Smoke	Air Quality
Responsibilities in Waste Management	**Compliance and Enforcement**
Traffic Fuels	Company Waste Management Officer Immission Control Officer
Circular Economy	
Circular Economy	
Circular Economy Requirements and Obligations	

1.3 Institutional capacity building

The delivery of waste management services requires the appropriate distribution of roles and responsibilities. This requires a degree of institutional capacity. An organisational structure with a staffing plan (that give due consideration to gender equality principles) and job descriptions has to be developed. Training and human resource development are crucial for an effective household waste delivery service. Therefore capacity-building measures should be embedded in the plan. This is required in all instances, but is especially important in developing states, where discrepancies often exist between the job requirements and the actual staff qualifications. Often waste authorities are viewed principally as waste collection and disposal authorities, and capacities related to waste diversion and development of appropriate resource recovery strategies are lacking. These issues can be addressed by attributing these roles to the authorities, conducting a training needs analysis and identifying gaps and appropriate actions. The development of waste prevention and recycling plans at a decentralised level can only happen if those on the field are trained to do so. The more diversion from the disposal site occurs, the more this is recognised and compensated.



Graph 1. Capacity Building Model-1

Source: International Review of Administrative Sciences, Vol. 76, Number.2, June 2010, pp. 197–218.

1.3.1 Integrating the informal sector

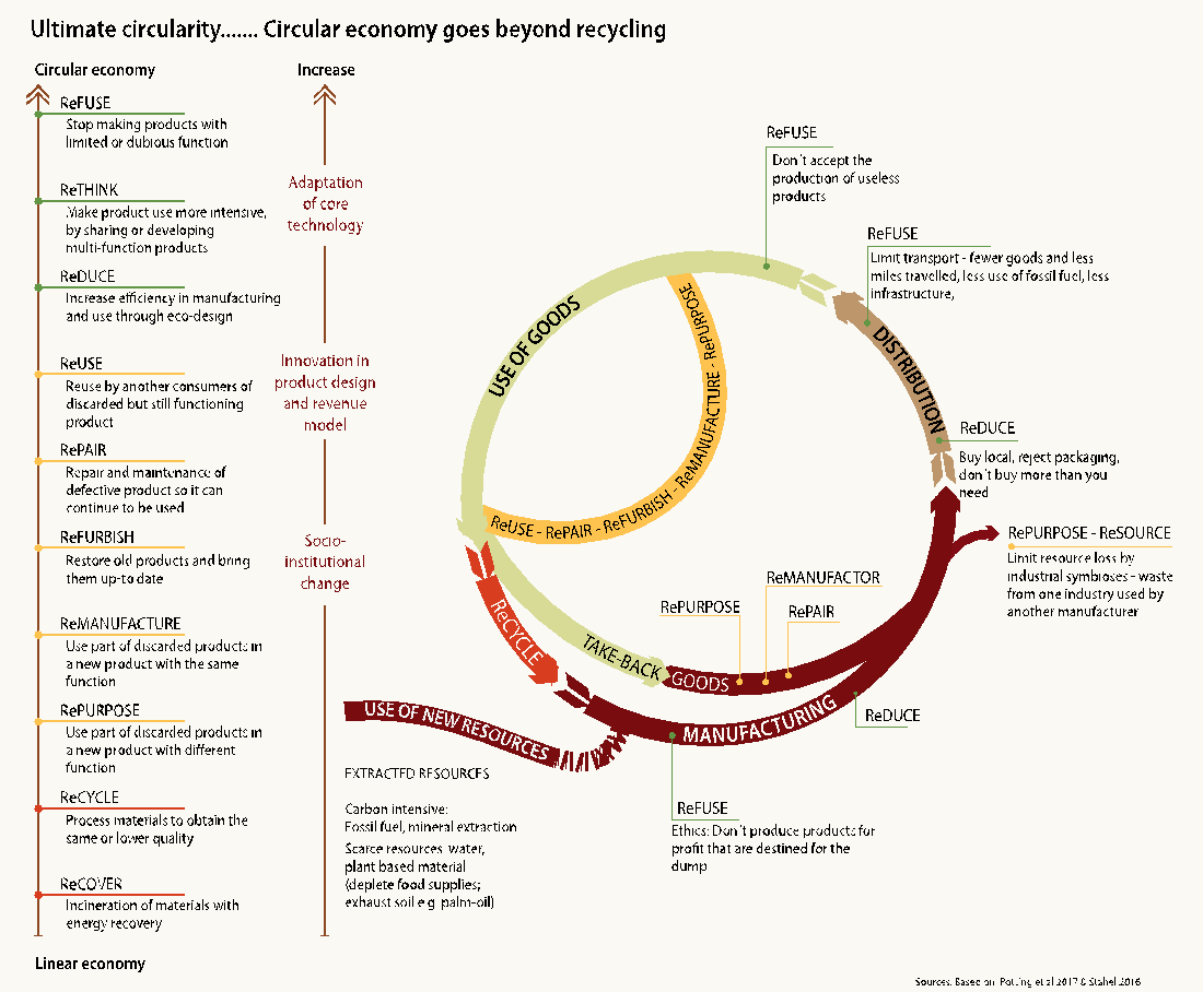
In many developing countries, a significant percentage of waste may be managed by the informal sector. These workers can be considered to be part of the private sector, as they are essentially self-employed. The private network is therefore composed of an informal collection service, while the rest of the waste management chain might include local operators or global corporations.

The challenge in developing countries includes integrating informal waste collectors into formal waste management programmes. Municipalities can integrate waste pickers into the collection of waste at the source, by giving them rights over recyclables and guaranteeing regular access to waste. To assign these rights, municipalities must enter into direct contractual or covenant relations with informal sector organizations. Given limited business knowledge, education, and socio-economic means, the informal sector needs support to

organize into cooperatives or other legal structures. Municipalities or NGOs can provide legal support in establishing cooperatives, providing training, and creating other services to improve working conditions (such as identity cards and access to health insurance). Public institutions at the national and local levels can facilitate and integrate the contribution of the informal sector. Initiatives to include the informal sector may also include dialogue between the informal sector and industry to develop a cooperative response that includes both sectors.

1.4 Decoupling waste generation from economic growth

Breaking the relationship between economic growth and the generation of waste through inefficient resource use, is referred to as decoupling. As the world's population expands and resources shrink it is not sustainable to maintain the "take, use, dispose" model of consumption that underpins the linear economy. The proposed alternative model incorporates the efficient use of resources and waste prevention and minimisation. Transitioning to this more circular economy, where resources are maximized requires a major shift in institutional, business and consumer thinking – a shift towards recognition of the finite nature of natural resources and the inability of the planet to accommodate increasing levels of waste without significant environmental impact. The ESM of household waste is one of the important elements in the transition to a circular economy that promotes intelligent equitable growth.



Role of Technology

Typically, waste streams travel through 5 stages before final disposal – Collection, Transportation, Aggregation, Recycling, Recovery and Disposal. The need for technologies at every stage requires a thorough understanding of the specific challenges faced at each stage. Additionally, waste management systems across the world are evolving towards waste minimisation, product redesign and elimination and these policy options have to be included in any analysis. Historically, technology has been used in the last two stages - recovery and disposal. However, the increasing complexities in urban waste management have allowed upstream innovations to emerge as well. The figure below captures the various stages and innovations that have emerged within them. It is important to note that the most successful among these technologies are the ones that have been designed to address specific challenges that emerge during the course of implementing the waste plans.

Cites like Pune, Indore and Chennai in India that have scaled up door-to-door collection have witnessed innovations. Interesting examples include - Indore has developed a mobile device with a biometric scanner to streamline and digitise daily rosters. This has helped cut absenteeism. Surat has plans to advance towards a retina scanning technology for the same application. Bangalore has joined with a private IT firm to launch a platform called 'I Got Garbage' with the aim of streamlining and empowering the work of the informal sector recyclers who are employed in the city dry waste collection centre. Chennai is in the process of improving the working conditions of its workers by introducing scientifically designed battery operated tricycles. A popular technology for organic waste management is the mechanical Organic Waste Convertor that cuts composting time to half. Several waste authorities in India and bulk waste generators have adopted this technology for food waste management.

Module 2 - Sustainable financing for ESM of household waste

2. Introduction

The sustainable management of solid waste from cities and communities is essential to the physical and economic health of society. However, both the physical infrastructure and the long-term operation of waste management can be the single highest budget item for many local administrations. Cities in low-income countries are spending about 20 percent of their budgets on waste management, and over 90 percent of waste is openly dumped or burned. As cities grow rapidly, waste management systems and budgets also need to grow in order to manage the increasing amounts of waste generated. Both low- and middle-income countries often face budget shortfalls for waste services and thus reduction of costs and recovery of fees is integral to the development of the sector.

Environmentally sound management of wastes from households will be optimized by selecting the appropriate economic instruments as described in this module. Economic instruments are not mutually exclusive but complement each other. There are various components and many possible combinations. Households may:

- pay a fee or tax for general waste services
- ´pay as you throw' for separately collected waste streams
- sell certain waste and scrap material to collection points
- pay an advance disposal fee or an extended producer responsibility scheme fee when purchasing a product,
- use deposit and refund systems in accordance with their consumption behaviour.
- be subject to additional charges that are aimed at behaviour change such as a plastic bag levy or a landfill tax.

The charges and taxes listed above may be earmarked and collected in specific funds to support waste management development.

Other conditions defined at the regional or national level may be equally important in the financing of waste management. For example, there may be an incentive or disincentive to develop advanced waste management facilities, such as waste-to-energy plants, depending on the availability of access to the electricity grid or a gas network, the price charged to the consumer (tariffs) and the level of subsidy. The environmentally sound management of wastes from households can only be achieved with the understanding, cooperation and involvement of all citizens. It follows that identifying and then communicating with all stakeholders is essential.

2.1 Guiding Principles related to financing

These seven guiding principles or "best practice statements" are intended to help readers to develop best practice financing mechanisms.

The **Polluter Pays Principle** holds those who produce a burden to the environment (in the form of pollution or waste) are responsible for the costs associated with the management of the waste. Therefore, whoever generates waste has to pay for its reuse, recovery or disposal. In this context, the "pay-as-you-throw" concept relates to the allocation of the costs to the different quantities of waste generated by a polluter.

The **Principle of (full) Cost Recovery** requires that all costs related to waste are properly accounted for and, in accordance with the polluter-pays-principle, assigned to the respective waste generators. The means that the total expenses for all steps of waste management should be recovered. The incomplete recovery of costs can lead to lack of or reduced services. If services are provided in the absence of full cost recovery, they may be diverting funds from other services. The principle of cost recovery is not an income generating scheme, in that payments should not exceed the cost of waste management.

The **Principle of Equivalence** aims to maintain balance between the actual delivery of services and the cost of services. Improvement in waste services or in individual waste reduction (that decreases the cost of service delivery), should be reflected in the amount charged for services.

The **Affordability Principle** aims to ensure that no part of society is overloaded with payment obligations for waste services and environment protection. 'Affordability of Costs' and the 'Willingness to Pay' go hand in hand. If people are willing to pay for the costs of a service, it is an indication that the service is valued. However, the willingness to pay for certain services is limited by how much one can afford. This discrepancy often limits the possibilities to develop a waste management system or reduces the ability of service providers to fully recover costs. It is there necessary to understand the limit of affordability in order to prevent failure in cost recovery.

The **Transparency Principle** requires the local government authority to publicly reveal the benefits and costs of all waste management services. It is most important that the users of the waste services understand the fee structure for the services they receive and their obligations to pay. Independent auditing and annual reporting of waste volumes and values assist in providing transparency. Tenders for local authority waste management contracts should be open and transparent.

The **Social Responsibility Principle** aims at encouraging and supporting voluntary initiatives including those run by citizen groups, informal sector cooperatives and environmental non-governmental organizations.

The **Fair Competition Principle** between public and private waste management service providers, including the informal sector will help to optimize the costs and benefits of managing household waste and similar wastes.

2.2 Waste management finance

Waste management finance is made up of two components – financing of infrastructure and financing of the service

2.2.1 Financing of infrastructure

Investments made by the municipality into waste management infrastructure generally include, waste collection equipment such as containers, dustbins, collection vehicles, etc, and the establishment, operation and aftercare of waste management and disposal sites and treatment facilities. The investment in infrastructure is generally the largest one-off investment, so municipalities need to develop adequate financing models, which take into account all the advantages and risks associated with the respective investment.
Waste infrastructure investment generally includes the following cost items:

- Real estate acquisition
- Site development, access roads
- Preparation of site and foundations
- Construction works
- Machines and equipment
- Measurement and control technology
- Planning, project preparation, studies and permits
- Interim finance / interest

These costs occur in different stages of infrastructure projects and can be covered from different sources, which include:

- Grants: Grants are issued for special purposes, are free of interest and do not need to be re-paid. These can come from national government, international donors, climate funds, development aid, etc.
- Loans: Loans have to be re-paid, and generally include interest and often have to be secured by guarantees from local or state level. Loan insurance may also be required. Loans can be sourced from (inter)national banks, donors, investors/investment funds.
- Bonds: Bonds can be issued to investors by the city or a state to raise capital for large infrastructure projects. Money is repaid to the bond holders with interest. Bonds can be a cost-effective long-term borrowing strategy for authorities;
- Own capital or private equity.

Depending on the source or the mix of sources of finance for the infrastructure projects, the total amounts for annual repayment and interest can differ considerably. The annual repayment and interest are capital costs (CAPEX) which are part of the total annual expenditures for waste management

Climate protection related finance

A number of national and global initiatives provide funding for waste management infrastructure projects that support the reduction of greenhouse gas emissions. For example, the Climate and Clean Air Coalition (CCAC; administered by UNEP) has provided over USD 6 million since 2012 in funding to the sector. The CCAC has also produced resources to aid cities wanting to access finance for municipal waste projects. These include a Financing Readiness Questionnaire for Municipal Solid Waste Sector, designed to assist cities to be finance ready, a waste initiative webinar that explains the finance ready toolkit and a Primer to help cities make good financial decisions when looking to secure finance for large projects. To assist with planning and feasibility studies, the primer includes a data collection tool for assessing the budget required by a municipality for the allocation of services, as well as its revenue and debt.

Some additional examples of funding Resources include:

- The UNFCCC Green Climate Fund (GCF) supports project preparation and large-scale project funding.
- The Climate Technology Centre and Network (CTCN) is a technology mechanism of the UNFFCCC that can provide technical assistance to develop projects for funding under the GCF or stand-alone projects.
- The NAMA-Facility is funded by European states and Denmark to accelerate low carbon development. The facility provides grants for climate mitigation projects.

Climate protection related finance: Mozambique – Sustainable Waste Management – Laying the Foundations for a Circular Economy

Waste management in Mozambique has not been able to keep pace with the increase in waste volume bought about by rapid urbanisation and economic growth. It is estimated that 98% of waste is deposited in uncontrolled dumpsites that release large amounts of greenhouse gas. The NAMA Support project is working to assist the government in designing and implementing a programme of sustainable waste management that supports a circular economy. The assistance includes enhancing the legal and regulatory framework to reduce waste, including implementing the Regulation on Extended Producer Responsibility, the promotion of investment in a broad scale of management and infrastructure projects and awareness raising and institutional capacity building programmes. The initiative, which is in the detailed preparation phase, is expected to achieve emission reductions totalling 500,000 tCO2e by the end of the NSP in 2024 and 2.8 million tCO2e by the end of 2030.

2.2.2 Financing the operation of waste services

Financing waste services and annual running costs (operational expenditure referred to as OPEX) of a waste system includes:

- Personnel, salaries/wages;
- Energy;

- Raw material, consumables and auxiliary materials;
- Administration;
- Taxes, Insurance etc.;
- Repairs, spare parts, maintenance;
- Replacements.

And, depending on market prices or tariffs, operational financing may include gains from sales of waste materials and/or sales of energy.

Annual expenditures of waste services (full costs) = OPEX + (annual repayment + interest for infrastructure development) + expenses for contracted services rendered by third parties/private sector. The total annual expenditures have to be recovered by the application of revenue-generating economic instruments, like waste service fees/tariffs, gate fees, taxes etc.

A tool for estimating the cost of constructing and operating an organic waste management project.

The Waste Initiative of the Climate and Clean Air Coalition (CCAC) provides a cost estimating tool for organic waste management. The Cost assessment tools can help modelling future costs in order to support decision making. The OrganEcs tool helps estimate the costs associated with constructing and operating an organic waste management project. It assists users in determining the expected internal rate of return, user inputs, appropriate gate fees, and the appropriate product sale price requirements (e.g. for compost, energy) in order to meet the specified investor returns.

2.3 Economic instruments

Economic instruments in solid waste management have two major objectives: to cover costs and thus improve service delivery; and to reduce impacts by promoting waste minimisation behaviour by means of the pricing mechanism. Economic instruments do not substitute but complement and strengthen regulatory and other approaches in the respective policy area. From a public administrator's perspective, a distinction can be made between: revenue-generating; revenue-providing; and non-revenue (guidance) instruments. At each stage of the waste management process, different economic instruments may be appropriate.

- Waste charges may create incentives for improved separation and waste reduction.
- Deposit-refund systems may improve waste separation and collection.
- Advanced disposal fees can provide the revenue so that the share of the recycling of certain materials increases.
- Landfill taxes are intended to divert waste from landfill to other waste management facilities (e.g. recycling or energy-recovery) or lead to the prevention of waste (however an unintended effect may be an increase in illegal dumping and littering).
- Favourable energy or fuel tariffs can set a supportive framework for the development of waste-to-energy solutions.

2.3.1 Revenue-generating instruments for waste management

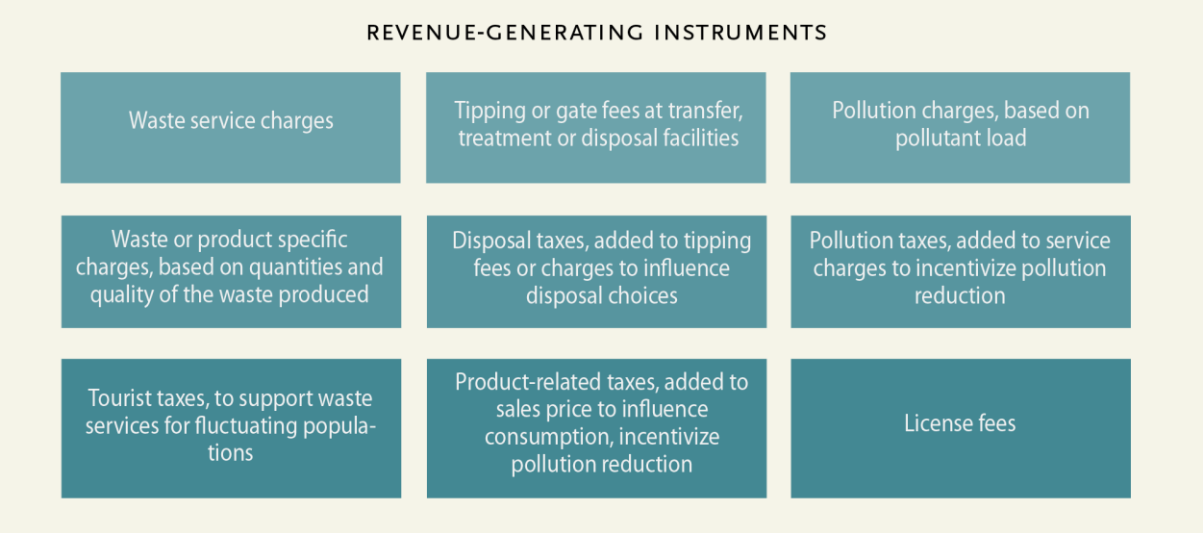
Revenue generating instruments can be in two forms:

(a) Those used to cover expenditure for waste management. For example;

- Waste service charge/ User charges for the collection, transportation and disposal services;
- Gate fees at the waste management facilities;
- Tourist taxes - small fees levied indirectly through accommodation providers and other services, designed to pay for household waste management;
- Licence fees for covering administration costs. etc.

(b) Those used to cover costs to influence consumer behaviour and for the development of the waste sector. For example,

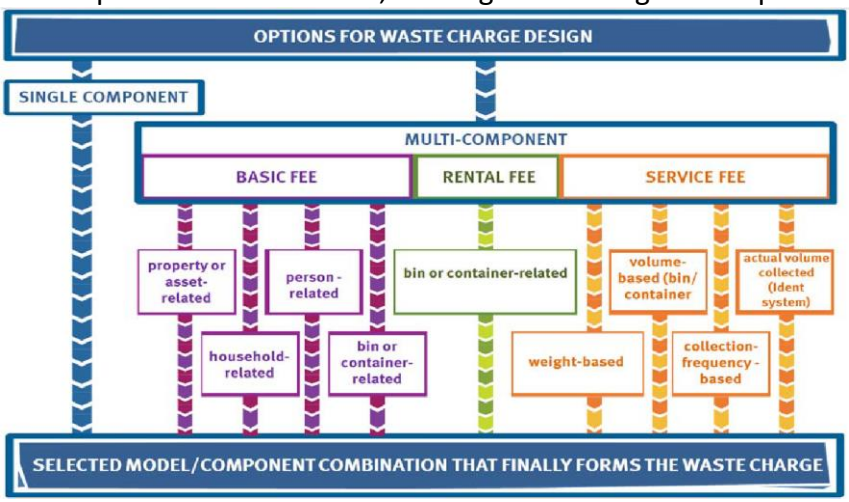
- Charges or taxes on waste generation;
- Landfill or disposal taxes in addition to gate fees;
- Charges or taxes on products at point of sale.



An ideal scenario would be to charge the entire waste service, in the form of cost-covering fees, to each individual user according to the waste they generate. A waste charging scheme should ensure there is full coverage of the waste management related costs and there is fair allocation of these costs to the population as beneficiaries of the services. However, fee calculations may also need to consider socio-economic aspects and the consumers ability to pay. Covering the full-service costs solely through user charges may result in user charges that are not affordable for the majority of the population. Therefore, the full range of economic instruments need to be considered (see GIZ Guidance (2015) on applying economic instruments for sustainable solid waste management in low- and middle-income countries).

Common waste service charging schemes (from Habil et al. 2018)

Single flat rate
This scheme consists of a single flat fee for all households. The fee covers the fixed and variable portions of the waste service and is independent of the amount of waste collected. The single flat fee provides no incentive to reduce waste, but it is transparent and simple to operate. Changes in the cost of the service may have little impact on disposal volumes.
Multiple component fee
A multi-component fee can be made up of a basic fee plus an additional fee for service. It can be charged per person, household, property and or by bin/s provided. The variable charges depend on the service and can relate to waste volume or weight, collection frequency, bin rental etc. Because multi-component fees include a fixed charge plus a variable fee they may be complex in administration, but might encourage waste prevention.



Components of a waste charging scheme

Common options for determining a waste fee include:

- **Volume-based (bin / container):** Charging for a fixed frequency of collection based on the volume of the bin.
- **Volume-based (waste volume collected):** Charging based on the waste volume. This requires knowing the volume, either by measuring or schemes like the prepaid bag or tag-a-bag.
- **Pickup frequency based:** Charging based on the frequency of emptying of a provided bin. A minimum number of pickups may be applicable.
- **Weight-based:** Charging per unit weight of collected waste (typically applying to residual and bio-waste collection). Can be charged in combination with a fee per emptying.

An example of linking waste service charging to electricity consumption

A novel scheme to finance waste has been introduced in Maputo, Mozambique. When first introduced consumers with an electricity connection (90% of households) paid a flat fee for waste collection. The system was refined in 2007 with the introduction of a tariff that links the waste charge to electricity consumption. This means that households with above average energy use can pay up to two times more than regular energy users. Qualifying commercial waste producers are also included in the scheme but pay a higher tariff. There there is a

separate licencing and registration system for non-household waste producers who produce large volumes of waste. While the waste charge is the main financial instrument, revenue is also generated from disposal fees for private operators, fees for additional services and fines for illegal waste generation. The city is working towards full cost recovery – in 2012 the revenue from all sources covered nearly 70% of the cost of waste services.

Maputo serves as an example for the effectiveness of attaching the waste fee to a public facility, in this case electricity. It also demonstrates that the method used for collecting the fee is as important as the fee itself. A municipality like Maputo does not have many other sources of revenue and depends on the capacity of its citizens to sustain its services. This means that the quality and quantity of services are determined by their affordability. Here the sustainability model and the cost analysis worked as a protective barrier against unsuitable, unaffordable solutions.

Gate Fees

Gate fees are levied on the volume of waste and type of waste delivered to a waste facility. The calculation of gate fees requires a detailed knowledge of the capital and operational costs of the facility and the development of a charging scheme for the different users of the facility or waste types delivered.

Tourist taxes

Tourist taxes can be a mechanism to also cover costs for waste management services in tourist areas. The increased volume of waste collection, transport and treatment as a result of visitors to an area can be considerable. This cost can be offset by an environmental tax or eco-tax.

Many countries charge a tourist tax. The tax may be collected at airports on departure, or as a tax included in airline or hotel bills. In the Balearic Islands that include the tourist hot spots of Majorca, Ibiza and Menorca, tourist pay a tax, of between 1 and 2 euros/day, depending on the length of stay. The revenue from the tax is used t provide information and surveillance at significant sites, cleaning of beaches and public sites, supporting circular economy activities (Govern Illes Balears 2018).

Landfill / Disposal Taxes

By increasing the price for disposal, landfill /disposal taxes may divert waste from landfill to recycling or energy-recovery. When the tax is collected in a specific fund, the revenue may be disbursed by specific mechanisms to aid waste sector development. An example is the disposal tax levied in Catalonia, Spain – it includes a land fill tax as well as an incineration tax. Both were introduced to discourage landfilling and incineration of municipal solid waste. The tax earnings from the Catalonia disposal tax are earmarked for the Waste Management Fund (Fons de Gestió de Residus) with the stipulation that at least 50% of the revenue generated must be used for financing waste pre-treatment. The Catalan Waste Management Fund is the most important instrument for the financing of waste management strategic goals and infrastructure development in the region.

Landfill, waste or product related taxes, which are collected in a special fund, need defined spending policies and procedures. The spending priorities, and the application and implementation requirements for obtaining financial support from the fund have to be clear and accessible for potential applicants. A transparent disbursement and control mechanism needs to be in place and the replenishing mechanisms of the special fund should be defined and transparent.

2.3.2 Revenue or other incentive providing instruments for waste management

Revenue providing instruments are subsidies, which are designed to encourage waste reduction practices such as recycling or improved waste management. These subsidies can be in the form of favourable energy tariffs, tax exemptions and lower prices for material usage such as renting of space or equipment to third parties. They can include schemes for collecting a refund (e.g. bottles and cans), take back or buy back (e.g. the traditional scrap yard) and cap and trade (e.g. for landfill).

Deposit systems for packaging containers, such as cans and bottles, are built on a principle where the purchasing price of a product includes a deposit amount that is paid back to the consumer when the container is returned after use. If well managed, the deposit system enables very high collection rates and the potential for high reuse and recycling. A deposit scheme may be run by a system operator on behalf of importers and domestic producers. Barcodes may be used to identify individual goods, to permit their return and to deliver the promised refund that may be in the form of traditional money, a reimbursement in kind, or another asset or award. The deposit system in Norway is has been running since 1999 and has an efficiency of 97 per cent. The collection systems are located in shops or petrol stations. Similar systems have been established in number of countries such as Canada, Estonia, Finland, Germany, Lithuania among others.

Take back or buy back systems may refund part of the original purchase price to encourage citizens to deposit used and end-of-life goods at collection points. Retailers may encourage the return of used and end-of-life with discounts on refurbished or new replacements.

Cap and trade systems can operate if for there is a cap on the total quantity of waste that can be landfilled. Individual allowances for landfill are allocated which can be subsequently traded. There are also credit-based schemes for packaging waste, which allocate targets for recycling to industry and require proof of target achievement through holding of tradable certificates that are produced when a tonne of waste is recycled.

2.4 Operation Models and Public Private Partnerships

Transferring municipal waste management tasks to the private sector is common throughout the world. It may involve all services or certain activities such as the operation of recovery facilities or for the collection and onward recovery of certain material streams. Municipalities often own areas or facilities, but out-source operation to the private sector. For example, private companies and charities provide containers on streets in order to organise collections of specific clothing, shoes, toys for reuse and recycling. Where the containers are on

municipal land, agreements with municipalities are made. Municipalities can also form public private partnerships to implement waste management. For example, the construction and day to day management of container parks where private companies separate waste within the container park and provide the onward transport and sale of materials to sorting and recycling companies. Local authorities may also just simply register waste facilities in their area of responsibility to carry out waste management services and then ensure the environmentally sound management of these facilities.

Result-Based Finance

Results-Based Financing (RBF) is a financial mechanism where payment for solid waste services are tied to the achievement and verification of pre-agreed targets. A basic feature of RBF is that financial payments or in-kind rewards are provided to a service provider conditional on the recipient undertaking a set of pre-determined actions or achieving a pre-determined performance goal. RBF offers opportunities to innovate in the use of development finance in the solid waste sector and to achieve results. Until recently, RBF principles and designs had not been widely applied in the solid waste sector, apart from the use of some performance-based contracting with private providers of solid waste services and carbon finance for methane mitigation. Given existing weaknesses and the challenges that cities face regarding solid waste management and service delivery, RBF can benefit the sector by ensuring that public funds are used efficiently and transparently.

The RBF model to improve solid waste service delivery and fee collection is an appropriate model for low income countries where service delivery is poor or non-existent or where fee collection to support waste collection and disposal is a major challenge. It is also an appropriate model to jump start the solid waste services in fragile and post-conflict situations. The RBF model to promote recycling and source separation is a good model for cities in middle income countries where the collection of waste is already high but where the effort of the government is focused on improving the financial and environmental sustainability of the sector.

Module 3 - Actions for prevention and minimization of the generation of household waste

3. Introduction

Waste prevention and minimization contributes to the protection of human health and the environment; more efficient production practices; resource efficiency, reducing the need for primary resources and the resultant economic benefits; and sustainable consumption patterns.

This module focuses on the upper elements of the waste management hierarchy, namely the prevention and minimization of the generation of household waste. Prevention means any measure taken **before a substance, material or product has become waste** and that serves to reduce the quantity of waste, the adverse impacts of waste on human health and on the environment or the content of harmful substances in materials and products. Prevention may include strict avoidance, source reduction and direct reuse. Waste minimization impacts products and materials **once they become waste** and includes strict avoidance, source reduction, direct reuse, reuse and recycling.

Waste prevention and minimisation are the highest priorities in the waste management hierarchy. They are positioned as such as they eliminate or reduce the need for recycling, energy recovery or disposal, and secondly, they avoid or reduce extraction of primary resources from the environment. Waste prevention and minimization shifts waste management policy from merely an end-of-life approach aimed at pollution remediation and best practice recovery and recycling, to sustainable materials management aimed at avoidance of the depletion of natural resources, pollution and energy use.

3.1 Approaches to waste prevention and minimization

Measures developed to promote waste prevention should focus on promoting the following objectives:

(a) **Strict avoidance** involves the prevention of waste generation by elimination of the need for a product, or material, or by a reduction of hazardous substances and inputs, or by reducing material or energy intensity in production, consumption, and distribution. Strict avoidance also includes designing products for prolonged life. Waste prevention in this latter context extends the life of products and acts as a diversion of waste flows.

In terms of household waste, a strategy that promotes strict avoidance might encompass a prohibition or a ban - for example, a ban on single use plastic.

(b) **Source reduction** involves altering production processes to minimize the use of toxic or harmful substances, minimizing material or energy consumption and/or substituting primary raw materials with secondary raw materials that result from high quality recycling. Waste prevention in this context reduces or eliminates waste and pollution at source through

process changes.

With respect to household waste, source reduction includes the promotion of durable, long-lasting goods and ensuring products and packaging are as free of toxics as possible.

(c) **Direct reuse** means using a product, object or substance that is not waste for the same purpose for which it was conceived without the necessity of repair or refurbishment.

There are numerous waste fractions from households that may be appropriate for direct reuse, including textiles, furniture and electrical and electronics that are still fully functional. Charities take items in good condition for resale and donation.

As outlined in the introduction, waste minimization not only encompasses strict avoidance, source reduction and direct reuse. It also includes actions taken to promote the reuse and recycling of products and materials that have become waste. Both reuse (see module 5) and recycling (see module 6) are covered in separate modules.

3.2 Strategies for waste prevention and minimization

There are a number of strategic options available to decision makers to promote waste prevention and minimization.

Throughout the product life-cycle, decision makers should consider the following four strategic areas to promote household waste prevention and minimization:

1. **Legislate: mandating change through regulatory action**

Regulatory strategies are an important tool in promoting the prevention and minimization of household waste. They can take many forms, including creating bans and prohibitions on the production of certain products or materials (strict avoidance) as well as imposing limits on the volume of waste allowed to be generated (source reduction) or landfill bans. Industry will most often be the target of regulatory strategies as they are in the driving seat with respect to product design and composition. Consumers too may be impacted by regulatory strategies such as “Pay as You Throw” schemes, prohibitions on certain products and landfill bans for certain wastes.

Name of the best practice (title)	Household waste data registration and motivation system (ELWIS) – “Waste under control”
Type of waste (e.g. plastic, metal, residues etc.)	mixed municipal waste, plastic, glass, paper, biowaste, metal
Where does the best practice apply in the waste hierarchy?	recycling, minimising mixed municipal waste
What is the primarily target group (government, private, households)	households, municipalities

What type of activity **(e.g., on-going practice, research, etc.)**	application of pay-as-you-throw scheme, on-going practice, optimising municipal waste management, minimising mixed municipal waste production
Location (city, country)	Slovakia (pilot phase in several municipalities in 2018 and 2019)
Description of the best practice (max. 300 words)	Introduction of this private initiative based voluntary system enables municipalities to know the real state of waste management, to evaluate the costs of its operation and to take adequate measures. Moreover, the gathered data allow setting up a motivation system, which rewards the households with responsible attitude to waste separation at source. How does it work? Each container with mixed municipal waste in the involved municipality was marked by labels with a QR code original for each household. Additional labels with QR codes distributed to the households are continuously used for marking and registration of bags with the respective type of sorted waste left in front of the house for pick-up. The municipality announces the introduction of the new system and each household receives a leaflet describing the operation of the system and a starter pack of labels for separate waste streams collection with instructions on how to use them. Only full containers and bags with separately collected waste streams should be left in front of the household for collection. At each collection, the labels are scanned by a handheld device. Gathered data is processed in a simple application and the municipality knows exactly where the waste is generated, the respective amounts and the level of separation at source. Based on this, direct steps to improve the functioning of the entire waste management can be taken. The aim is to motivate the households to divert waste that can be sorted and to minimise the amounts of mixed municipal waste and costs related to transport operations and landfilling. If the household separates the waste and the full container with mixed municipal waste is pulled out e.g. only once a month instead of using the 14-days

	collection period, the respective household is rewarded by fee reduction instead of paying a full fee. The analysis before introducing the system showed, that up to 40% of the volume of containers with mixed municipal waste is biodegradable and paying for its collection and transport to landfill is irrational. The data evaluation enables effective and targeted application of incentives and education for increasing the home composting and thus reducing the burden for waste collection and processing. The whole initiative results in saving finances for municipal waste management and improving the source separation. Advantages offered: - increased separation at source - real data gathering - motivation and reward system - revealing gaps - saving the budgeted resources
Explanation of key insights (e.g. potential drivers and barriers, lessons learned) for successfully replicating this best practice (max. 200 words)	Primary costs and education, as well as suitable equipment and software are initial requirements for application of the system. Also, the system is applicable only in the areas where kerbside collection of mixed municipal waste and recyclables is established. Evaluation of the data and comparing the same months between years 2018 and 2019 revealed decrease of mixed municipal waste production of up to 20% in the involved municipalities. Further analysis will be made based on the data reported at the end of the year. Incentives provided and motivation of the households under this system will be continuously improved. Similar systems of municipal waste data gathering are used in many variations in other countries. One example with a specific approach to the motivation aspect is a system called “Motivation and registration system for waste management” (MESOH), which is used by the voluntarily involved municipalities in Czech Republic.

	The motivation system consists of awarding the residents by “ECO points” for overall approach to their waste management in a concrete time period. ECO points are divided into several categories: - for effective use of the containers or bags - for minimising the production of wastes - for reasonable energy consumption - for composting - for the level of involvement - for reasonable shopping - for donating unwanted things. Tracking of the score is allowed by the on-line waste account, which the residents are invited to use for the overview of their household waste management. At the end of the time period, the scoring is evaluated and converted to discounts on the fee for waste management. This initiative is used in over 100 municipalities across the Czech Republic and experiences a great success in minimising the production of mixed municipal waste.
Sources of information	https://moderneodpady.sk/ https://www.mojeodpadky.cz/obec/

Sustainable design requirements, producer responsibility initiatives and environmental controls through permitting and take-back measures are all examples of regulatory strategies. Other regulations have sought to restrict the use of hazardous substances in new products. For example, the European Union directive on the restriction of the use of certain hazardous substances (ROHS) seeks to ensure that electronic products sold on the European market contain less hazardous substances.

The following section outlines the most commonly used regulatory strategies to promote the prevention and minimization of household waste.

a) Planning measures

Planning measures may include:

- Disposal bans through which wastes may be excluded from landfill which obliges producers to recycle materials or eliminate them from production processes;
- Stringent environmental permitting requirements, requiring business and industry to ensure waste generation is minimized and waste that can’t be avoided is properly sorted for reuse, recycling and if needed, final disposal;
- Pay-as-you-throw systems with variable rate pricing for waste collection by weight or volume which ensures the consumer is responsible for the products they buy and the waste they generate;

- Support for research and development on consumer behaviour, socio-economic demographics, resource efficiency and sustainable materials management.

b) Taxes and incentives

Regulators may consider a package of taxes, fees and charges to incentivize actions towards waste prevention and minimization, including:

- Taxes and fees levied on specific waste streams or on final quantities of waste collected (such as in pay-as-you-throw systems);
- Tax exemptions or incentives for reuse and repair centres to promote reuse and repair;
- Subsidies or incentives that serve to promote eco-efficient products in the market.

c) Extended Producer Responsibility (EPR) policies

Extended producer responsibility (EPR) is a policy instrument whereby producers take financial responsibility for their products once they become waste. EPR policies aims to shift some of the costs of disposal back to producers, thereby stimulating investment in material efficiency to reduce the quantity of waste generated, and in eco-design, to extend the lifecycle of products and materials.

Further information on EPR can be found in the Basel Convention practical manual on EPR and financing: http://basel.int/Implementation/CountryLedInitiative/EnvironmentallySoundManagement/ESMToolkit/Overview/tabid/5839/Default.aspx.

d) Eco-design requirements

Eco-design means producing goods and services that use a minimum level of resources and have a minimum impact on the environment and society. Those engaged in eco-design commit to certain principles in product design and development, including:

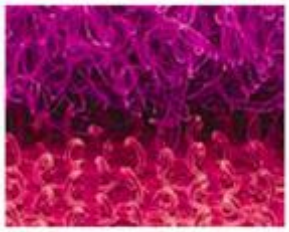
- using materials with less environmental impact
- using fewer materials overall in the manufacture of products
- using fewer resources during the manufacturing process
- producing less pollution and waste
- reducing the environmental impacts of distributing products
- ensuring that products use fewer resources when they are used by end customers
- ensuring that products cause less waste and pollution when in use
- optimising the function of products and ensuring the most suitable service life
- making reuse and recycling easier
- reducing the environmental impact of disposal

In addition, governments may select particularly problematic waste streams, for example, electronics, and apply a supply side policy, such as an eco-design requirement to increase the durability, reparability and recyclability of products that would otherwise be landfilled.

Some examples of eco-design products include[3]:

	**The body raft** uses local elm wood and contributes to the local economy. If it is sold outside of the region, the lightweight chair is inexpensively shipped. David Trunbridge, New Zealand 4 Efficient distribution		**This iron pot's** aesthetic and material quality references both the past and the future. By Timo Sarpaneva, Finland: 5 Optimized lifetime
	**The Celle chair** by Herman Miller uses fewer material types, reduces production costs and enables easy disassembly for recycling: 3 Optimized manufacturing 7 End of life		**The IXI bike** is a compact urban vehicle that encourages pedal-powered trips and mass transit, thereby reducing CO2 emissions and traffic congestion: 5 Low-impact use
	**Dyson Dual Cyclone Cleaner**, bagless vacuum technology 5 Low-impact use		**The Karcher power washer** uses few types of material and easy disassembly for recycling: 7 Optimized end-of-life

[3] Sustainable Minds LLC https://app.sustainableminds.com/learning-center/ecodesign-strategies/examples-of-ecodesign-strategies

	**MP3 technology** (such as the Apple IPod) affords efficient distribution of digital content, eliminating impacts from packaging and shipping: 1 Innovation 4 Efficient distribution		**This sun-powered robotic lawn mower** grooms up to 1440 square yards every few days. By Husqvarna, Electrolux, Sweden 5 Low-impact use
	**This lightweight polypropylene beer keg** keeps the beverage fresh while minimizing transportation weight and emissions. The Netherlands 4 Efficient distribution		**Used water from the sink** is re-used in the toilet, reducing overall water demand: 5 Low-impact use
	**The Prius** automobile not only uses energy efficient regenerative braking technology; its console teaches drivers how to drive more efficiently. By Toyota 5 Low-impact use		**The Sloppy Joe boot** is compostable. It is constructed entirely from leather, biodegradable glues and plant fibers. By Simple Shoes 7 Optimized end-of-life
	**The Velo taxi** is a modern rickshaw that reduces traffic and CO2 emissions. Designed in Berlin. 5 Low-impact use		**Velcro** mimics the structure of seedpods that cling together. 1 Innovation: biomimicry

2. Educate: Public awareness to encourage behavioural change

Actions for the prevention and minimization of household waste must involve a change of

societal patterns that relate to production and consumption. Creating awareness amongst the general public as well as the business community is fundamental to changing behaviour and introducing new attitudes and habits to the way people consume resources and generate household waste. Sharing practical information and guiding tools about how individuals or companies can prevent and reduce waste in their daily lives, is a critical first step.

Actions undertaken in the area of education and public awareness may involve the following:

a) Access to information on chemicals in products

Greater access to information and knowledge of flows, risks and the management of chemicals in products will improve the possibilities for substitution of hazardous substances and enable producers, suppliers and consumers within the supply chain to make informed choices.

A link may be made to the Chemicals in Products (CiP) Programme[4], a global programme providing information on hazardous substances in products that has been developed within the framework of the UN Strategic Approach to International Chemicals Management (SAICM). The goal of the CiP Programme is for stakeholders to have access to information on chemicals in products to assist them in making decisions and taking appropriate action on chemicals exposure, risk and management.

b) Awareness raising campaigns

Awareness raising strategies for the public employed by governments, NGOs, industry and other stakeholders have been widely successful in transferring knowledge about life-cycle, environmental and other benefits. Information campaigns about prolonging product use, through choosing durable rather than disposable products, like refillable water bottles, reusable tea or coffee cups or reusable shopping bags are but one example. Such information campaigns are a prime example of where public awareness activities over the past decade have led to a transformational shift in attitudes and behaviours away from single use bags or containers. Another example is the policy of some schools to provide drinking water to their students and urging them not to bring packaged beverages to school. Further information on awareness raising campaigns is available in module 9 on awareness raising.

Name of the best practice (title)	Expiry dates
Type of waste (e.g. plastic, metal, residues etc.)	Organic
Where does the best practice apply in the waste hierarchy?	Avoid and Reduce waste

[4] For further information: http://www.saicm.org/Default.aspx?tabid=5473.

What is the primarily target group (government, private, households)	Households
What type of activity (e.g., on-going practice, research, etc.)	On-going
Location (city, country)	European Union
Description of the best practice (max. 300 words)	According to the Waste and Resources Action Programme, planning meals in advance; checking cupboards before shopping; making a shopping list; storing meat and cheese in appropriate packaging; storing all fruit (except bananas) in the fridge; freezing food; portioning rice and pasta; using leftovers and labelling dates on food help to reduce household food waste.
Explanation of key insights (e.g. potential drivers and barriers, lessons learned) for successfully replicating this best practice (max. 200 words)	Socio-demographics (age, education and occupation); behaviour (perceptions of the need for improved information about 'best before' and 'use by' date labelling on food products and understanding the labels; frequency of checking date labels when shopping and preparing meals) influence food waste reduction. The study found that younger participants tend to misinterpret 'best before' labels and consequently waste food while older participants are more likely to misjudge "use by" dates. This practice may lead to health implications. Attention should be placed on the unnecessary use of date labelling on non-perishable food items such as rice and pasta.
Sources of information	https://link.springer.com/article/10.1007/s12351-017-0352-3

c) Information on waste prevention and minimization processes and techniques

Information sharing can sometimes be all that it is needed to initiate waste prevention technologies and management processes. For example, in a cleaner production programme in Thailand, students of a number of universities acted as interns in private enterprises to assess and make recommendations on how to reduce resource inputs, energy and waste. This was an educational programme for students while at the same time raising awareness among producers. It is often the case that waste prevention results in greater efficiencies and reduced disposal costs. Part of the awareness raising then involves explaining the return on investment to process and product changes. Much work has already been done examining industrial processes for their waste prevention potential. These efforts are often characterized as clean or cleaner production.

d) Education and training programmes for employees and other stakeholders

The inclusion and support of stakeholders is integral to the success of waste prevention programmes. All employees and other stakeholders responsible for the implementation of the programme should receive an appropriate level of training.

e) Eco-labelling

Eco-labelling is another important example of a tool to raise public awareness. Eco-labels help consumers identify environmentally preferable products through voluntary labelling programs. Product labels advertising less use of toxic or harmful inputs into products such as lead-free paints, phosphorous-free detergents and mercury-free light bulbs or thermometers are all examples. Report cards grading consumer products on environmental impacts is another similar approach. The Electronic Product Environmental Assessment Tool (EPEAT)[5] provides a comprehensive registry of computer equipment brands and models that use less toxic inputs among other environmental criteria. It identifies "sustainable electronics" such as computers, displays, imaging equipment and televisions. Consumers are thus conveniently and accurately informed to be able to easily make choices which prevent and minimise hazardous waste.

3. Motivate: Measures that incentivize change or disincentivise the status-quo

a) Support for voluntary agreements

Voluntary commitments to waste prevention targets are generally sector specific, highly effective in achieving agreed goals and increase public awareness of the issue. Voluntary agreements, as defined in the EU Packaging Waste Directive, entail a "formal agreement concluded between the competent public authorities of the Member State and the economic sectors concerned, which has to be open to all partners who wish to meet the conditions of the agreement". In the absence of national targets for waste prevention, support through funding, promotion activity and logistical support for voluntary agreements is highly recommended. For example, the UK Government's Courtauld Commitment[6] is a voluntary agreement aimed at improving resource efficiency and reducing waste within the UK grocery sector.

b) Promotion of reuse, refurbishment and repair

Reuse and repair centres provide a crucial service by extending the life of a wide range of consumer products and have significant potential in diverting consumer waste from landfill. They are often operated by social integration enterprises working with disadvantaged groups such as the long-term unemployed, who are trained in technical repair skills, thus also serving a social function. Effective promotion of reuse and repair is strengthened by the provision of early access to the waste streams for reuse centres, as well as appropriate handling and storage conditions. This is part of 'preparing for reuse' in the waste hierarchy and supports the overall aims of waste prevention.

c) Promotion of environmental management systems

An environmental management systems (EMS) is a tool providing a structure for evaluating an organisation's environmental impact, and aids in increasing material efficiency, long-term planning and often in reducing costs. A proliferation of EMSs is the key tool in addressing

[5] https://www.epeat.net/
[6] http://wrap.org.uk/content/what-is-courtauld

business, packaging, industrial and construction and demolition waste. The EU EMAS tool can be widely promoted at larger administrative levels; local authorities may choose to develop or promote simple evaluative tools for specific sectors. Concordia University in Canada, for example, uses a waste and recycling audit tool[7] that analyses campus waste output with the help of student volunteers.

d) Sustainable consumption and production incentives

Clean consumption incentives differ from taxes as economic instruments by motivating waste preventing behaviour without imposing a penalty. The Business Waste Prevention Fund of Alameda County in California[8], for example, offers a stipend of up to $100,000 for investments in waste prevention projects. Successful recipients have purchased reusable shipping and packaging materials that have created huge annual financial and waste savings.

e) Promotion and dissemination of research and development

Research efforts can help national authorities and decisions makers identify priorities, frame waste prevention programmes to address major issues and select suitable integrated and sustainable waste management systems. Investment in economic and social research formed the first phase of development for the National Waste Prevention Programme of Ireland, organised through the EPA STRIVE Programme[9]. Their annual National Waste Report helps to inform waste prevention policy and provides detailed information on the composition of municipal waste streams.

4. Innovate: Promoting, funding and rewarding innovation

a) Design for the environment

Design for the Environment, or eco-design, is a design approach to reduce the overall human health and environmental impact of a product, process or service, where impacts are considered across its life cycle.

For further information, see the eco-design section above.

b) Promoting alternative materials

Developing new materials considering sustainability, such as biodegradable plastic, compostable plastic or bio-based plastic, should be promoted. Research and design, in particular, impact assessments of a material's life-cycle, and its integrated design for reuse, repair, disassembling (when appropriate), recovery and recycling, should precede production and delivery of services.

---

[7] https://www.concordia.ca/campus-life/sustainability/zerowaste/wasteaudits.html

[8] http://www.stopwaste.org/about/news/grants-available-alameda-county-nonprofits-waste-reduction-programs

[9] https://www.epa.ie/researchandeducation/research/researchpublications/strivereports/

c) Product longevity and product services

Product longevity and strict avoidance can be enhanced by promoting the leasing of products rather than selling them. Businesses that lease rather than sell products have more of an incentive to ensure a product's durability, longevity and reduced impact as they retain ownership at the end of the lifecycle.

Further information on prevention and minimization can be found in the Basel Convention Guidance to assist Parties in developing efficient strategies for achieving the prevention and minimization of the generation of hazardous and other wastes and their disposal: http://basel.int/Implementation/CountryLedInitiative/EnvironmentallySoundManagement/ESMToolkit/Overview/tabid/5839/Default.aspx.

3.3 For waste that cannot be prevented or minimised

The separation of waste at households is an essential step in a cost effective and environmentally sound waste management strategy. Proper sorting directly supports material recovery as it results in the production of a homogenous and ultimately higher value waste stream. Source separation can enable the processing of certain waste streams higher up the waste hierarchy than would otherwise be possible in a mixed waste stream. It is extremely important when high quality material is required such as organic wastes which can produce compost and mulch.

Some Practical tips for householders

When buying, householders should purchase:

- unpackaged goods
- more durable products
- reusable shopping bags
- concentrated products
- goods in refillable packages

Some reduction can also occur when householders:

- repair rather than replace old, worn or broken goods
- hire, share and borrow equipment such as garden tools
- use long life bulbs

The next module takes a closer look at the separation, collection and transport of household waste.

Module 4 - Source Separation, Collection and Transport of Household Wastes

4. Introduction

This module provides guidance on mechanisms for source separation, collection and transportation of separated and commingled household wastes and onsite separation.

In order to capitalise on the valuable components of generated waste streams, countries should first conduct a waste characterisation assessment to determine the quantities and types of wastes being generated, establish collection systems and material recovery mechanisms for various waste streams based on available resources, and promote source separation through increased public awareness on the risks and value of certain waste components. Further separation of waste streams could be facilitated through the development of waste sorting facilities and Material Recovery Facilities (MRFs).

The separation of material is performed by the users at the source or separated from mixed refuse at a central processing facility. Material separation at the source involves users separating the material into different components, followed by transporting from the point of generation to a secondary material dealer

After on-site storage in the household, the next step in the process is collection. The primary collection is the collection of waste from the point where the waste is produced. In some cases, these collection points can be located outside of an individual household, with communal containers serving several households or a general waste bin/skip that takes waste from households in the surrounding areas. With the encouragement of source separation at the household level, the communal containers can be labelled and separated according to certain waste streams, often recyclables and non-recyclables. Certain collection days can be allocated for different waste types and drop-off sites can be identified and coordinated for the waste streams not included in the collection system, i.e. bulky waste and electric and electronic waste.

The collected waste may be taken to a final disposal site or sorting facility, material recovery facility or to a transfer station which is contingent on the collection vehicle and the distance to the site. Secondary collections can occur where the waste from a number of primary collections is taken from the transfer station to the final disposal site.
The appropriate frequency of collection will depend on conditions. As biodegradable waste (especially food waste) decomposes much faster (and may potentially attract disease spreading insects) at higher temperatures and humidity, under these conditions more frequent collection may be required. In some cities such as Shanghai, multiple daily pickups are available.

4.1 Source Separation

4.1.1. Overview

Source separation includes separating of household waste into different material streams or categories of material streams for separate collection and transportation. This may be achieved using separate bin collection services, bulky waste collection services, or through direct delivery of specific wastes to drop-off facilities. Household materials commonly targeted for source separation include:

- biowaste (such as food waste and garden waste)
- packaging (such as cardboard, glass, plastics and aluminium cans)
- office paper
- reusable items (such as textiles and clothes, household items and appliances)
- hazardous wastes (such as paint, batteries, chemicals and biomedical items).
- construction and demolition waste (such as concrete, bricks and timber)

Benefits:

Separation of waste at households, is an essential step in a cost effective and environmentally sound waste management strategy offering the following benefits:

- Proper sorting of waste at source directly supports material recovery since could lead in the production of a homogenous and less contaminated materials which are easier and less costly to recover.
- Source separation can enable the processing of certain waste streams, such as food waste higher, up the waste hierarchy than would otherwise be treated as mixed waste.
- Source separation can also enhance behaviour change of households towards waste preventions, recycling and also consumption patterns.

Barriers:

Separating household waste is challenging in many countries due to several factors including:

- Rapid urbanisation and increased use of packaging materials
- Absence of an enabling environment to facilitate sorting at the household level
- Absent of recycling infrastructures in place

4.1.2 Source separation patterns

Source separation patterns are classified by:

- The stakeholder that performs the collection (public, private, informal collection)
- Targeted waste (Recyclables, organic waste, bulky waste, non-combustibles, hazardous waste etc.)
- The stakeholder that performs the separation. (household, community, informal sector)
- The charging system (see Module 2 for more information)
- The collection method (see below)

A household waste separation scheme could focus on either a multiple waste stream source separation scheme (See Figure 4.1) or limit source separation to only two waste streams (See Figure 4.2). The latter could be the case in developing economies where resources may be limited. Therefore, the source separation may be confined to only two streams such as wet and dry waste only or as much as five (5) streams including wet, dry, sanitary, hazardous and garden waste as detailed in Figure 4.2.

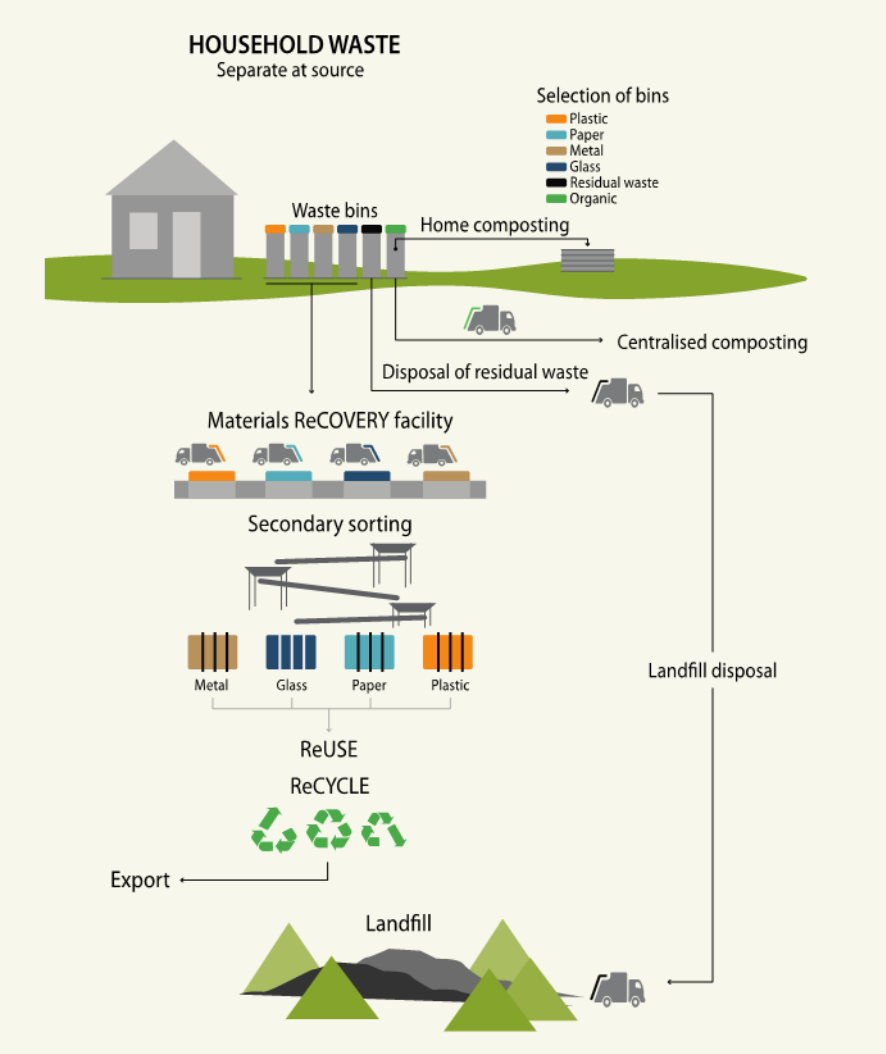


Figure 4.1. Steps showing different scenarios for source separation, collection and transport

Figure 4.2 Source separation of five material streams suitable for developing economies

Shanghai waste sorting strategy

On 1 July 2019 the Chinese municipal government in Shanghai replaced the voluntary two-tier waste sorting system with a mandatory four category system. All residents, businesses and government bodies are now required to sort waste into labelled bins for recyclable, hazardous, residual, and organic waste.
Fines apply for improper sorting - approximately US$29 for residents, and up to US $7,000 for businesses and institutions with increases for repeat offenders (a number of fines were issued on the first day of the new system). To support the system, the city has installed more than 40,000 public waste bins.

The waste sorting is part of a strategy that includes an ambitious recycling target of 35% by 2020 - currently in Shanghai 36 % of domestic waste is incinerated (with energy recovery) and 50% goes to landfill, with less than 10% being recycled. There are also initiatives to minimise and prevent waste, such as a ban on automatically providing hotel guests with disposable toiletries and restaurant patrons with disposable tableware. Social media enabled waste-sorting networks and renewable-resource recycling networks are also being developed.

There are 46 Chinese cities currently involved in household waste sorting pilot programs that should be operational by 2020. The Chinese government is investing US $ 3.1 billion to build additional waste facilities in these cities.

Organic Waste

In developing countries, economies in transition and small island developing states (SIDS), organic fractions form the largest part of the waste generated and usually range between 50% to 70% of the total waste volume. In high-income countries organics typically account for between 20% to 40% (ref).

Organic waste comes primarily from kitchen waste – fruit and vegetable peelings, food scraps and leftovers and garden waste – grass cuttings, hedge clippings, leaves and branches, flowers etc. Although organic waste is biodegradable, it can still have adverse impacts on landfills. It attracts scavengers such as feral animals and birds and the liquid released during breakdown can carry harmful chemicals from other non-biodegradable waste items into water systems and the soil. Further, organic waste that is dumped in a landfill, undergoes anaerobic decomposition and subsequently generates methane.

Organic waste is a valuable resource that can be turned into compost for home gardeners or collected by the municipality for larger scale compost production. In the absence of home composting, bins for storage and curb side collection of separated organic wastes are often provided by the municipality, in an effort to divert organic material from going to landfilling as a component of mixed residual waste. Advanced systems also include the use of compostable bag liners, which increase the ease of handling wastes and are fully biodegradable.

Contamination of organic waste with other household waste is an issue in the production of compost. The use of clean source-segregated organic material is preferable, and essential if the (composted) digestate is to meet end of waste criteria and be used for food production. In developed countries, regulations allow the use of waste-derived composts for food production, only if clean source-separated feedstock is used. For an organic fraction separated mechanically from either mixed municipal solid waste or from residual solid waste, such as at a mechanical biological treatment plan, he digestate can go through a composting (maturation) step and be used as a compost-like output, however contamination is also a major issue in this process.

Terrace Farming in plastic bottles (Ram C. Sah, CEPHED, Nepal)

4.2 Primary and Secondary Collection

4.2.1 Overview

Primary waste collection is the collection and transport of household waste from point of generation to transfer points or community bins[10,11], while secondary household waste collection is the collection and transportation of waste from transfer points of community bins to waste treatment or disposal sites[10] .

4.2.2 Waste collection methods

Waste collection services may be performed on a small scale, providing primary collection on neighborhood level, or on a larger scale, providing either secondary collection or integrated collection services on a municipal level[15]. While the main systems can be distinguished in collect systems and bring systems the most common systems are:
Most common waste collection methods are[10,12]:

- Door-to-door collection systems: household wastes are frequently collected mixed (co-mingled) or as source separated (single streams) in bags, bins, containers collected directly from the households.
- Bring points: Householder brings their waste at community binds and/or containers placed at public fixed points.
- Civic amenities / Civic amenity sites/Green points: Citizens could bring recyclables and special waste such as hazardous household waste, bulky waste, waste of electrical and electronic equipment, used batteries, construction and demolition waste, solvents, paints etc. to
- Deposit and return: typically applied on beverage bottles (cans) made of glass, plastic, (metal)

4.2.3 Frequency of collection

Frequency of waste collection is defined as the number of times in a week or a month that waste is collected[14]. In general, the frequency of waste collection shall be higher in developing countries than in temperate industrialized countries, and the frequency shall be acceptable to the residents, otherwise waste may be dumped in the streets. Some communities are accustomed to a collection seven days a week, whilst other collection agencies are striving for just once each week. If fly breeding is to be controlled, the waste should be collected twice a week in hot climates. Other factors to consider are the odours

[10] C. Zurbrügg, "Urban solid waste management in low-income countries of Asia: How to cope with the garbage crisis," Present. Sci. Comm. Probl. Environ. Urban Solid Waste Manag. Rev. Sess. Durban, South Africa, no. July 2013, pp. 1–13, 2003.
[11] D. Hoornweg and P. Bhada, "What a Waste. A Global Review of Solid Waste Management," Urban Dev. Ser. Knowl. Pap., vol. 281, no. 19, p. 44 p., 2012.
[12] BiPRO/CRI 2015, Assessment of separate collection schemes in the 28 capitals of the EU, Final report, November 2015, Available at: http://publications.europa.eu/resource/cellar/2c93de42-a2fa-11e5-b528-01aa75ed71a1.0001.01/DOC_1

caused by decomposition and the accumulated quantities. If residents are accustomed to daily collection it may not be politically feasible to reduce the frequency to twice a week. In some cities waste may collected on the day of rest (Sunday or Friday). Some may collect waste at night, perhaps for cultural reasons or because of the weather or traffic congestion[13]. It is very desirable that the frequency does not vary, so that householders and shopkeepers know when their waste will be collected. Small adjustments to collection frequency may be needed because of public holidays, and it is important that generators are informed of these changes in advance[14] [20].

4.2.4 Waste collection service charge

A waste collection service charge (WCSC) for mixed waste can be designed to encourage households to reduce their waste load by recycling and composting, whilst financing local authorities[15]. In designing a WCSC, charging method, payment vehicle, features of service package and challenges in implementing should be considered. Charging method can be:

1. a flat rate (fixed): the same tariff is applied to all households [16, 15].
2. quantity based charge: where households are charged according to the amount of waste (weight or volume) or frequency of collection[17],[15].
3. variable charge differentiated according to household income: Different charge categories or proportionately rising charges bases on water/electricity consumption or size of the household or residential area[18]
4. combination of options 1 and 2 or 1 and 3.

For more information on waste service charge please refer to Module 2 of the Technical Guidelines.

4.3 Equipment of Waste Storage, Collection & Transportation

4.3.1 Overview

A widespread problem which continues to plague solid waste services especially in developing economies is the use of inappropriate equipment for waste storage, collection and transportation that might not work for all type of waste and areas and also current transfer capacities along with waste collection frequency are not enough leading in many cases in

[13] Centre for Integrated Urban Development Services, "Micro and small enterprises involvement in municipal solid waste management in developing countries: workshop papers," pp. 14–18, 1996.
[14] UN-HABITAT, Collection of Municipal Solid Waste in Developing Countries. Nairobi, Kenya, 2010.
[15] U. N. E. P. (UNEP) and I. S. W. A. (ISWA), Global Waste Management Outlook. 2015.
[16] E. Gunsilius, "Economic Instruments in Solid Waste Management," Dtsch. Gasellschaft für, 2012.
[17] United Nations Environment Programme (UNEP), SOLID WASTE MANAGEMENT: (Volume I). 2005.
[18] E. Gunsilius, "Economic Instruments in Solid Waste Management," Dtsch. Gasellschaft für, 2012.

overfilled vehicles and uncollected waste. [19,37] Selecting adequate waste storage, collection and transportation equipment in terms of type and size could potentially increase collection efficiency of waste in terms of volume collected and cost of logistics.

4.3.2 Storage means

Primary waste storage means could be temporary containers, such as cardboard boxes, plastic bags, baskets and a range of different types of waste bins (plastic bins, oil drums, galvanized bin, etc.), that could be placed within households.
Secondary -community waste storage means are waste bins, carts and/or containers that are filled either directly by the householders or by primary collection vehicles (such as tricycles or handcarts) and could be either stationary (fixed) or portable[14].
A secondary storage waste bin or other storage facility (fixed or portable) must satisfy a number of requirements[14]:

- The storage volume must be adequate to the needs of the implemented waste management program. Size of the storage means depends on the type of waste collected, family type and collection frequency.
- Loading of the waste into the collection vehicle should be economical hygienic and safe.
- The containers should be sufficiently durable, resistant to mechanical damage, corrosion, etc.
- Storage means much secure that there is no access to the waste animals (e.g. rats) and insects (e.g. flies) flies and is protected from weather conditions such as heavy rain falls.

[19] N. Yukalang, B. Clarke, and K. Ross, "Barriers to effective municipal solid waste management in a rapidly urbanizing area in Thailand," Int. J. Environ. Res. Public Health, vol. 14, no. 9, pp. 9–14, 2017.

Bag for mixed waste [20]	Blue bag for recyclables [21]	Compostable bag for organic waste [22]	Box for recyclables[23]
			
Household waste recycling bags[24]	Metal or plastic cans	Rear loading cart/bin (small –medium)[25]	Rear loading bin (large)[26]
			
Bell-shaped recycling bin for glass [27]	Underground waste bins[28]	Front-end loader bins[29]	

Examples of household waste storage means

4.3.3 Collection and transfer vehicles

The size and type of vehicles used are normally determined by the level of service desired, the amount of waste generated, and the type of waste being collected. In case there is a need to upgrade the waste collection system in place then it might be needed to change the existed storage containers so as to match the vehicle selections.

[20] https://www.voussert.com/black-trash-bag-150-liters-strengthens-package-100-fp-13536.html

[21] h https://www.gerdmans.no/lager-og-industri/milj%C3%B8-og-avfallsh%C3%A5ndtering/avfallsdunker-s%C3%B8ppelb%C3%B8tter/s%C3%B8ppeldunk-240-liter-med-lokk-og-hjul-gr%C3%B8nn?gclid=EAIaIQobChMItpHTq4O35QIVB6maCh3FNgpoEAQYAyABEgKg3_D_BwE

[22]https://www.google.com/search?q=Compostable+bag+for+organic+waste&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjx-cWChbfIAhXmsosKHbB-CwwQ_AUIEigB&biw=1745&bih=881&dpr=1.1#imgrc=yXM54YpIYbwaZM:

[23] https://www.teignbridge.gov.uk/recycling-and-waste/bin-collections/what-goes-into-my-bins-and-boxes/green-recycling-box/

[24] https://www.lakeland.co.uk/25100/3-Household-Waste-Recycling-Bags-44L-each

[25] ttps://www.amazon.com/Recycling-Trash-Gallon-Garbage-Tasker/dp/B0771WR2C7

[26] http://www.gekasmetal.gr/wme/ru/?p=344

[27] http://greendot.com.cy/en/public/how-should-i-recycle

[28] https://www.molok.com/molok-products/molokclassic

[29] https://www.artemeswaste.co.uk/services/front-end-loaders-fels/

			
Hand carts/ trolleys [30]	Waste collection tricycle[31]	[32] Tricycle waste collection vehicle (electric)	Enclosed light truck[33]
			
Rear Loader Compactor	Semi- automated Rear Loader	Side Loader Compactor	Automated Side Loader[34]
			
Front-end loader[34]	Dual Compartment Rear Loader	Open-top Self-unloading Trailers -Top loading transfer stations	Compaction Trailers- Compactor transfer stations

4.4 Transfer stations

[30] https://www.thesheetalgroup.com/trolley-bin
[31] https://grabcad.com/library/rikshaw-1
[32] https://www.alibaba.com/product-detail/Electric-garbage-tricycle-three-wheel-trash_60709138674.html
[33] https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=80575&printable=1
[34] https://en.wikipedia.org/wiki/Garbage_truck

4.4.1 Overview

Transfer points or stations are facilities where household waste is unloaded from small collection vehicles or containers into larger or faster vehicles for long-distance transportation to final disposal sites or facilities[35].
There are two main reasons for constructing a transfer station:

- *Economics:* A transfer station or point needs to be considered when destination of the wastes is far away from the area in which they are collected in order to improve costs of logistics.
- *Service:* For municipalities without a waste collection service in place, a transfer station is often provided as a service to residents, so that they do not have to drive far to drop off their wastes.

Benefits:

- Transfer stations make solid waste collection more efficient and reduce overall transportation costs, air emissions, energy use, truck traffic, and road wear and tear.
- Modern transfer stations designed to collect wastewater, control spills, and minimize blowing litter, odor, and dust have a minimal impact on the environment.

Barriers:

- *Environmental*. Transfer station could be source of pollution from blowing litter, dust, spills, if operation is not controlled. In addition, transfer stations may attract of vectors such as rodents, insects or birds. It is therefore important that operators of the transfer station shall monitor and control daily operations to limit environmental and health hazards.
- *Safe working*. Scavenging at transfer stations in developing economies could be a serious challenge to the operation of transfer stations and so should be prohibited. However, if special arrangements have been made to set aside an area for the drop-off and safe storage of goods and materials, then controlled salvaging should be encouraged36.

4.4.2 Transfer station systems

Transfer stations could be divided in two basic categories which are:

- *Open top transfer stations* at which *waste is* either unloaded directly into the "open top" of the trailer or on the tipping floor to allow for materials recovery and waste inspection.
- *Compactor transfer stations* which have stationary compactors using a hydraulic ram to compact waste and increase capacity of transfer trailers.

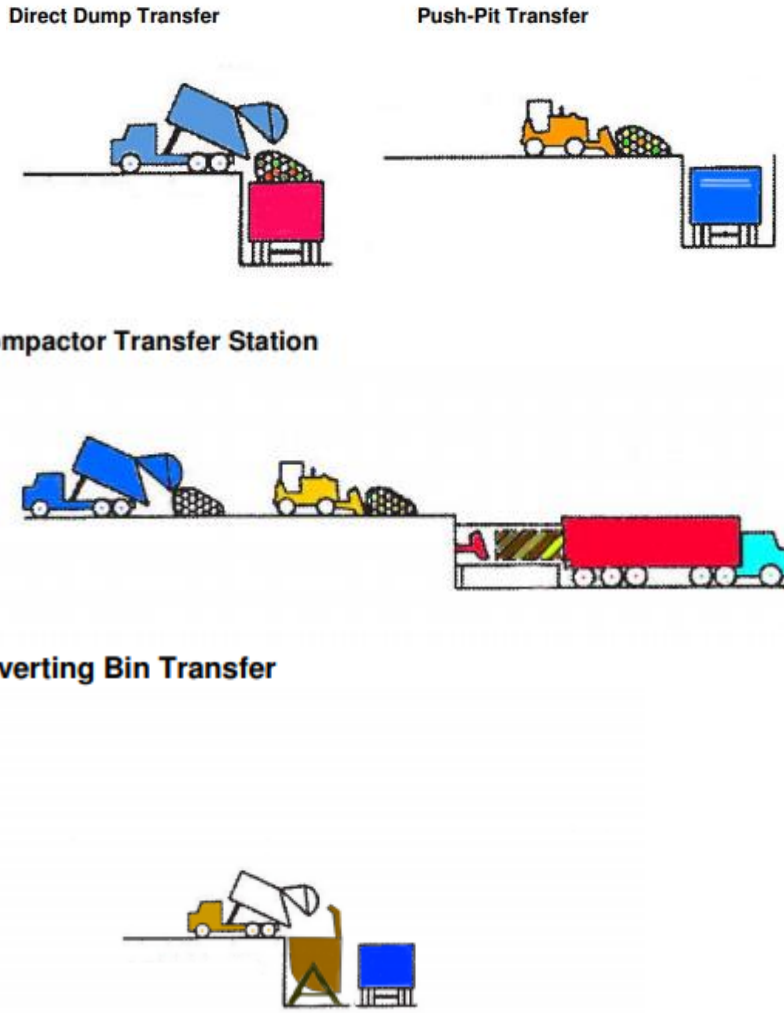
In addition, based on the equipment transfer stations may be either fixed (stationary) or mobile.

---

[35] S. Kumar, Municipal solid waste management in developing countries, 1 edition. CRC Press, 2016.
[36] Guidelines for Establishing Transfer Stations for Municipal Solid Waste, Section 4: Operational Guidelines. Available at: https://www2.gov.bc.ca/assets/gov/environment/waste-management/garbage/guidelinesestablishingtransferstationsmunicipalsolidwaste.pdf.

Below some of the most common systems of transfer stations around the word.[37]

- *Direct discharge transfer stations*: waste is unloaded directly into the transfer vehicle or container from the collection truck
- *Inverting bin system*: waste is unloaded into a bin that in turn empties into the transfer vehicle
- *Push-pit transfer station*: waste is unloaded from collection vehicles onto a concrete floor (tip floor) then pushed into the transfer vehicle.
- *Compactor transfer station:* waste either unloaded directly into compactor feed hopper or onto a tip floor and pushed into the feed hopper; compactor loads into the transfer vehicle



[38]

[37] United States Environmental Protection Agency, 2002, Waste Transfer Stations: A Manual for Decision-Making. Available at: https://www.epa.gov/sites/production/files/2016-03/documents/r02002.pdf

[38] Source of photos: http://aep.alberta.ca/waste/waste-facilities/documents/AlbertaTransferStationGuidance-Sep2008.pdf DO NOT PUT AS A SOURCE

4.4.3 Design considerations

Transfer stations should be carefully located, designed and operated to avoid problems from dwellings nearby, creating no environmental or health hazard [35]. Basic considerations that need to be taken into account into the design phase of a transfer station are in brief:

- Types of transfer stations (see section 4.4.2)
- Transfer station equipment that could be either fixed or mobile.
- Site layout concerning size unloading area, access, storage for peak volumes etc.
- Location in terms of distance from collection area and final disposal sites, minimum public objections, convenient haul routes, etc. Often transfer stations are established at a landfill site after it has been closed and rehabilitated because residents have already connected the location to waste management activities.
- Capital and operation costs need to be taken into account.

4.5 Secondary sorting

4.5.1 Overview

When recyclable materials are not recovered at household level, it is advised to sort waste for recycling at waste sorting units or at transfer stations prior to disposal. Sorting could be either performed manually or mechanically. In emerging economies, the material's value alone can be sufficient to drive formal or informal collection and sorting of some waste fractions, mainly manually[14].

Waste sorting facilities work in parallel with the waste collection infrastructure and act as a means to further segregate waste in order to obtain sorted material fractions that can be diverted directly into manufacturing or sold as commodities on the local or global market, while simultaneously reducing the volume of waste to final disposal.

Sorting could be either manual or automated/mechanical. The sorting technique that would be applied dependents upon the type of waste input, and the plastic recycling market in place. In the Global South, manual and/or low-tech solutions for sorting waste are the common practice in sorting waste due to the fact that these countries could not afford on applying more sophisticated techniques due not only to capital costs, but also to labor costs and maintenance programs. Countries of the Global North, with better market structures applies more sophisticated technology-based sorting solutions. Manual sorting operations are usually part of the mechanical sorting techniques at pre-sorting stage aiming to remove unwanted or contaminated input materials and the efficiency of downstream automated process. In addition, manual sorting applies in quality controls at the end of the sorting process to ensure that sorted plastics meet the technical specifications of the market[39].

Sorting facilities require a critical mass in order to ensure that they are sustainable and economically viable.

[39] McKinnon, D., Fazakerley, J., Hultermans, R., (2017), Waste sorting plants – extracting value from waste, Vienna, Austria: ISWA

Benefits:
Secondary sorting is essentially required in order to:

- Store recyclable material for reuse separately;
- Ensure that waste which can be processed for recovery of material and energy (through suitable technology such as composting) does not become co-mixed with undesirable elements;
- Store hazardous material for disposal in hazardous waste landfills or appropriate processing separately;
- Minimise the waste and ensure reduction in landfill space for final disposal.

4.5.2 Shorting at Material Recovery Facilities (MRFs)

Material Recovery Facilities can further separate clean, source segregated dry materials for either recycling or to produce fuel. They may use automated or manual sorting systems or in some cases a combination of the two systems. These MRFs are used widely in the developed countries in conjunction with the source separation of the mixed recyclables. The MRF receives, separates and prepares recyclable materials for marketing to end-user manufacturers. The main function of the MRF is to maximize the quantity of recyclables processed, while producing materials that will generate the highest possible revenues in the market. MRFs can also process wastes into a feedstock for biological conversion through composting and anaerobic digestion. 'Dirty' MRFs accept mixed waste from which dry recyclable materials are separated out from the organic fraction. Specific purpose MRFs are specialized material recovery facilities and these generally treat specific waste streams, such as e-waste, construction and demolition waste, or plastic waste.

Table 1:Type of input waste and sorting in developed economies

Type of input waste	Type of sorting in developing economies
Mixed municipal waste	MRFs- "dirty" sorting- removing primary metals, plastic and glass.
Mixed dry recyclables	MRFs- "regulated" sorting- removing primary metals, plastic, paper and glass.
Source separated recyclables (e.g plastics)	e.g Plastic recycling facilities – fine-sorting- removing individual material fractions

A typical sorting process includes several sorting stages to separate materials from the initial stream. The design of a sorting plan for material in the countries of the Global North may vary from place to place but typically the following sorting methods are applied (Table)**Error! Bookmark not defined.**.

Table 2: Sorting technologies per separation method that could be found in a MRF. ***Adapted from*** *Error! Bookmark not defined.*

Sorting methods	Scope	Technologies	Comments
Manual shorting	Removal of bulky items, cardboard and films	.	Employees are positioned beside the conveyor and manually remove materials

Sorting methods	Scope	Technologies	Comments
Screen	Removal of small/light 2D materials such as film, paper Removal of heavy pieces such as glass and stones	Trommel screen	An angled rotating cylinder with holes that allow waste of a given size to fall through
		Disk Screen	A bed of vertical-spaced discs that transports large waste items but allows smaller items to drop through the gaps.
		Oscillating screen	A vibrating/oscillating declined bed that allows smaller waste to pass through while transporting larger waste to the end.
Air classifiers	Removal of small/light 2D materials such as film, paper Removal of heavy pieces such as glass and stones	Zigzag air classifier	Waste is dropped through an upward air current in a zig-zag shaped flue. Light waste is blown to the top, while heavier waste falls to the bottom
		Rotary air classifier	A trommel screen separator with an air current that captures the lightweight fraction.
		Cross-current air classifier	Waste is fed on a conveyor and dropped through an air stream. The light components are blown horizontally to a collection point and the heavy components drop through.
		Suction hood	Sucks light weight waste directly from the conveyor belt.
Ballistic Separator	Removal of small/light 2D materials such as film, paper Removal of heavy pieces such as glass and stones		A steeply inclined bed with a perforated plate screen deck, with alternate vibrating elements. Light fractions are lifted by cams to the top of the bed, heavy fractions fall to the bottom
Overband magnet	Removal of ferrous metals		Magnets either lift ferrous metal from the waste, or hold ferrous metal to the conveyor while other waste is allowed to drop.
Eddy current separator	Removal of aluminum		Eddy currents are used to push non-ferrous metals with magnets into separate collection points, with non-metallic waste falling into another
Optical sorting	Removal of 2D items such as paper and cardboard from 3D items such containers	NIR (Near infrared)	Used to differentiate between plastics (PET, HDPE, PVC, PP and PS).
		VIS (Visual spectrometry)	Used to identify materials based on color.
		XRF (X-ray Flourescence)	Used to differentiate between metals / alloys (for example, copper from steel).

Sorting methods	Scope	Technologies	Comments
		XRT (X-ray Transmission)	Identifies materials based on atomic density – for example, halogens and organic components.
		EMS (electromagnetic sensor)	Identifies metals based on their conductivity.

4.5.3 Sorting centres

These facilities primarily exist in developing countries. For example, the city of Pune city in India has set up a number of mainly manual waste sorting centres which serve to integrate the informal sector into the mainstream waste management system. Centres which involve the informal sector but use a mix of manual and mechanical sorting are common in Brazil and some other countries. In many instances these sorting centres deal with plastic waste.

Dry Waste Collection Centre

Dry Waste Collection Centres (DWCCs) are an important aspect of decentralized waste management. Bangalore became the first municipality in India to set up DWCCs. The concept, modelled around neighbourhood recycling centres, aims to facilitate the collection and buy back of all recyclable dry waste from local residents, contract workers, and waste workers or scrap dealers, including informal waste workers. The centres operate with zero subsidy from the municipality, so need to be financially viable. The operation prevents land-filling of recyclable and other non-biodegradable material which can be alternatively processed. They integrate the many informal workers through employment opportunities in the DWCCs and provide a locality for recycling that serves as a dissemination point for information. The consolidation of recycling activity creates economies of scale and back-end integration, as well as providing an interface for engagement with industry. This engagement helps facilitate actions on extended product responsibility.

4.5.4 Sorting by the informal sector

In developing countries, the informal sector often plays a significant part in waste collection. The International labour organization estimates that 15 to 20 million people work in the informal waste sector and 4 million are employed in the formal waste sector (ref). However, the contribution of waste pickers to waste recycling is poorly understood. The challenge in developing countries includes integrating informal waste collectors into formal waste management programmes and providing them with access to training on the risks associated with improper waste sorting and waste handling. Municipalities or NGOs can provide legal support in establishing cooperatives, providing training, and creating other services to improve working conditions (such as identity cards and access to health insurance).

Waste Pickers part of the waste management solution.

Benefits	Actions required to improve conditions for workers and sustainability of livelihoods
● Efficient – 70% of waste recycled in Santiago de Chile; 80% of waste recycled in Cairo. ● Labour intensive solution as opposed to capital intensive, so easier to establish in developing countries ● Provides jobs and income for people ● Reduces pollution, diverts recyclables from landfill or entering waterways ● Reduces raw material costs for local industries by providing recycled material ● Save municipalities the cost of collection and transport fleets	• government recognition as workers, and formal inclusion in waste management • strengthening organization through the establishment of co-operatives to improve working conditions • develop supportive and inclusive policies and laws that enable both formal and informal systems of waste management and recycling. • development of programs that provide stability of employment – need to be considered when considering the adoption of other technologies such as incineration that displace waste pickers and reduce recycling.

A review of the informal waste sector by GIZ (2012) found several conditions important for integration, including inclusion of informal waste workers contribution in public policies, regulations, and procedures, the organisation of informal workers, the technical and managerial capacity these workers have as economic actors, and the networks they establish with formal companies and other institutions like providers of business or financing services.

4.6 Planning

4.6.1 Overview

Solid waste management planning is important when looking to establish or improve a municipal waste management system. The lack of technical or financial resources needed to develop a solid waste management plan can be a drawback for many local authorities.

4.6.2 Stages

Stages of waste management planning prior to implementation include:

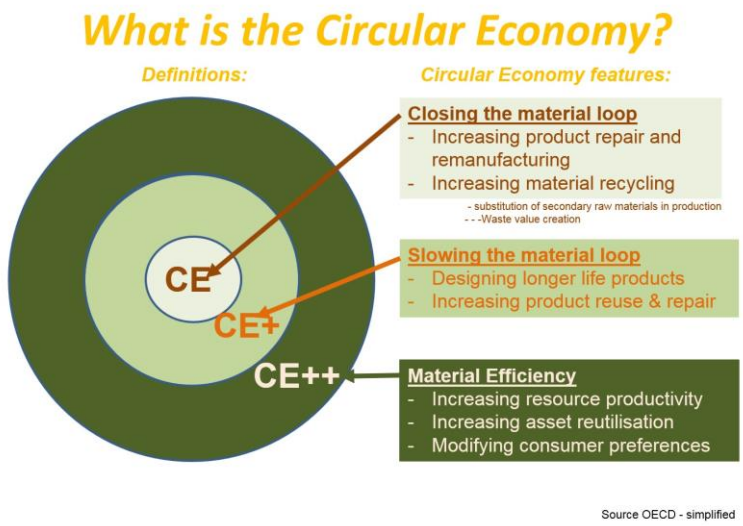
1. Drafting the baseline
    - Socioeconomic profile of the area under study
    - Sources of waste
    - Existing waste management practices
    - Identify Existing Regional Programs or Infrastructure
    - Waste Assessment /Audit (Waste characterisation)
2. Techno-economic analysis
    - Estimate future waste generation quantities
    - Define goals
    - Create scenarios and define costs of each scenario
    - Assess and select scenario for implementation
    - Analysis of the technical and economic aspects of the selected scenario

MODULE 5 - Reuse (except direct reuse)

5. Introduction

From the point of view of the Circular Economy it is most desirable to reuse goods. Goods that are directly reused are not normally classed as wastes, for example a mobile phone that passes from one person to another to be reused does not become a waste in that process. However, those wastes collected from households that require preparation for reuse through repair and refurbishment are considered wastes in some jurisdictions. Examples of household goods that though no longer wanted by the householder may then become available for reuse after repair and refurbishment are electrical and electronics equipment, domestic appliances and consumer electronics, furniture and textiles.

The Basel Convention's Annex IV Section B of Recovery Operations does not yet include "R14: preparing for reuse (e.g., checking, cleaning, repair, refurbishment)", however the proposal for its inclusion has been made in 2018 by the Expert Working Group on the Review of the Annexes. Irrespective of the revision of the Basel Convention, reuse, refurbishment and remanufacturing should be encouraged where appropriate as these operations are at the core of the Circular Economy and similar sustainability concepts[40]. Each of the three defined elements of the Circular Economy are related to reuse: (i) CE closing the material loops; (ii) CE+ slowing the material loops; and (iii) CE++ material efficiency. Regarding material efficiency, consumers preferences should be directed towards accepting used products that have been repaired and refurbished. Also, consumer preferences for purchasing longer life products that are also repairable should be encouraged. At the core of the Circular Economy is the repair and refurbishment of goods, also their remanufacturing. Clearly a well-functioning Circular Economy will require well-functioning markets for the repaired, remanufactured and refurbished goods.



[40] e.g., Zero Waste concept, Cradle to Cradle concept

5.1 Principles

A core focus of the Circular Economy is to keep products in use. Many countries have an existing culture of repair, however growing consumption requires a more comprehensive approach. An overarching step is legal support allowing consumers to fix their own products, access parts which are needed for repair, open access to repair manuals and making affordable tools available.

Reuse of products can be stimulated by taking the following actions:

- Product design (e.g., make consumer product parts easily accessible and replaceable, make the spare parts available)
- Access to information (e.g., access to appropriate product information so that repair and reuse is possible)
- External support (e.g., simulate reuse by financial incentives)

These principles usually are cost beneficial to other community objectives providing job opportunities or social support. For example, in Belgium 'De Kringwinkel' uses the income from its sales to give people, who have little or no chance to get on the normal labour market, a suitable job. In this way they gain back experience and get a future perspective.

Consumer products such as electrical and electronical devises are increasingly designed for a short-time use. Better design of products for a long-life time and their design to be repairable will keep products in use longer and so mitigate impacts of their disposal or recovery, and of their replacement. Designers should design goods to ensure that all the materials in the product are recyclable without loss of quality, thereby reducing the impact of the product when it becomes a waste. There are also concerns that on repair, components being replaced and so being discarded could have an unwanted environmental impact if not designed for recycling.

Free access to repair service documentation should enhance product repair. The principle of ‘supply and demand’ applies to repaired goods. Wastes that are repaired or refurbished become goods again, such goods will only be reused when there is a demand for them. Without a demand for repaired or refurbished goods the recovery operations of repair or refurbishment will not be economically viable. With higher general awareness about unsustainable consumption patterns, there could be little acceptance or demand for refurbished goods.

The implementation of these principles can be stimulated by economic instruments such as tax deductions. Example can be sourced from a number of European countries[41]. For instance, in Sweden the government introduced 50 per cent tax reduction of labour costs for repairs of

[41] Rreuse (2017). Reduced taxation to support re-use and repair. Available from: http://www.rreuse.org/wp-content/uploads/RREUSE-position-on-VAT-2017-Final-website_1.pdf

large size household appliances[42]. This financial instrument was put in place to reduce throwaway behaviour which is common practiced in many societies.

5.2 Products

5.2.1 Textiles

According to the UK House of Commons Environmental Audit Committee, textile production contributes more to climate change than international aviation and shipping jointly. It uses gigantic volumes of fresh water in cotton production, consumes energy and finally leads to pollution of the environment. As the result, synthetic fibres are being found in the deep sea, in Arctic sea ice, in fish and shellfish[43].

The garment industry is reportedly one of the world's biggest manufacturing industries. In 2016, it generated US$ 1.65 trillion annual revenues from apparel and footwear items[44]. Projections are that by 2030 the global apparel consumption will rise by 63%, from 62 million tons today to 102 million tons[45]. However, the way clothes are made, used and thrown away is unsustainable. In Europe, about half of the used clothed are collected for reuse or recycling, but very little is recycled into new clothes[46].

The lifetime of clothes is shortening over time putting more pressure on natural resources and waste management. These are concepts on how to prolong the lifetime of clothing [47]:

- Slow fashion. In contrary of fast fashion, the slow fashion encourages consumers to buy fewer clothes of better quality.
- Improve collection for reuse, repair and upcycling (e.g., second-hand clothes in regular shops; repair programs that allow consumers to send their worn or lightly damaged clothing to be repaired; to charity shops; and selling in markets).
- Fashion as a service (e.g., clothes rental services, renting wedding clothing or special occasion clothing for instance in India; or clothes subscription services).

There is an increasing trend for people to sell their unwanted clothes as used or second-hand clothing over the Internet platforms such as https://www.vinted.com or www.ebay.com. Shops selling second-hand clothing are fairly common in cities. Certain shops specialize in Designer clothing of high value, others sell clothing as individual items, or by weight. Certain shops selling second-hand clothing and other goods are linked to or owned and operated by charities. In contrast to sales online, here examples of 'bricks and mortar' physical outlets.

---

[42] Ibid

[43] House of Commons Environmental Audit Committee (2019). Fixing Fashion: clothing consumption and sustainability. Available from: https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/1952/1952.pdf

[44] Global Fashion Agenda & The Boston Consulting Group (2017). Pulse of the Fashion Industry.

[45] Ibid.

[46] European Parliament (2019). Briefing. Environmental impact of the textile and clothing industry. What consumers need to know. Available from: http://www.europarl.europa.eu/RegData/etudes/BRIE/2019/633143/EPRS_BRI(2019)633143_EN.pdf

[47] Ibid.

Some of the examples in practice.

Designer / Brands clothing shop	Clothing shop selling by weight	Charity shop	Selling in a market
			

Textiles that are not directly reusable, but may be reused after repair or refurbishment, may be classified as waste in national legislation. Textiles from households that are only fit for material recycling, for fibre recycling, are commonly classified as waste. Textiles from households that are only fit for final disposal by incineration or landfill are classed as wastes. The Convention Annex IX List B has under entry B3030 "- Worn clothing and other worn textile articles". Whilst the Convention listing is coherent with the World Customs Organisation Harmonised System code "6309 00 00 Worn clothing and other worn articles", used clothing from households are commonly collected together with shoes and accessories that may not be just of textile, and collected with other used textiles goods such as tablecloths, curtains etc.

To prepare for door-to-door collections, free collection bags are delivered door to door beforehand, so people have time to sort out unwanted textiles such as clothing, cloth, footwear etc., The filled bags are then collected soon after. People are also encouraged to put their textiles for reuse into on-street containers. Some on-street container collections provide income for charities. People may also take their unwanted textiles to collection points in charity shops, schools or community centres. The onward sale of such items commonly provides income for charitable activities.

Collected textiles need to be sorted to determine which are suitable for reuse, which need cleaning or repair, and of those unsuited for reuse which can be used to make wiping cloths and which for fibre recycling, or other forms of material recycling. Textiles that cannot be recycled are usually destined for waste -to-energy, incineration or landfill.

5.2.2 Furniture

Household furniture can be designed for different purposes to be used indoors or outdoors, and it includes various objects such as tables, chairs, desks, beds, dressers, and cupboards. These items can be made of single material such as wood, bamboo, rattan, metal and plastic or mixture of different materials. It is important to ensure that furniture for reuse is free of hazardous materials, such as lead paint, and free from prohibited flame retardants and free from flammable materials. Most furniture when broken may be repairable, much depends on the severity of the damage and the materials and skills available to affect a repair. Repair and

reuse of furniture is not a new activity, after all the antiques trade has been around as long as the antiques themselves.

Similar to other waste streams there are several ways how to reduce the quantities of furniture send to landfills.

- Furniture repair and refurbishment
- Eco-labelling criteria (e.g., information that supports recycling)
- Service providing concept (e.g., furniture rental solutions, furniture leasing)

Householders may sell furniture for reuse or donate furniture to charities. Otherwise private enterprises may collect furniture from households or purchase furniture with a view to selling after necessary repair and refurbishment. Used furniture is sold in charity shops, in second-hand shops, and over the internet. qv. www.ebay.com for used furniture, or pre-owned furniture.

5.2.3 Electrical & Electronic Equipment

Electrical and electronic goods in the home comprise so-called home or domestic appliances, those mostly white goods such as cookers, washing machines and refrigerators and freezers, and consumer electronics such as televisions, computers, games consoles. These goods first appeared and there numbers have grown ever since the 1900s. Reuse of electrical of electronic equipment is the preferred options in the waste management hierarchy. Household electrical and electronic goods benefit from maintenance and repair. Domestic appliances are larger and heavier and may require plumbers or electricians to service and repair them, whilst consumer electronics are not typically serviced, but do require high technical knowledge and skills to repair them.

The reuse of electrical and electronic equipment largely depends on

- product design;
- the freely available information on how to carry out repairs;
- the availability of spare parts and tools.

Worthy of note, in some jurisdictions manufacturing goods with planned obsolescence is illegal.

Local authority waste management services may include less frequent kerbside collection for domestic appliances and consumer electronics, whether these are then destined for repair or refurbishment or final disposal depends on the waste management service. Whether the goods are at ‘end-of-life’ or not, people who no longer want them may deposit them in container parks or at collection points. Also, under arrangements with retailers, old domestic appliances and consumer electronics may be collected when their replacements are delivered and installed.

Householders may sell domestic appliances and consumer electronics for reuse or donate them to charities. Private enterprises may collect them from households for free or purchase them with a view to selling after necessary repair and refurbishment. Used

domestic appliances and consumer electronics may be sold in charity shops, in second-hand shops, and over the internet. qv. www.ebay.com for used or pre-owned domestic appliances and consumer electronics.
The Basel Convention regulates and guides issues of electrical and electronic waste and non-waste. The main supporting tools:

- Guidelines on transboundary movement
- Guidelines on mobile phones
- Guidelines on end-of life computing equipment.

Repair and refurbishment, including of domestic appliances and consumer electronics, are covered in its interim Basel Convention technical guidelines on transboundary movements of electrical and electronic waste and used electrical and electronic equipment, in particular regarding the distinction between waste and non-waste under the Basel Convention.[48]
The Mobile Phone Partnership Initiative under the Basel Convention produced the guidelines document on the environmentally sound management of used and end-of-life mobile phones[49].

The Basel Convention Partnership for Action on Computing Equipment (PACE)published the guidance document on the environmentally sound management of used and end-of-life computing equipment (2013).

5.3 Reuse statistics

Some countries set targets for reuse for certain product groups. Targets for reuse are most commonly associated with Extended Producer Responsibility Schemes. Set targets require measurement and data collection.

5.4 Customs codes and international trade

Goods that have been repaired, refurbished, remanufactured are no longer waste, they are classified as products so are not controlled in international trade by the Basel Convention. Laws may apply, for example for electrical and electronic goods where evidence of functioning should be supported with a copy of record such as certificate. For the international trade in these goods, the customs codes for repaired, refurbished, remanufactured goods are as for those products. There are exceptions for example the customs code 6310 is used for both “Used or new rags”. Whilst Circular Economy policies are gaining wider acceptance, some countries have national laws prohibiting imports of certain used goods.

[48] Technical guidelines on transboundary movements of electrical and electronic waste and used electrical and electronic equipment, in particular regarding the distinction between waste and non-waste under the Basel Convention (E-waste)

[49] Guidelines Document on The Environmentally Sound Management of Used and End-of-life Mobile Phones.

MODULE 6 - RECYCLING OF HOUSEHOLD WASTE

6. Introduction

Household waste generation and resource depletion have been major concerns in many countries, and increased household recycling has been seen as a means to reduce these problems. Currently, about 2.01 billion metric tons of municipal solid waste (MSW) are produced annually worldwide from which only 13.5% is recycled and 5.5% is composted. World Bank has estimated that annual global waste production could increase 70% by 2050 if current conditions persist[50].

Meanwhile, worldwide material consumption has reached 92.1 billion tons (2017), up from 87 billion in 2015 and a 254 per cent increase from 27 billion in 1970, with the rate of extraction accelerating every year since 2000. Furthermore, material footprint per capita has increased considerably as well: in 1990 some 8.1 tons of natural resources were used to satisfy a person's need, while in 2015, almost 12 tons of resources were extracted per person."

These numbers reflect the increased demand for natural resources that has defined the past decades, resulting in undue burden on environmental resources. Without urgent and concerted political action, it is projected that global resource extraction could grow to 190 billion tons by 2060[51].

Recycling of household waste could play a major role on sustainable management of waste and could be regarded as a replenishment of the available anthropogenic stock of a resource, decreasing extraction rates from the natural environment introduction of secondary raw materials to the industry.

Household recycling relies heavily on contributions from individual households. Some countries use economic incentives and regulations to stimulate this effort; in others, few or no incentives exist. Authorities in many countries provide recycling facilities (bins, containers, etc.) with virtually no official sanction possibilities. Despite this, households make considerable efforts—sorting, folding, washing, carrying and transporting sorted waste, even when no economic incentives exist. This implies that noneconomic motivations are important for household recycling activities. When intrinsic motivations are important, introducing economic incentives or other regulations may affect how households see their role in providing recycling services.

---

[50] "Kaza, Silpa; Yao, Lisa C.; Bhada-Tata, Perinaz; Van Woerden, Frank. 2018. What a Waste 2.0 : A Global Snapshot of Solid Waste Management to 2050. Urban Development;. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/30317 License: CC BY 3.0 IGO."

[51] United Nations, 2019, Special edition: progress towards the Sustainable Development Goals, Report of the Secretary-General. Available at: https://undocs.org/E/2019/68

In many industrialized countries, sophisticated recycling programmes have been introduced for household waste. Nevertheless, too many valuable resources are still being wasted through inadequate separation, collection and recovery systems. In some developing countries, components of waste streams are usually segregated and used. Meanwhile, the segregation, recycling and reuse of household waste can have a major impact on the economies of some developing countries. Individuals involved in informal waste segregation activities can be brought into the formal sector and remunerated for their work. Valuable items or "pickings" can be sold through intermediaries to small recycling entrepreneurs. The entire recycling activity - including transportation - generates employment, and the economic status of all those employed in recycling is improved.

For authorities to achieve their aim of increased household recycling and to secure the most efficient design of the chosen policy instruments, it is thus important to understand the mechanisms behind recycling contributions and how they are affected by the introduction of economic incentives.

Furthermore, to guide best-practice recycling it is important that aspects such as supply and demand of secondary raw materials and quality of recyclables are taken into consideration.

Secondary raw materials are a substitute for primary raw materials and in competition with them in terms of price and quality, and therefore in terms of supply and demand. Without a demand for secondary raw materials, recycling will not be economically viable. Improving quality of recyclables, by improving sorting and recycling processes, would also adding value to secondary raw materials and meet the next buyer's needs.

This module serves as a guideline for the implementation of household wastes recycling with focus on collection and processing of different recyclables. In addition, emphasis is drawn upon the economics of recycling, and the markets for secondary raw materials.

6.1 Household waste recycling

6.1.1 Overview

It is commonplace to encourage people to recycle - for example, by use of symbols on paper, metal, glass and plastic packaging and on goods themselves such as mobile phones and computing electronics. Almost all goods bought by householders could be marked with advice on how to recycle. Every householder, therefore, becomes a recycler in a general sense and has a key role to play as the first link in the chain of recycling processes. It is in their households that each person, having chosen to dispose of something, makes the decision that what he or she is throwing away is not for reuse but for recycling.

Benefits:

- Recycling saves raw materials (Preserves huge amounts of water; Reduces energy minimizing forest and mining activities demands during manufacturing)
- Recycling reduces our impact on climate change (each tonne of recycled materials saves 2.8 tonnes greenhouse gases)
- Bypasses air, water and soil contamination during mining and disposal (dumps, incinerators);

- Recycling costs less
- Recycling creates jobs

Barriers:
The main barriers to recycling in the early phase of waste management are:

- Citizens' attitude towards recycling: some citizens are not willing to participate because it requires diligence and extra effort.
- Low political priority.

Then at the end of life stage one of the basic barriers could be:

- Market for secondary materials not well developed or none exist

Incentives to recycle, besides 'doing the right thing', are that there can for certain materials be an economic incentive. For example the amount paid to householders by scrap collectors for metals is dependent on the type and quality of the waste and scrap being sold for recycling. Other incentives can come from legislation that sets targets for recycling, common in extended producer responsibility schemes. Legislation setting recycled content requirements on manufacturers can also increase the demand of recyclables and so increase collection.

6.1.2 Collection of post-consumer recyclable household waste

In the case of recycling, householders are advised to present the waste in an appropriate way. They take the first action in recycling by: putting their wastes in appropriate containers for door-to-door collection; putting designated wastes into on-street containers; taking their end-of-life goods and materials to deposit or sell to recycling centres/scrap yards; or returning designated end-of-life goods to retailers when buying new undertake-back schemes.
Collection of post-consumer recyclable household waste may be performed in:

i) mono-material collection systems where a specific recyclable is segregated at source as one material fraction
ii) co-mingled collection systems where several types of source separated dry recyclables (e.g. metals, glass and plastics) are collected together, and
iii) mixed waste collection systems where recyclables are collected together with the rest of household waste and often are contaminated by the presence of organics and other impurities[i].

Mono-materials can also be recovered from deposit systems such as deposit systems for the collection of beverage bottles (see also module 4).

Recyclables collected along with the rest of municipal waste could be a cheap collection option, however then there is a greater effort required to separate recyclables from mixed waste and remove contaminants. Therefore, it is very important in order to get relevant clean recyclable streams to collect the wet fraction of municipal waste separately. In this sense, separate collection schemes of recyclables enhance the capture of clean material securing low levels of contamination from other waste such as organics.

However, even separately collected wastes from households commonly need further sorting to sort out the different types of recyclables as well as to remove any impurity. In contrast, separately collected wastes from households through take-back deposit-refund systems are of a higher quality since the individual items need to be evaluated for the refund payment.

It is also common for some hazardous wastes to be generated from households - such as medicines, garden pesticides, paints and batteries - which may or may not be separated and separately collected. The demands put on householders to separate wastes for collection are determined by the later processes to recycle, recover or finally dispose of the wastes by incineration or in a landfill. The effort required of householders to present the waste they have produced, particularly in single stream or as a designated co-mingled stream for collection, reduces the cost to the householder by in turn reducing the onward cost of recycling, other forms of recovery, and/or final disposal.

6.1.3 Recycling operations

After the householder has discarded their waste and sent it on its way to a recycling operation, a series of recycling steps takes place in order to separate the waste like properties from the waste and transform the waste into secondary raw materials, most commonly by both manual and mechanical means.

Recycling operations comprise the reprocessing of waste into products, materials or substances, though not necessarily for the original purpose. Resources are saved by recovering material benefits from the waste. Recycling is to be distinguished from operations that recover energy from the waste. In some countries, where material is used once merely for its physical properties (e.g. for backfilling), this does not amount to recycling.

Definition of recycling

The UNEP Basel Convention's Glossary of Terms defines recycling as "Relevant operations specified in Annex IV B to the Basel Convention". The Glossary recognizes, in its explanatory notes, pre-existing definitions in the "Technical guidelines on transboundary movements of electrical and electronic waste and used electrical and electronic equipment, in particular regarding the distinction between waste and non-waste under the Basel Convention" and the "Revised guidance document on the environmentally sound management of used and end-of-life computing equipment". The "Revised technical guidelines for the environmentally sound management of used and waste pneumatic tyres" defines tyre recycling as: "Any process by which waste tyres are reprocessed into products, materials or substances for any purpose." It does not include energy recovery or reprocessing into materials for use as fuels or in backfilling operations. Furthermore, the "Technical guidelines on the environmentally sound recycling/reclamation of metals and metal compounds (R4)" defines recycling as: "(a) The preparation of recovered items and pieces so that they may be used directly (e.g. in direct remelt) or sent for reclamation; (b) The series of activities, including collection, separation, and processing, by which products or other materials are recovered from the solid waste stream for use in the form of raw materials in the manufacture of new products, other than fuel for producing heat or power by combustion."

After the first recycling step of the householder separating his or her wastes and presenting them for collection according to the advice of the waste collector, collected waste is likely to be transported to a temporary storage facility where the collected waste is gathered together by type for onward transportation to a manual and/or mechanical sorting facility.
The overall philosophy of each link along the chain of the recycling processes is to add value to the wastes by removing hazardous and unwanted materials. Much of this can be done by manual sorting and mechanical processing. During sorting, the waste-like properties are removed, resulting in a secondary raw material that can substitute for a primary raw material in the marketplace. These secondary raw materials are sold to manufacturing industries that make new goods.

Recyclables make up a substantial fraction of waste streams, ranging from 16 percent paper, cardboard, plastic, metal, and glass in low-income countries to about 50 percent in high-income countries. As countries rise in income level, the quantity of recyclables in the waste stream increases, with paper increasing most significantly (ref.)

'What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050' targets decision makers, policy makers, and influencers globally, including local governments, international organizations, academics, researchers, non-governmental organizations, civil society, and financiers. The aim of the report is to share objective waste management data and trends, as well as good and unique international practices, with the hope of improving waste management globally and enabling the optimal use of limited resources.

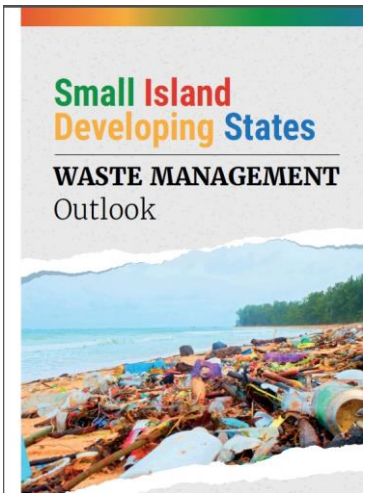
At every stage of the waste value chain, the maximum value is obtained by continuing to increase the quantities, cleanliness and quality of the waste and scrap.

Subsequent bulk transportation to industrial consumers of the secondary raw materials, obtained from processing wastes to meet industrial infeed specifications, becomes more economic. Furthermore, industrial consumers need a steady infeed as few can accept infrequent small deliveries of variable quality from many suppliers.

The diagram below shows the pyramidal nature of the recycling industries, and of recycling material flows. The many "collectors" includes separate collection from households, whereas fewer recovery sector facilities are sorting and processing the waste and scrap to meet industry specifications. The secondary raw materials are then delivered to the relatively small number of manufacturing industries.

Scheme: The inverted pyramid structure of the recycling sector

Small island developing states cannot be expected to have every type of facility to recover every waste fraction collected from households. It follows that, after collection, wastes for recycling will have to be exported in order to reach environmentally soundly managed recovery facilities. Provision of Regional solutions for the recovery of certain wastes are being explored.



The Small Island Developing States Waste Management Outlook provides an assessment of solid, liquid and gaseous waste generated in 58 Small Island Developing States. It also recommends a series of

---

6.2 Illegal or are undesirable recycling operations

International agreements such as the Montreal Protocol, the Minamata Convention and the Stockholm Convention prohibit the recycling of certain chemicals such as ozone-depleting substances, mercury and persistent organic pollutants. Regional and national laws existing to protect both human health and the environment also specify other substances which may not be recycled. Objects comprising or containing these substances or materials which should not be recycled may be collected from households. Appropriate steps should be taken to ensure non-recyclables do not enter the recycling stream.

Laws cannot cover every eventuality and there are activities promoted as recycling that are harmful to both human health and the environment, whether immediately or likely in the near future. For example:

Making “plastic bricks”

Photo taken by Josephine Chan and Ian Christie - www.ecobricks.org

6.3 Recycling of different household waste streams

The most commonly recycled materials collected from households are ferrous metals (eg. steel cans) and non-ferrous metals (e.g. aluminium cans), paper, plastic and glass. At the time of writing many new legislative interventions are being made to increase plastic recycling around the world and to reduce the volumes of difficult to recycle and unrecyclable plastics.

6.3.1 Metal recycling

Metals represent one of the most valuable waste streams and can be recycled numerous times without degradation of quality. There are two principal categories: ferrous (e.g. steel, iron) and non-ferrous (e.g. aluminium, copper, zinc).

Main recycling steps for metals are - collection, sorting, either manually or mechanically, and processing to an industrial commodity grade specification, for subsequent delivery to a foundry or metalworks that manufactures metal goods.

Important to note, depending on the volumes of metal scrap available in a country the facilities that carry out the main recycling steps of collection, sorting, either manually or mechanically, and processing to an industrial commodity grade specification will be economically viable and established by private entrepreneurs. However, few countries will likely have a foundry or metalworks for every metal or metal alloy.

Guidelines on Best Available Techniques

Guidelines on Best Available Techniques and provisional guidance on Best Environmental Practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants, Section VI.L concerns “Smoldering of Copper Cables. It observes that Scrap copper is often recovered by open burning of plastic coatings from electrical cable and wiring. Chemicals listed in Annex C of the Stockholm Convention are probably formed from plastic and trace oils with copper as a catalyst at smouldering temperatures between 250°C and 500°C. It concludes that the smouldering process is not a best available technique or best

environmental practice and should not be practiced. Best available techniques include mechanical cable chopping, stripping.

Most common metals at household level that are included in recycling programs are:

- empty aluminium food and drinks cans. In UK the average household uses 600 aluminium food cans and 380 aluminium metal drinks cans each year.
- aerosols
- aluminium foil trays and household foil
- non-packaging metal items: electrical items, like irons, or bulky items like bicycles and pans, paint cans and nuts etc.

Collection schemes of metals at household level includes: (i) kerbside collection, (ii) household waste recycling centres (also known as civic amenity sites), and (iii) bring sites/banks (see also module 4).

Process for beverage cans recycling

After collection aluminium beverage cans are usually recycled by the following method[52]:

1. Sorting
Cans are separated from the household waste stream or mixed recyclables either manually or mechanically using eddy current separator at Material Recycling Facilities/ sorting facility or a transfer station.

2. Reprocessing
Bales of aluminium cans are then taken to a reprocessing facility. Processing of aluminium involved four stages: shredding, de-coating, melting, and casting.
At the final stage the molten metal is cast into large ingots.

3. Rolling
Ingots are transported to rolling mills and rolled out to make sheet aluminium, from which new packaging can be made.

4. Converting
Aluminium sheet is converted into a diverse range of packaging items.

Process for copper wire recycling

The steps in the chain of recycling activities for copper wires from household appliances are illustrated below. Showing the changing classification of the copper-bearing waste and the different controls for transboundary movements, until in some jurisdictions the processed copper ready for consumption by manufacturing industry is no longer classified as waste.

1. Collection
Collection of household appliances at a collection centre; many items have an electric cable and plug.

[52] https://alupro.org.uk/consumers/how-is-aluminium-recycled/

end-of-life electrical and electronic equipment, as collected at a waste site and classified as unsorted e-wastes.

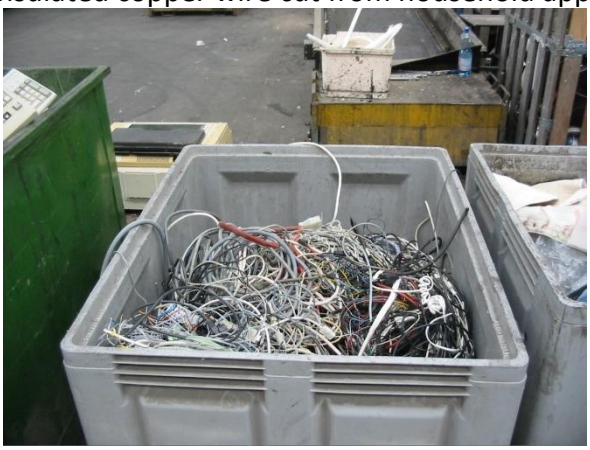
The transboundary movement of these waste household appliances as collected will be under notification if hazardous. Advice on classification is given in the Basel Convention Factsheet on Electrical and Electronic Waste (e-waste).

The revised "Technical guidelines on transboundary movements of electrical and electronic waste and used electrical and electronic equipment, in particular regarding the distinction between waste and non-waste under the Basel Convention" were adopted, on an interim basis, at the fourteenth meeting of the Conference of the Parties by decision BC-14/5.

For countries that have neither the means for the further processing of end-of-life electrical and electronic equipment nor the means to build facilities, exporting to a country that has environmentally soundly managed facilities and that allows such imports is an alternative to landfill.

2. Sorting

Insulated copper wire cut from household appliances and collected together.



I

insulated copper wire

For transboundary movement, the classification of these wires can be as:

B1115	Waste metal cables coated or insulated with plastics, not included in list A A1190, excluding those destined for Annex IVA operations or any other disposal operations involving, at any stage, uncontrolled thermal processes, such as open-burning.

Certain national standards set quality requirements for imports of wire & cable scrap. Q.V. National Standards of the People's Republic of China - GB 16487.9—2017 - Environmental Protection Control Standard for Imported Solid Wastes as Raw Materials—Waste Wires and Cables.

3. Processing- Stripping of the insulation from cables.
The processing step of stripping insulation from wires and cables can be done by hand with simple instruments. However, that is labour intensive. Simple cable stripping machines are readily available. Depending on the volumes of cable to be processed, complete cable granulation systems may be employed.

Simple wire stripper

Cable Granulation System

4. Exporting to End-user
Sorted and processed copper wire ready for delivery to metalworks or foundry locally or for export.

Sorted and processed copper wire – stripped in a simple cable stripper - in a shipping container for export.

Sorted and processed copper wire – granulated output of a complex granulator system.

If exported. Exported under Customs Code 7404 00 10 - Copper waste and scrap: Of refined copper.

With waste code of Basel Convention Annex IX List B, entry B1010 Metal and metal-alloy wastes in metallic, non-dispersible form: • Copper scrap

There are a limited number of destinations for high quality copper in this form, as not every country has a copper smelter, remelter or foundry. Therefore, trade routes and destinations are well known within the metals industry.

Standards and specifications

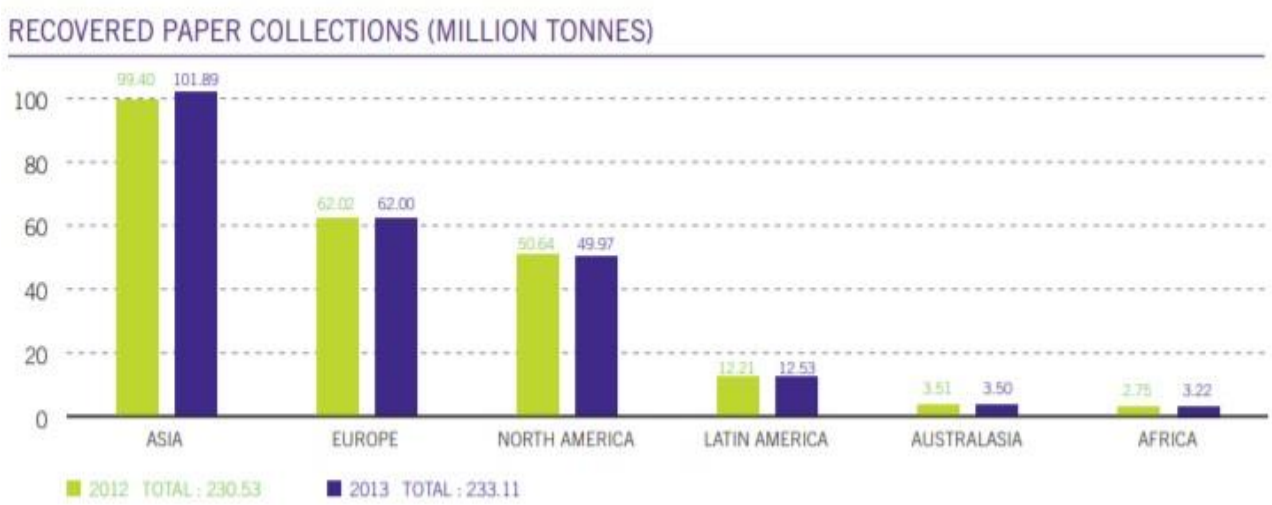
Certain national standards set quality requirements for imports of copper scrap:

- ISRI Scrap Specifications Circular - http://www.scrap2.org/specs/ for the standards and practices for the non-ferrous commodities traded internationally (See Pages 4-16 of the specifications)
- National Standards of the People's Republic of China - GB 16487.7—2017 - Environmental Protection Control Standard for Imported Solid Wastes as Raw Materials—Nonferrous Metal Scraps

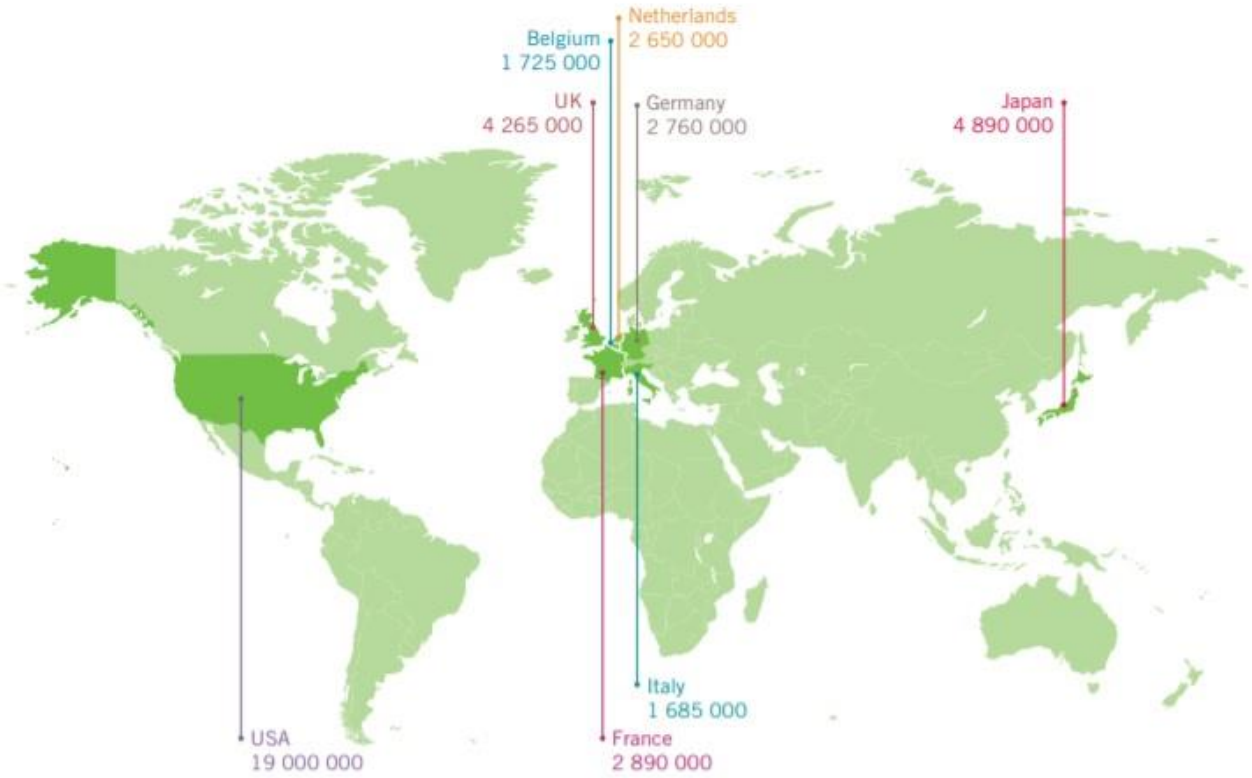
Note that in some jurisdictions the same material, if it is certificated as meeting the conditions and criteria for ceasing to be waste, is no longer controlled as waste but as a product. For instance, Commission Regulation (EU) No 715/2013 of 25 July 2013 establishing criteria determining when copper scrap ceases to be waste under Directive 2008/98/EC of the European Parliament and of the Council.

6.3.2 Paper and cardboard

Globally, the majority of paper is landfilled. Transboundary trade of paper amounts to 40-50 MT/y which accounts for about 10% of total global production (ref)



WORLD'S MAJOR EXPORTERS OF RECOVERED PAPER (TONNES)



One hundred percent recycling of paper is not possible thereby making it difficult to close the loop. This arises as mass is lost from storage of paper, as well as the shortening of fibres during re-pulping. This results in a quality loss, as it relates to strength. Recycled paper will have to be mixed with virgin pulp to compensate.

Production of paper from recycled materials instead of virgin wood pulp, reduces wood, water and electricity consumption. In general, according to several Life Cycle Assessment Studies, recycling generally has a better environmental performance than landfilling and incineration of paper, particularly as the trees would then not be felled and so continue on their natural cycle acting as carbon sinks.

Household waste recycling programs for post-consumer paper recovery may include the following materials:

- printing (e.g. magazines, newspapers, books etc.) and writing paper,
- paper packaging (e.g cardboard)

Collection of paper at household level includes: (i) kerbside collection, (ii) household waste recycling centres (also known as civic amenity sites), and (iii) bring sites/banks (see also Module 4).

Processing for paper recycling

The recycling of paper follows a series of steps which may vary depending on the type of paper and its degree of deterioration.

Paper sorting and baling

Baled corrugated carton

Rotary sorting station

1. Sorting

Paper products must be separated according to their composition and degree of deterioration. Different types of paper can sometimes be mixed. Others, such as paperboard, are recycled using a single-grade process, meaning that no other type of paper can be mixed in during its processing.

2. Baling

Large quantities of paper are packed using hydraulic machines that apply enormous pressure to compact recovered paper into blocks that are easier and more cost-effective to transport.

3. Shredding

Recovered fibre is shredded into smaller pieces and mixed with water to make pulp.

4. Washing

The pulp is washed, refined and cleaned, then turned into a slush that undergoes filtering through screens and other separation processes to remove contaminants such as ink, clay, dirt, plastic and metals. Dyes, coatings and other additives can be introduced during this process. Water is continuously drained and cleaned for reuse.

5.Bleaching

In order to whiten paper, the pulp can be bleached using hydrogen peroxide and chlorine.

6.Pressing

The resulting paper sheet, known as 'web', is pressed between massive rollers to extract as much of the remaining water as possible and to ensure uniform smoothness and thickness. The semi-dry web is then run through heated dryer rollers to remove any remaining water.

7.Rolling
The finished paper is processed into large rolls ready to be manufactured again into new consumer products.

Standards and Specifications

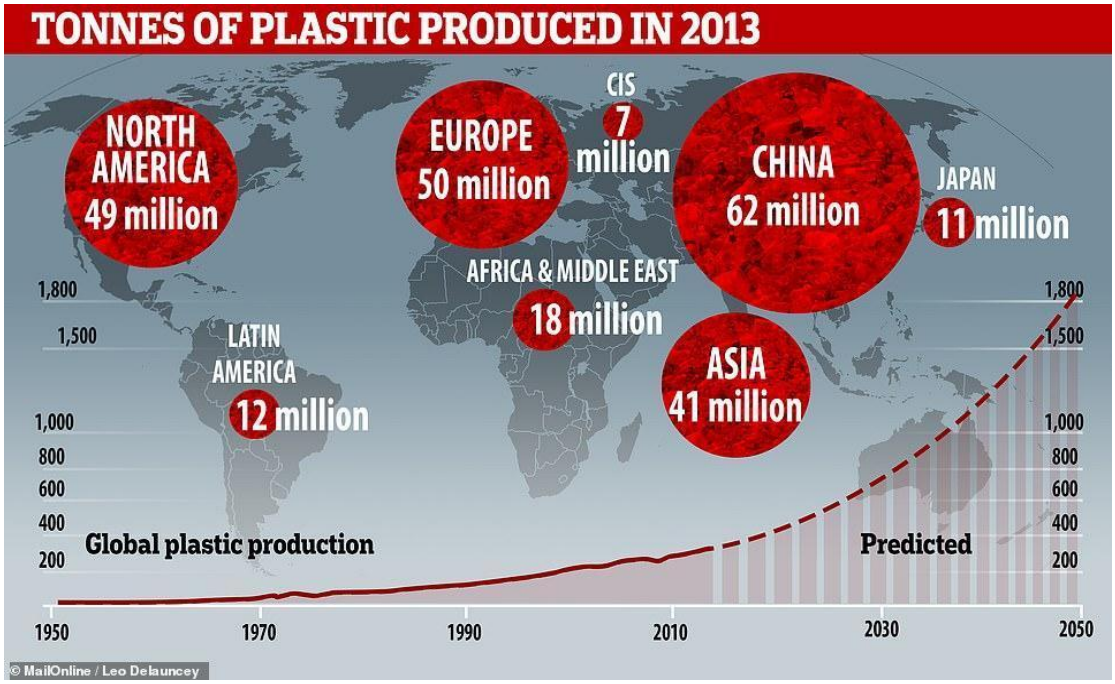
- ISRI Scrap Specifications Circular - http://www.scrap2.org/specs/ for the standards and practices for the paper stock commodity traded internationally (See Pages 26-32 of the ISRI Scrap Specifications Circular).
- The European Standard EN 643 divides collected and manual or mechanically sorted used paper into five groups: ordinary grades, medium grades, high grades, kraft grades and special grades. Each of these groups has some subgroups which specify the recovered paper grade at a detailed level. The EN 643 also defines and sets tolerance levels such as unusable materials, non-paper components, paper and board detrimental to production and moisture content.
- National Standards of the People's Republic of China - GB 16487.4—2017 - Environmental Protection Control Standard for Imported Solid Wastes as Raw Materials—Waste and Scrap of Paper or Paperboard

6.3.3 Plastics

Plastics are predominantly made from oil. Approximately 4% of petroleum consumed worldwide is used to make plastics, while another 4% is used to power plastic manufacturing processes[53].

The amount and variety of plastic put on the market around the world, and the projected enormous increase in production coupled with the current very low global plastic recycling rate shows there is a potential for enormous capacity increases in plastic recycling. However, recycling has to be economic and there has to be a market for the recycled plastic flakes or pellets for manufacturing new goods.

[53] The Globalist, 2015, The Rise of Plastic. The past, present and future of plastic production. https://www.theglobalist.com/the-rise-of-plastic/



(Need updated)

Furthermore, there is the challenge for householders who need consistent advice on what plastics to separate, and what to collect together in containers or in pay as you throw bags. Based on their chemical composition and ease of separation plastics are classified into different groups for collection and subsequent sorting. It can be observed that separate collection advice often differs from city to city, region to region and country to country (see Module 4).

Certainly countries, for example Small Island Developing States, with little space and no economically viable sorting and processing facilities may face the challenge of having to notify those mixed plastic wastes, as collected, that cannot comply with the higher standard B3011 listing, for shipments to States with such recovery facilities.

Post-consumer plastic packaging (e.g. disposable plastic cups, plates, takeaway containers, plastic bags etc.) is usually the major targeted stream to be included in a household recycling program.

There are six common types of plastics packaging products:

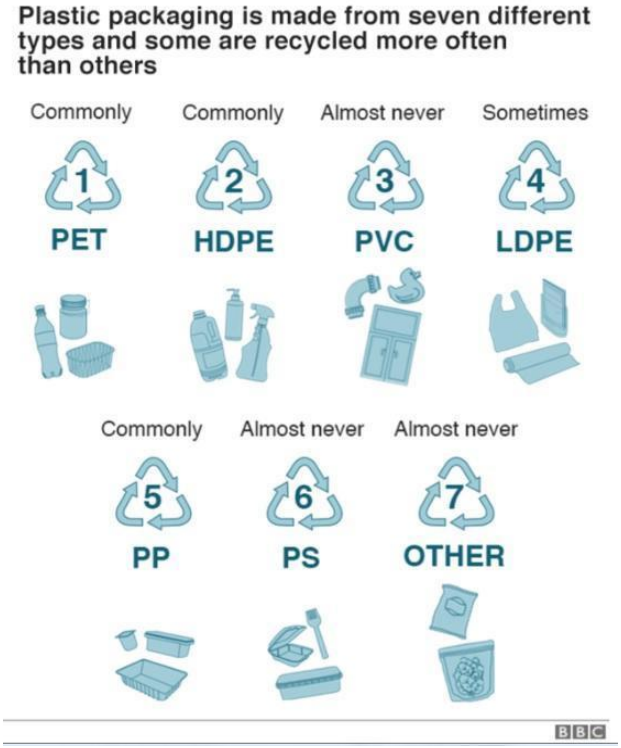
- PS (Polystyrene) –e.g. plastic cutlery, containers, yogurt.
- PP (Polypropylene) – e.g. take away food containers, ice cream containers.
- LDPE (Low-density polyethylene) – e.g. garbage bags or films of packaging products
- PVC (Plasticised Polyvinyl chloride or polyvinyl chloride) — e.g. juice or squeeze bottles.

- HDPE (High-density polyethylene) – e.g. shampoo containers or milk bottles.

- PET (Polyethylene terephthalate) – e.g. water & soft drink bottles

Currently, PET, HDPE, and PP plastic products are recycled under curb-side recycling programs. Other types of plastic packaging are not that common to be recycled. "To recycle or Not to Recycle" is a big question when it comes to plastic recycling. Some plastic types are not recycled because they are not economically feasible to do so.

The new plastic listings in the Basel Convention are intended to facilitate recycling of easy to recycle plastics in Annex IX whilst protecting countries from imports of unrecyclable and difficult to recycle plastics listed in Annex II, which can only be imported with prior informed consent.



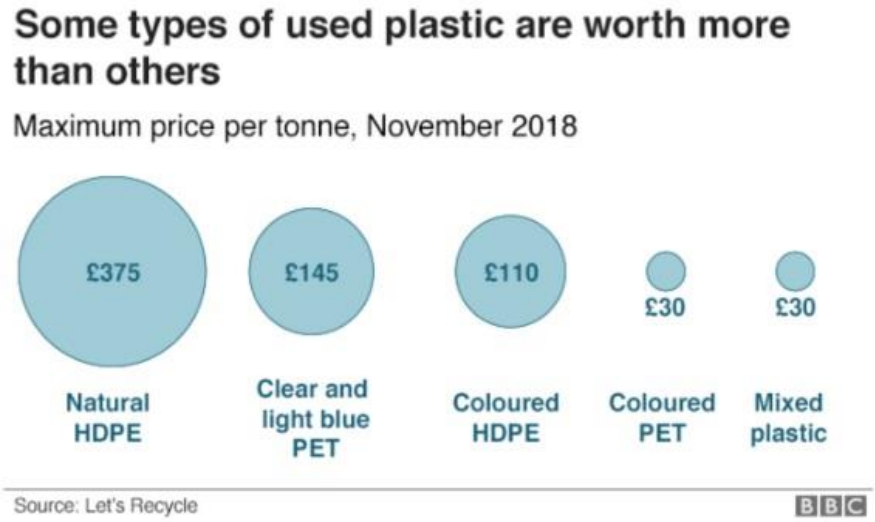
Categorization of plastic according to ASTM International Resin Identification Coding (RIC) System and preference to be recycled by the recycling industry [54]

Household plastic waste such as, plastic furniture (e.g. broken plastic chair) and household equipment made of plastic at the end of their life, could also be included in a plastic recycling program.

[54] Wesley Stephenson, (2018), All the plastic you can and cannot recycle. Available at: http://www.hantsfoenet.org.uk/all-the-plastic-you-can-and-cannot-recycle/

Collection schemes for plastics could then vary: (i) kerbside collection, (ii) household waste recycling centres (also known as civic amenity sites), and (iii) bring sites/banks (See Module 4).

It is desirable that the householder cleans the plastics before putting them in collection systems. Plastics recycling faces issues due to the presence of contaminants and foreign items such as organic waste. Furthermore, the mixing of different types of plastics can affect certain features of the subsequent mixed recycled plastic, properties like its strength and flexibility, that also affects the decision on the most appropriate plastic waste treatment technology. Quality of plastic scrap for recycling also affects marketability and price of secondary plastics.



Scheme: Indicative values of polymers sold to manufacturers of new goods[54]

Process for plastic recycling

Plastic recycling refers to the process of recovering waste or scrap plastic and reprocessing it into useful product including activities such as collection, sorting, grading, classification, cleaning, baling, trading, storing, or transporting of waste plastic and recyclates. The methods employed in recycling plastic nowadays are energy recovery and material recovery.

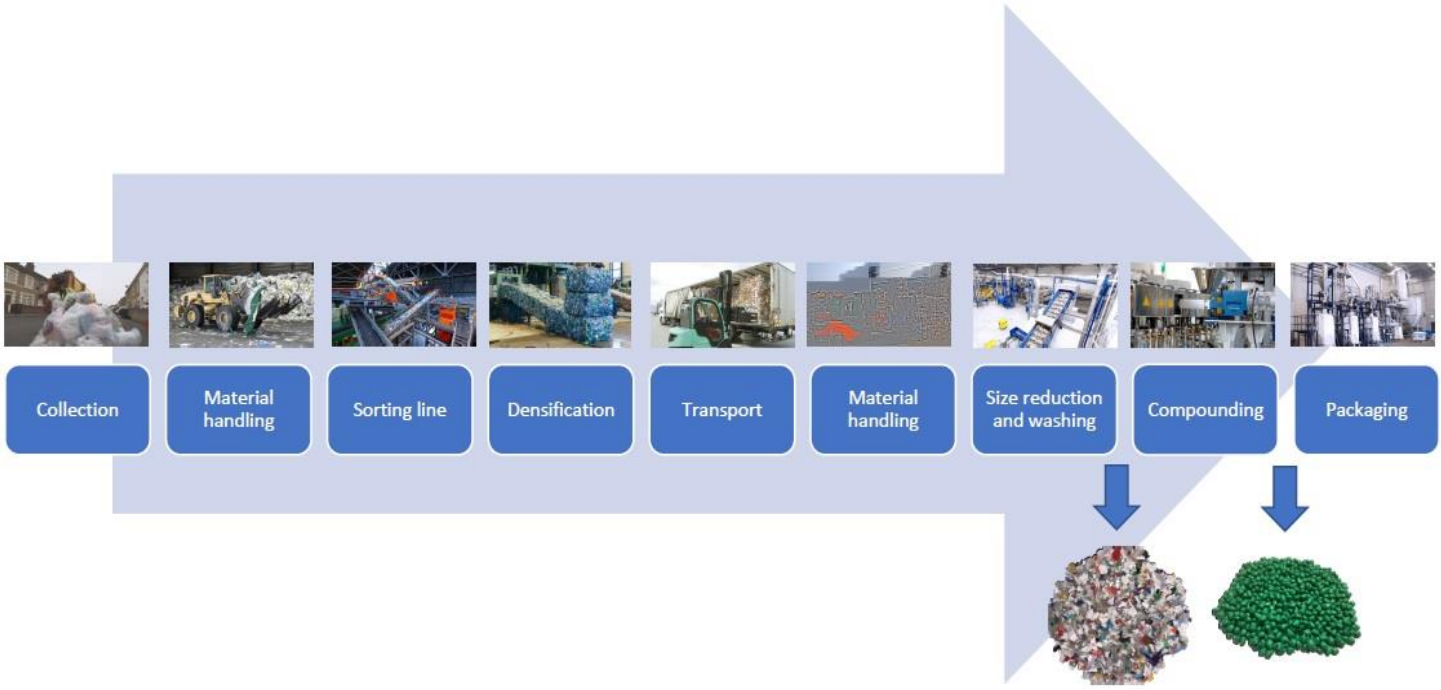
Material recycling can be further sub-divided into mechanical recycling, the most common practice, and into chemical recycling or feedstock recycling which are less common and usually require a gate fee, otherwise they are not economically viable.

Mechanical recycling is considered as one of the most common plastic recycling processes around the world. The simplest processes included in reprocessing of plastic waste typically involves collecting (1), sorting (2), granulate-shredding (3), washing (4) & drying), extrude-melting (6), cooling (7) and pelletizing-cutting (8). The process varies according to the plastic resin or type of plastic product. In general the simplest recycling facilities are following 1) sorting of plastics (either manual or automatically) to remove contamination and to sort polymers in different types, and 2) melting down plastics directly into a new shape or

shredding into flakes then melting down before being finally processed into granulates[55] (see Module 7).

Feedstock Recycling or Chemical Recycling is the depolymerization of long polymer chains into monomers through a chemical reaction by means of heat and/or chemical agents to produce monomers, chemical raw materials and/or fuels[56].

Energy recovery in the form of heat, steam or electricity generation is the process of utilizing waste (plastics) as substitutes of primary fossil fuel resources for the production of fuel, for energy recovery[57]. Energy recovery from waste plastics is realized in waste incineration plants, cement kilns and rarely co-combustion of waste plastics in power plants[58].



Common plastic waste recycling steps which can be carried out at different scales (ref).

Standards and Specifications

[55] Ragaert, K., Delva, L., Geem, K., (2017), Mechanical and chemical recycling of solid plastic waste, Waste Manag., vol. 69, pp. 24–58

[56] Grigore, M., (2017), Methods of Recycling, Properties and Applications of Recycled Thermoplastic Polymers,Recycling, vol. 2, no. 4, p. 24

[57] SS-ISO 15270:2009, (2009), "Plastics - Guidelines for the recovery and recycling of plastics waste," Euro code SS-EN-1191-2, vol. SS-ISO 152, no. 138227, p. 28

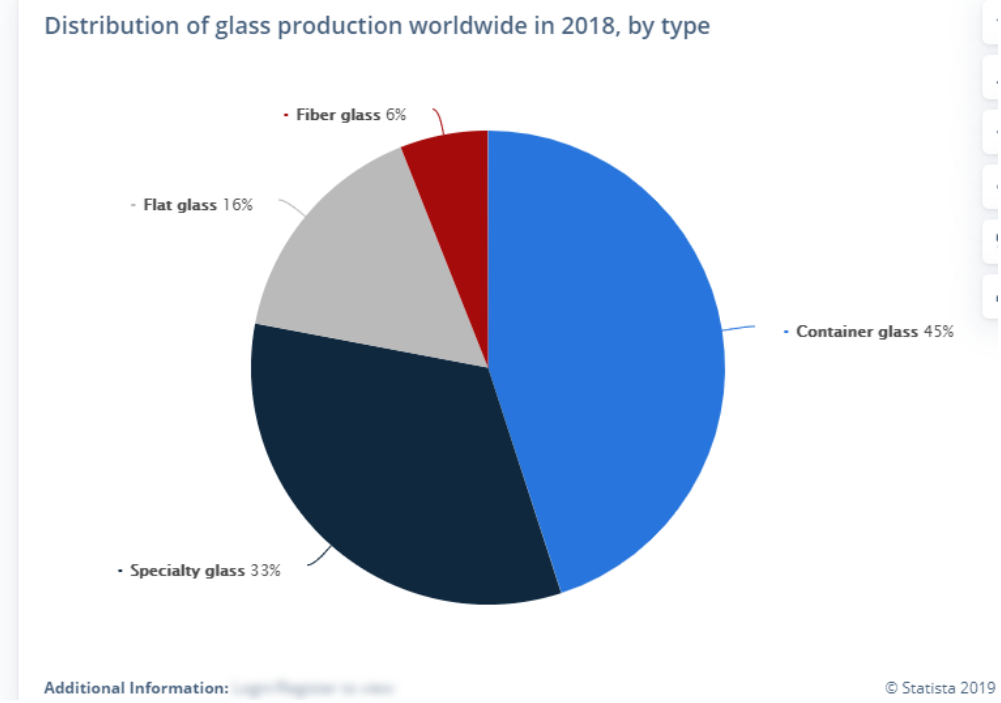
[58] Autio, J., (2015), Recycling and sustainable environmental practices in the plastics industry

- ISRI Scrap Specifications Circular - http://www.scrap2.org/specs/ for the standards and practices for the plastic scrap commodity traded internationally (See Pages 33-43 of the ISRI Scrap Specifications Circular)

- National Standards of the People's Republic of China - GB 16487.12—2017 - Environmental Protection Control Standard for Imported Solid Wastes as Raw Materials—Waste and Scrap of Plastics [NB: The separate listings of wastes prohibited, restricted and automatically licensed for import]

6.3.4 Glass

In 2018, glass containers accounted for around 45 percent of the glass produced worldwide, while fiberglass products only accounted for six percent of the world's glass production in that year.



distribution of glass products (ref)

Household glass bottles and jars are commonly collected door to door in separate, or in co-mingled collections (comingled is not recommended as broken glass contaminates other recyclables). Otherwise glass is collected through on-street containers, or containers in recycling parks. (see Module 4)

Process for glass recycling

1. The glass is broken into smaller pieces called cullet.
2. This cullet is then separated and washed (manually).
3. The cullet is then introduced into a furnace to be re-melted for production of new bottles for sale.

Cullet helps extend the furnace life as it melts at lower temperatures. Once contaminants are removed there is no quality loss of glass in recycling, however, once coloured cullet is mixed then the quality is lowered.

Standards and Specifications

- Commission Regulation (EU) No 1179/2012 of 10 December 2012 establishing criteria determining when glass cullet ceases to be waste under Directive 2008/98/EC of the European Parliament and of the Council

6.3.5 Textiles

The apparel industry consumes more energy than the aviation and shipping industry combined[i], accounting for 10 per cent of the global carbon emissions[ii]. Chemicals from dyes make their way into the environment, polluting the air, water, and also harming marine life. The fashion industry:

- Produces 20 per cent of wastewater[ii]
- Is responsible for 8-10 per cent of the world's greenhouse gas emissions[ii]
- $500 billion is lost every year due to clothing underutilisation and lack of recycling[ii]

Used clothing and accessories, household textiles and toys and shoes are collected door to door, or through householders using textile banks. The textiles are taken to sorting centers where they are sorted by material (wool, cotton, synthetic), by type (dress, shirt, trousers) and judgements are made about reusability, repairability, item value and future market-place. Second-hand clothing and accessories may be sold in second-hand shops, in charity shops, or in market-places. There is trend and an increase in the use of internet sales, whether by individuals or by private enterprises.

More sophisticated businesses will buy, market and sell second-hand clothing and accessories over the internet, delivering by courier on a sale or return basis.

If there is no reuse value the used textiles goods are sold to the 'flocking' industry. Mills-grade incoming material according to their type and colour. The colour sorting means no re-dying is needed, saving energy and avoiding pollutants. The Textile materials are shredded or pulled into fibres. Depending on the end use of the yarn, other fibres may be incorporated. The blended mixture is carded to clean and mix the fibres. The yarn is re-spun ready for later weaving or knitting.

Depending on the final application, fibres sometimes do not need to be spun into yarns, they can simply be compressed to create new textile fillings. In the case of polyester-based materials, the recycling starts by cutting the garments into small pieces. The shredded fabric is then granulated and turned into polyester chips. The chips are melted and spun into new filament fibres used to make new polyester fabrics.

- Knitted or woven woollen and similar materials are reused by the textile industry in applications such as car insulation, roofing felt, loudspeaker cones, panel linings and furniture padding.
- Cotton and silk is used to manufacture paper and to wiping and polishing cloths for a range of industries from the automotive to the mining sector.
- Other types of textiles can be reprocessed into fibres for upholstery, insulation, and even building materials.

6.3.6 Hazardous household wastes

Hazardous wastes from households comprise items such as- solvents, acids, alkalines, photochemicals, pesticides, fluorescent tubes and other mercury-containing waste, discarded equipment containing chlorofluorocarbons, Inedible oil and fat, paint, inks, adhesives and resins containing hazardous substances, detergents containing hazardous substances, cytotoxic and cytostatic medicines, Ni-Cd and Mercury containing batteries and accumulators, electrical and electronic equipment containing hazardous components; and wood containing hazardous substances.

The first step is sound hazardous waste collection and storage. Thereafter there are specificities to the recycling of each of these items.

A Waste Electrical and Electronic Equipment (WEEE) Centre in Kenya offers recycling services to the general public, business, learning institutions, government and NGOs.
Source: Waste Electrical and Electronic Equipment (WEEE) Centre

6.4 Markets for secondary raw materials

6.4.1 Demand

Recycled materials are in competition on the market with primary raw materials. The material consuming industries, manufacturers of semi-products and products often have a choice to use either primary raw materials or secondary raw materials. Such choices are principally economic and so most industrial consumers will buy secondary raw materials when they are priced lower than the competing primary raw materials. The consequence is that there is most often a price ceiling for secondary raw materials. Other incentives may be used to encourage manufacturers to use secondary raw materials rather than primary raw materials - for example, by setting recycled-content targets for manufactured goods.

The point in the supply chain that secondary raw materials substitute for primary raw materials is precisely “in the marketplace”, that is, before consumption by the manufacturing industries that make new products.

6.4.2 Measures to establish and optimize markets for secondary raw materials

The following legal measures may be used to optimise the markets for secondary raw materials and so stimulate the chain of recycling activities:

- Setting recycled content requirements in new goods
- Setting legally binding targets for recycling to increase the supply of recycled materials, enabling economies of scale, and reducing costs
- Prohibit landfilling and incineration of recyclable materials

Other non-legal measures may be taken to boost the market for recycled materials such as:

- Raising public awareness and concerns to create a demand for recycling, reducing dumping and waste and environmental damage
- Using public sector procurement to buy goods of recycled materials or with high recycled content

6.4.3 Quality standards for recycled materials

Recyclers depend on a marketplace for their recycled materials. Industry standards and specifications are used to set the quality of secondary raw materials so they may be purchased and used by consuming manufacturing industries, and so substitute primary raw materials.

- ISRI Scrap Specifications Circular http://www.scrap2.org/specs/II/
- EFR Steel Scrap Specifications https://www.euric-aisbl.eu/facts-figures/standards-specifications/download/172/146/32

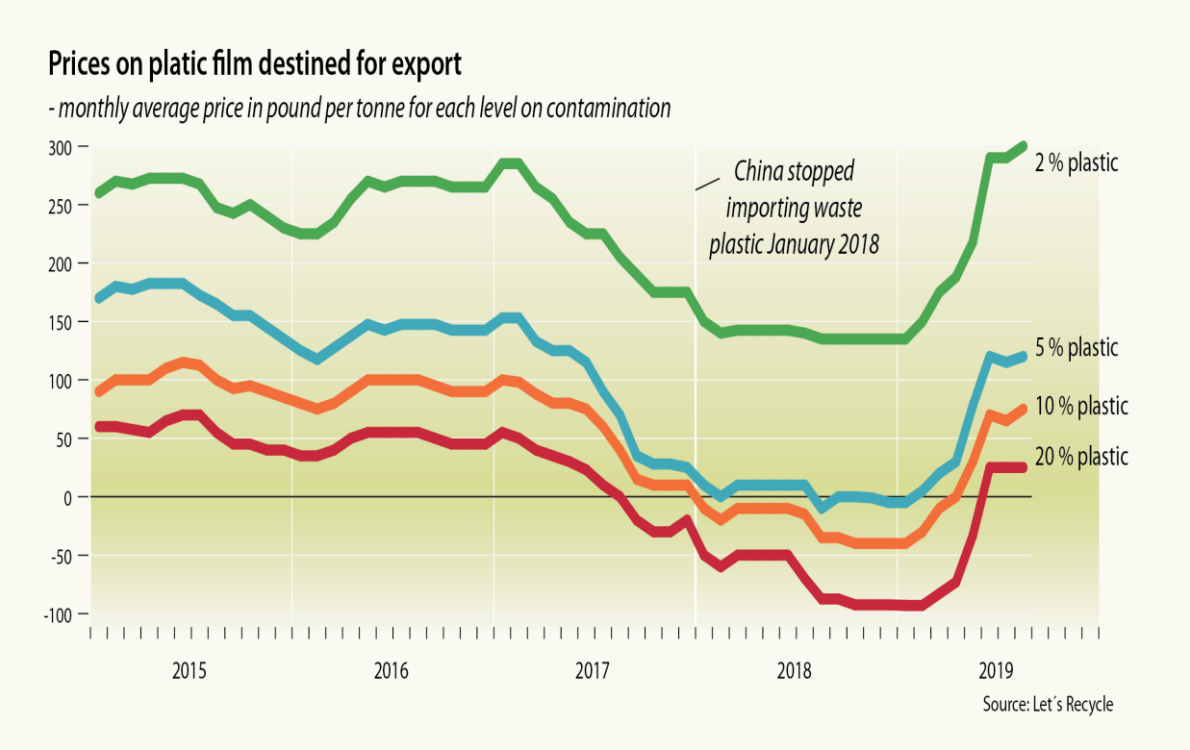
6.5 Economics of recycling

A comparison of the costs of running a commingled collection, against the cost of running a single stream collection system and the subsequent downstream costs of each would be informative. However, there are very many variables such as the frequency of collection itself which may be a significant factor.

Policies that seek to increase recycling will certainly create jobs as recycling requires more personnel than either landfilling or incineration.

The principle of continual quality improvement (see Module 2) and its effect on the value of collected and sorted material are illustrated by the following graph which shows value linked to contamination, where the more contamination by unwanted or deleterious materials in the waste and scrap, the lower the value. This example shows that the value of collected waste and scrap can become negative in the absence of a market; in such a case, the recycling, energy recovery or disposal of the waste has to be paid for.

Furthermore, as plastics are predominantly made from crude oil, it is most unlikely the price of recycled plastic pellets could pass that ceiling.



[59]

6.6. When does waste cease to be waste?

There is no consensus yet amongst countries setting the point at which each waste ceases to be waste. In addition to standards, however, laws and regulations may also set quality requirements for when waste ceases to be waste.

Wastes are defined as being disposed of and destined to go to an Annex IV Operation. It follows that when a waste has ceased to be waste it has gone through an Annex IV Section B Operation and has been recovered. Recycling is a type of recovery operation.

For some recovery operations, there may be a question of when waste may cease to be waste and reaches end-of-waste status. The Basel Convention does not clarify when a waste ceases to be waste. Some countries have set stringent criteria in their national legislation for waste to gain end of-waste status in order to ensure that there is sufficient certainty of use and that the products, materials or substances are not subjected to a disposal operation.

Possibilities for when a waste ceases to be a waste include:

(i) *It has been prepared for reuse*

A used good may meet the waste definition in some countries, e.g. if an owner intends to dispose of a used good. Reusing goods may promote resource efficiency. For a used good that has become waste, there needs to be sufficient certainty that it will actually be reused. This

[59] Plastic ZERO - Public Private Co-0perations for Avoiding Plastic as a Waste, n.d., Report on assessment of relevant recycling technologies, LIFE program

might be done by establishing that a used good works properly through checking, repairing or cleaning. Although such operations are not currently listed in Annex IV, national legislation may recognize them as recovery operations necessary to ensure that the waste is suitable for reuse.

(ii) *It has undergone a recycling operation and that operation is completed*

Recycling operations involve the reprocessing of waste into products, materials or substances, though not necessarily for the original purpose. An example is used lubricating oil re-refined so as to result in high-grade oil which is valuable for its chemical properties. Hence, that would be a recycling operation. Once the operation is complete, the substance or object is no longer waste. Some recycling operations are listed in Annex IV to the Basel Convention.

(iii) *It has otherwise gained end-of-waste status as a result of a recovery operation*

In some countries, the result of certain recovery operations may be products, materials or substances that do not require further recovery operations to enable them to be used, and are therefore no longer waste. An example might be waste catalysts that have undergone operation R8.

The Joint Research Centre, under **Sustainable Production and Consumption** (SUSPROC)**,** has been supporting the Directorate General (DG) for Environment in the elaboration and implementation of the Thematic Strategy on Prevention and Recycling of Waste since 2004. This long-term strategy aims to help Europe become a recycling society that avoids waste and uses any unavoidable waste as a resource.

Linked to this, since 2008 SUSPROC has collaborated closely with DG Environment in the implementation of the mechanism of end-of-waste criteria, introduced by Article 6 of the Waste Framework Directive of December 2008. The objective of end-of-waste criteria is to remove the administrative burdens of waste legislation for safe and high-quality waste materials, thereby facilitating recycling. The objective is achieved by requiring high material quality of recyclables, promoting product standardisation and quality assurance, and improving harmonisation and legal certainty in the recyclable material markets.

- End-of-waste Criteria for Iron and Steel Scrap: Technical Proposals
- End-of-waste Criteria for Aluminium and Aluminium Alloy Scrap: Technical Proposals
- End-of-waste Criteria for Waste Paper: Technical Proposals
- End-of-waste Criteria for Copper and Copper Alloy Scrap: Technical Proposals
- End-of-waste Criteria for Glass Cullet: Technical Proposals
- End-of-waste Criteria for Biodegradable waste (compost/digestate): Technical Proposals
- End-of-waste Criteria for Waste Plastic: Technical Proposals

Module 7 - Other Recovery Processes and Treatments

7. Introduction

Household waste has a huge potential for resource and energy recovery. The organic fraction of the waste is suitable for composting or anaerobic digestion, the recyclable fractions for reprocessing into new materials while the remaining fractions may be utilised for energy recovery. There is no standalone or single solution for household waste management and this should rather be an integrated system consisting of several techniques like recycling, composting and energy recovery. Based on the waste management hierarchy, recycling should be favoured followed by composting, anaerobic digestion and other waste-to-energy (WTE) solutions. Any sustainable solid waste management system must be an integrated approach in line with the waste management hierarchy prioritising waste prevention, minimisation, reuse, recycle, energy recovery while disposal must be the last option. However, no solid waste management system can be successful or effective if it is based on a standalone or single technology. A multitude of waste management technologies comprising both of resource and energy recovery is thus essential to ensure a continuous and effective waste management process.

However, any waste-to-energy technologies, particularly thermo-chemical systems (incineration, gasification or pyrolysis), must be preceded by a well-established waste-to-resource system through recycling and composting. The wastes that can be recycled must be recycled while those that cannot be recycled are then sent to the waste-to-energy system. In addition, any residual waste from the recycling process can also be subjected to the waste-to-energy system. As such, recycling and waste-to-energy must complement, rather than compete, with each other. Waste-to-energy systems must only compete with landfilling since this is the least favoured option of the waste management hierarchy.

Both recycling and waste-to-energy can form part of an integrated waste management system. However, waste-to-energy solutions must complement recycling and not replace or substitute the latter as this would not only lead to an ineffective waste management system but also result in loss of several jobs. Any thermal waste-to-energy system should thus only be implemented once the collection and recycling system is well-established and fully operational.

Prior to embarking on any large-scale composting or WTEB technologies, several steps need to be followed. This module serves as a guideline for the implementation of household waste recovery and treatment processes for instance composting, anaerobic digestion or other WTE technologies such as incineration, gasification or pyrolysis. Any of the options discussed in the module requires supporting political, social-economic, and cultural aspects. In addition, these systems can be stimulated by different economic instruments, for instance high landfill taxes.

7.1 Mechanical and Biological Treatment

Mechanical and biological treatment (MBT) is comprised of mechanical segregation followed by a biological technology like composting or anaerobic digestion. As such, MBT plants operate as material recovery facilities and accept co-mingled household wastes to sort the waste streams into the individual components (organics, paper, plastics, glass, metals, etc.). The recyclable fractions may be sold to recyclers while the organic fraction of the household wastes is used as feedstock to the composting or anaerobic digestion process. While the MBT system eliminates the need for source separation of household wastes and the associated costs of source segregation, this system also has several drawbacks. Since often the household wastes are collected mixed, the input material is often contaminated. Subjecting contaminated organics to composting or anaerobic digestion plants may hinder the biological processes while the compost produced may also not meet stringent standards. Besides, the quality of recyclables such as paper is greatly reduced when these get into contact with wet organics.

As such, the materials/products from MBT plants are often of lower quality and hence, not easily marketable. In this context, it is preferable to source segregate household wastes into at least two fractions (wet and dry) to improve the subsequent recovery and treatment processes. facilitate recovery of recyclables, reduce the disposal of hazardous waste (due to the sorting), generate fuel pellets (Refuse Derived Fuel, RDF). An example of successful implementation is Phitsanulok in Thailand where a MBT system of capacity of 100 tonnes/ day of mixed municipal waste has been in operation for more than a decade.

7.2 Composting

Composting is the decomposition of organic matter in the presence of oxygen by a microbial population to produce a humus-like product (compost) that has high nutrient content (Nitrogen-N, Phosphorus-P, Potassium-K). The compost may then be used as a soil-amendment to improve the nutrient content, water retention capacity, drainage and porosity of the soil while also acting as a buffer to the soil pH. Composting can be centralized (e.g., large scale municipal composting) and/or decentralized composting (e.g., local domestic composting).

What are the main benefits (supporting factors) of composting?

- **Finances**: Financially affordable options in most of the countries as can be started with very little capital and operating costs. It also allows savings as it increases overall waste diversion from final disposal, especially since as much as 80% of the waste stream in low- and middle-income countries is compostable.
- **Social-economic**: There is potential high recycling culture to the segregate at source. The recycling culture may also provide high organic content. It can integrate existing informal sectors involved in the collection, separation and recycling of wastes.
- **Policy**: Composting may help countries in reaching national goals and targets (e.g., in lowering greenhouse gas emissions from the waste sector). It also enhances recycling and incineration operations by removing organic matter from the waste stream.

What are the main barriers in composting?

- **Physical barriers**: composting requires land however some countries and Small Islands Developing states as well as mountain countries may lack this land.

- **Finances**: there is a lack of market for the final compost, however the market can be stimulated by the financial incentives such as reduced payment for domestic waste services.

7.2.1. Suitability of the Composting Process

The composting process is mostly suitable for wastes with a high organic matter content and having a moisture content varying from 40 to 60%. Materials that may be composted include food wastes, yard wastes, paper and other organic waste streams. The composting process may be carried out at the household level (e.g. local domestic composting) or on larger scale as windrows composting, aerated static pile or in-vessel composting (e.g. municipal scale). In addition to the moisture content, the carbon:nitrogen (C:N) ratio and particle size of the feedstock are important parameters to be monitored prior to and during the composting process. For an effective composting process, the C:N ratio must vary between 25:1 to 30:1 while the particle size of the substrate must be sufficiently small to ensure an increased surface area for enhanced degradation but not too fine as this may prevent air flow within the pile.

7.2.2. Local domestic composting or household composting

Household composting is an effective way of reducing the quantity of waste collection. It is the decomposition of organic waste, kitchen waste and garden waste, in the presence of oxygen. Diverting waste from the landfill offers a number of benefits namely reduction in the release of methane and leachate, savings in transportation and disposal costs, minimal ongoing capital expenditure after the purchase of the compost bins and no market is required. Organic wastes make up to 60 to 70 % of wastes being disposed in a number of developing countries.

The success of household composting requires effective planning and a trial phase. These include the following steps:

- Selection of the target area for the trial scheme;
- assessing current level of knowledge of composting;
- advertise the benefits of composting;
- assess feasibility of offering and distributing composters;
- provide backup support for problems and clarification;
- monitoring of the success of the scheme.

7.2.3. Operating a large scale composting plant

Prior to setting-up of any large scale composting process, there are some prerequisites that need to be satisfied (Refer to Section 8.5.1). Once these prerequisites are satisfied and the compost plant has been set-up, the following steps are generally applicable:

- Acceptance of organic wastes at the facility.
- Shredding of organic wastes to achieve a suitable particle size.
- Blending of the wastes while also adjusting for the C:N ratio and moisture content.
- For windrows composting: Laying the blended wastes into long piles “windrows” and aerating at regular intervals.

- For aerated static pile: Laying the wastes into piles over pipes connected to air blowers. Blow air at regular intervals to ensure aeration of the static pile.
- Fine shredding of the compost material.
- Test the final compost to ensure that it meets with applicable regional or national compost standards.
- Packaging of the final compost for sale.

Case Study: Reduction of household waste by composting in Surabaya, Indonesia

Name of the best practice (title)	Integrated Waste Management - Case of Surabaya City
Type of waste (e.g. plastic, metal, residues etc.)	Organic wastes
Where does the best practice apply in the waste hierarchy?	Recovery
What is the primarily target group (government, private, households)	households and communities
What type of activity (e.g., on-going practice, research, etc)	Waste Separation (sorting) and Composting (public awareness and promotion of environmental education)
Location (city, country)	Surabaya, Indonesia
Description of the best practice (max. 300 words)	The Takakura composting method enabled the establishment of twenty-one (21) small-scale composting centres throughout the city that were convenient and low cost for both household and community composting.

Fig. Surabya Composting Centre. Source: Authors, 2016

In tandem, one (1) large 15-tonne capacity waste sorting facility called the Super Depo was established to support composting activities through a JICA public-private partnership with a Japanese based waste company Nishihara, in March 2013, when it was realized that the several temporary disposal sites around the city, lacked proper facilities and capacity to handle the appropriate of waste. The Super Depo utilized best practice for waste sorting along a conveyor belt, in a clean and well kept facility with trained staff wearing uniforms and PPE as applicable.

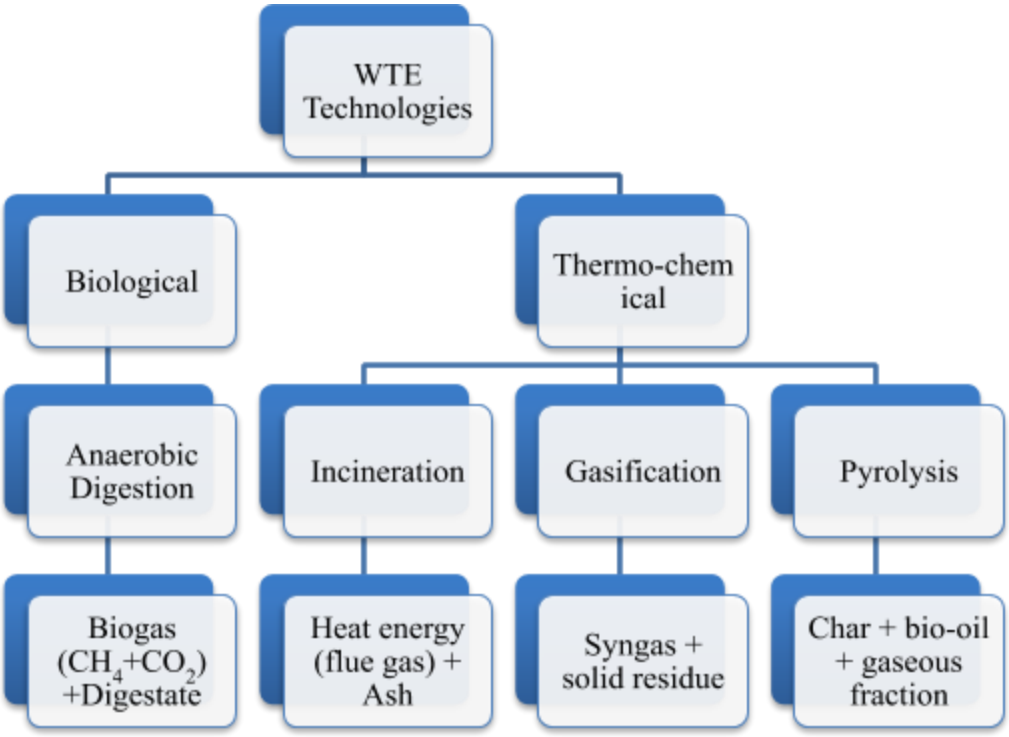
A separate composting house, using windrow composting was also set up by Nishihara in September 2014 to support the expansion of mixed waste separation and composting.

	 *Fig: Nishihara Super Depo (above) and Composting Centre (below). Source: Authors, 2016*
Explanation of key insights (e.g. potential drivers and barriers, lessons learned) for successfully replicating this best practice (max. 200 words)	***Driver:*** By 2001, the city of Surabaya was facing a severe waste management challenge as it was producing nearly 2000 tonnes of municipal solid waste per day, and one of the two landfill sites, Keputih, in the city closed. In response to this, the city implemented a 3R (reduce, re-use, recycle) strategy which included the establishment of waste sorting and composting facilities, supported by community based initiatives. In 2004, the project was used to promote the reduction of waste generated by way of both composting activities, at both the household and city level. The project was funded through a technical cooperation formed by Kitakyushu International Techno-cooperative Association (KITA) from Kitakyushu City, Japan and Pusdakota, a local NGO operating in Surabaya City. ***Benefits*** • large potential for cost saving in waste disposal and management through reduction and diversion activities • total potential market value of compost is approximately US$21,076,300 • cost of infrastructure for separation and composting facilities is significantly less compared to construction costs for the Benowo landfill • Environmental: improved neighborhoods, eradication of open dumping; reduction in amount of waste sent to the landfill; • Social: • increased job creations as it would require a total of 468 people to cover all of Surabaya's waste management (382 for

	non-organic and 86 for organic waste). The market value of recyclables is able to cover the wages. • greater civic involvement in waste management • development of waste banks ***Barriers*** • lack of public participation - addressed through public awareness campaigns that started off as small pilot scale composting projects to educate the public on how to compost. • disincentives: tackled by creating incentives such as additional income and pride in the community • inadequate number of composting centres for the volume of generated organic waste • improper sorting facilities with limited space; this attracts scavengers who attempt to recover recyclables • ***Lessons learned*** • waste reduction is possible with both political and community will with the right stakeholders • Both the Takakura composting method and the windrow method is low tech and simple with little training necessary • composting is cost effective for solid waste management • access to financing or financial incentives is required • capacity building and technical knowledge transfer is necessary at all levels
Sources of information	http://www.ccet.jp/sites/default/files/2017-10/CCET%20Surabaya%20Case%20Study_PrintingVer0718_2.reduced.pdf

7.3 Waste-to-Energy Technologies

WTE technologies may be classified as either thermo-chemical or biological. Thermo-chemical techniques include incineration, gasification and pyrolysis while biological WTE techniques include anaerobic digestion (Fig. 1).



WTE technologies and expected outputs

7.3.1 Anaerobic Digestion

Anaerobic digesters are alternatives to managing organic residual materials with the benefit of energy recovery. This degradation process takes place in an oxygen-free environment with anaerobic bacteria (bacteria that don't require oxygen). The digestion process produces biogas (methane, carbon dioxide and water) which can be converted into energy and digestate - solid remnants of the original input material, which can be taken for composting or used as fertilizer. Rigorous source separation and an effective collection system is necessary in order to provide good quality source material.

The anaerobic digestion requires supporting legislation and regulations in place. These are linked to energy sector (such as linking to energy grids), regulating the qualities of material etc.

What are the benefits?

- It defers recyclables and compostable material from final disposal in the landfills

What are the barriers?

- There are technical barriers such as the process does not operate properly at low temperatures
- It is process sensitive to high temperature variation (night and day, seasonal)
- Requires high investments
- Anaerobic process produces digestates which is based on feedstock material. Digestates require a separate management according to the quality of the digestates (Loga 2019). Markets for digestate and energy may be a problem, if not designed and studied in advance.

7.3.2. Suitability of the Anaerobic Digestion Process

The anaerobic digestion process is suitable to the organic fraction of household wastes (food wastes, yard wastes and to some extent, paper). The anaerobic digestion process may be operated at low or high solids. Depending on the system chosen, the moisture content of the feedstock is adjusted accordingly. Besides, other parameters such as C:N ratio, pH and temperature of the feedstock need to be adjusted to ensure effective digestion. Similar to the composting process, the optimum C:N ratio for effective digestion is 25:1 to 30:1; the optimum pH is 6.7 to 7.2 while the anaerobic digestion process may be either mesophilic (~37^{o}C) or thermophilic (~55^{o}C).

Operating a Biogas Plant

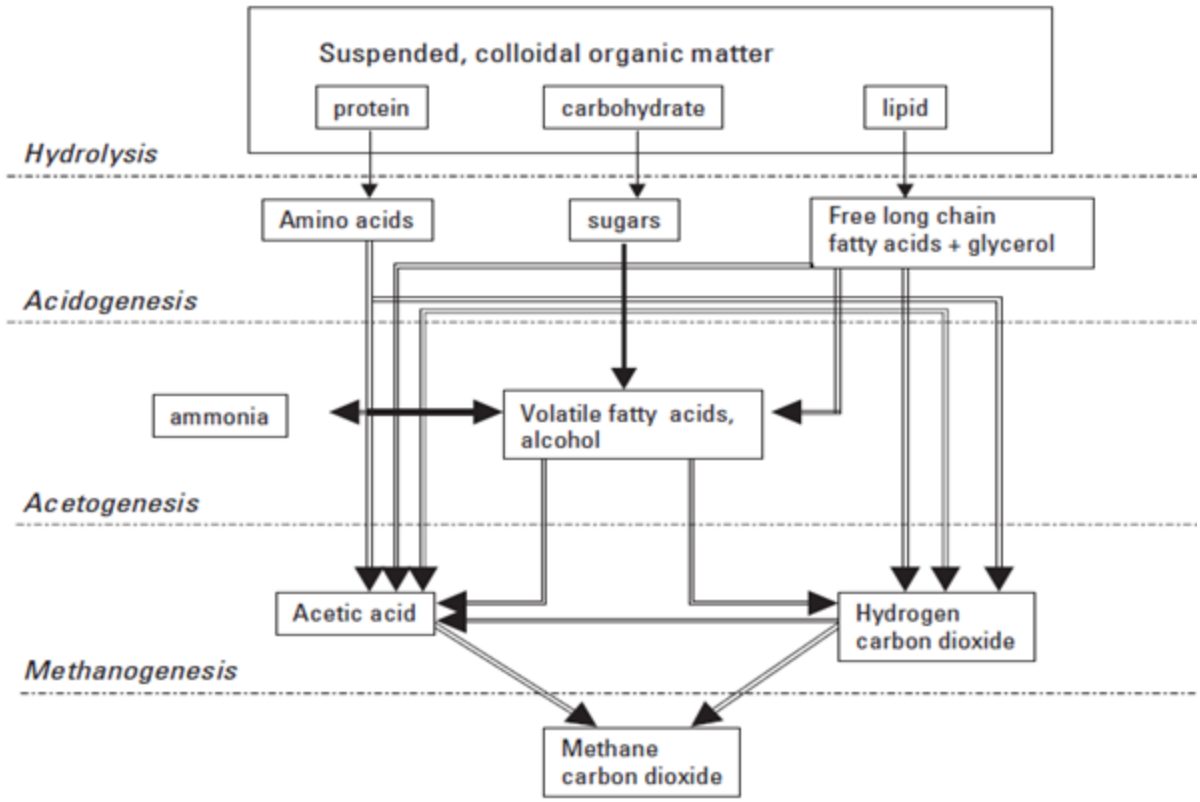
The anaerobic digestion plant, also referred as a biogas plant, consists of a multitude of unit operations namely feed/preparation tank, conveyors, shredder, pumps, bio-reactor or digester, biogas holder, dewatering equipment, gas scrubber, waste heat boiler, generator, among others. Commissioning of a biogas plant requires specific skills, techniques and knowledge. Considering that a biogas plant has high investment costs, it is important that the pre-requisites prior to setting-up of such a plant are satisfied (Refer to Section 8.5.1). Once these pre-requisites are satisfied and the biogas plant has been set-up, the following steps are generally applicable:

- Acceptance of the organic wastes.
- Preparation of the waste streams (shredding, adjustment of pH, C:N ratio, moisture content, temperature).
- Feeding of the prepared substrates into the bio-reactor.
- Mixing in the bio-reactor to ensure effective contact between the substrates and the microorganism.
- Recuperation, cleaning and storage of the biogas produced.
- Combustion of the biogas to produce electrical energy.
- Recuperation and treatment of the digestate produced or use as bio-fertiliser.

Muangklang Municipality in Rayong Province and Sam Chuk Municipality in Supanburi Province, both in Thailand, are examples where small-scale AD facilities (1.5-2 tonnes of organic waste per day) have been successfully implemented.

7.3.3 Landfill gas to Energy

Landfills produce gases which is the product of microbiological decomposition of landfilled waste and consists of around 50-55% methane and about 40-45% carbon dioxide.

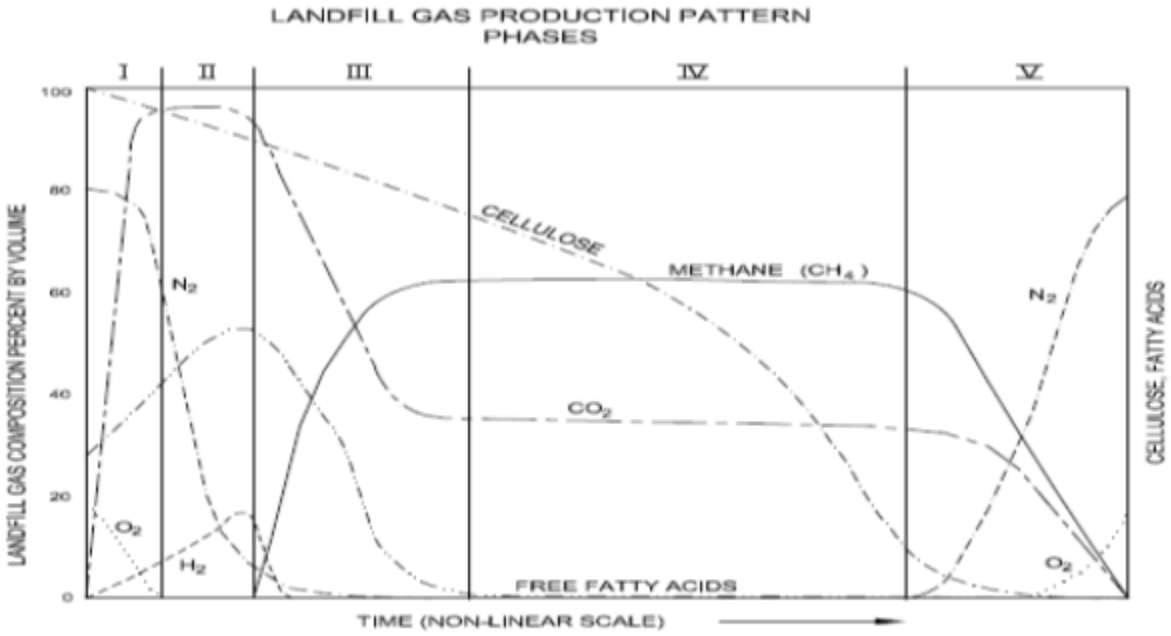


Nitrogen, oxygen, complex organic compounds, hydrogen sulphide and other sulphur compounds account for the rest. Methane, the major component of natural gas, is also a potent greenhouse gas. It is 21 times more potent than CO_2.

Landfill Gas (LFG) has odorous, toxic, and carcinogenic trace components. LFG is potentially flammable and explosive when concentrated in confined spaces. Long-term exposure may have harmful health effects and it can damage vegetation.

The combustibility of methane can be viewed as an asset and a liability. An asset when the gas becomes a source of energy recovered and a liability when subsurface migration of the gases results in hazardous conditions. Landfill gas can thus be used in place of conventional fossil fuels.

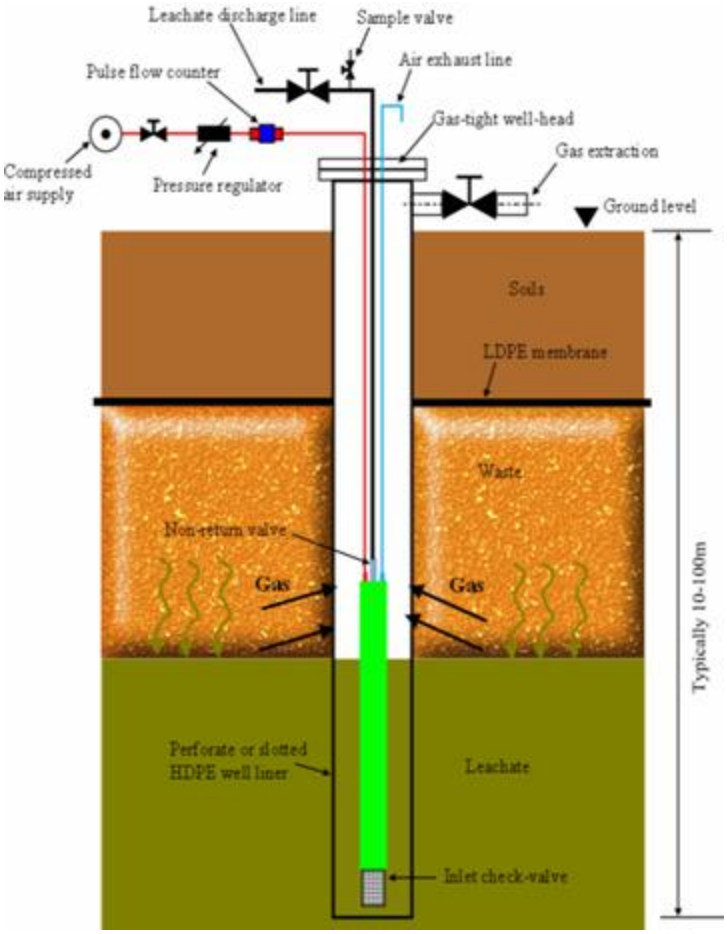
The diagram below shows landfill gas production pattern in landfills.



PHASES	CONDITION	TIME FRAME - TYPICAL
I	AEROBIC	HOURS TO WEEKS
II	ANOXIC	1 TO 6 MONTHS
III	ANAEROBIC, METHANOGENIC, UNSTEADY	3 MONTHS TO 3 YEARS
IV	ANAEROBIC, METHANOGENIC, STEADY	8 TO 40 YEARS
V	ANAEROBIC, METHANOGENIC, DECLINING	1 TO 40+ YEARS
TOTAL		10 TO 60+ YEARS

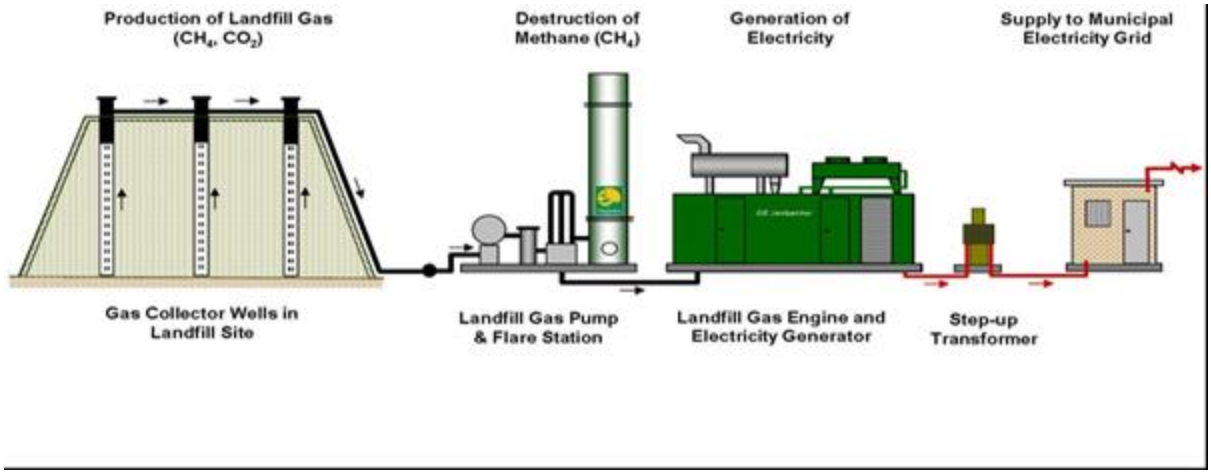
SOURCE: FARQUHAR AND ROVERS, 1973; AS MODIFIED BY REES, 1980; AND AUGENSTEIN & PACEY, 1991.

LFG can be removed from the site by the use of a series of wells and a vacuum system that channels the collected gas to processing. An active extraction system is thus necessary. This would involve a vertical extraction well, horizontal gas collection trenches, condensate handling equipment, blowers/compressors, scrubbers, flares and flame arrestors and/ or engine generator sets or energy recovery facilities.



Vertical well

Horizontal well



Landfill gas to energy plant

7.3.4 Incineration for Energy Recovery - Heating and Cooling

Globally, there are over 1200 Waste-to-Energy (WtE) plants in operation across more than 40 countries and is strongly developing in new countries along with a growing economy and along with the implementation of waste regulation. These plants recover the energy from

the MSW for power and/or heat and can recover non-combustible solids such as glass and metals from the bottom ash.

On more than 1000 of the 1200 WtE plants there are no pre-treatment of the MSW before it is combusted using a moving grate.' (ISWA Guidelines: Waste to Energy in Low and Middle Income Countries August 2013)

Incineration is the controlled burning of waste for production of ash and hot flue gas that can be used to produce steam for electricity generation via a turbine and generator. Incineration may result in waste volume reduction of 90% (mass reduction of ~70%).

7.3.4.1 Suitability of Incineration

Incineration, like all thermo-chemical WTE technologies, is suitable for wastes having a relatively low moisture content as well as a high calorific value. As per a report by the World Bank (Rand et al., 2000), the net calorific value of a waste stream must be on average 7 MJ/kg (but never less than 6 MJ/kg) for the incineration process to be sustainable. To ensure that a waste stream is combustible, the Tanner diagram may be used whereby any waste stream falling in an area with an ash content <60%, a moisture content <50% and combustible content >25% is deemed self-combustion (Tanner, 1965). For any waste stream not within the area boundary of these 3 parameters, a "combustion support" (e.g. fuel oil) is then required to assist in the combustion of the waste stream.

The net GreenHouse Gas emissions are usually low and comparable to those from biomass energy systems. Another advantage of the WTE over landfilling is it reduces the waste volume and its mass and recovers the energy and heat from wastes.

7.3.4.1 Operating an Incineration Plant

An incineration plant is a complex facility consisting of several unit operations including a bunker, hopper, grate, furnace, boiler, turbine, generator, scrubber, etc. Considering the high investment costs of such a facility, several prerequisites need to be satisfied prior to considering the implementation of this technique on a large scale. Once these prerequisites are satisfied (Section 8.5.1) and the incineration plant has been commissioned, the following steps are generally applicable:

- Waste reception
- Waste sorting and shredding
- Waste storage in bunker
- Waste feeding into furnace via the hopper and feeding grate
- Collection of ash and management
- Waste flue gas to waste heat boiler
- Generation of steam in the boiler
- Production of electrical energy via turbine and generator
- Treatment of flue gas

7.3.4.2 Ash Processing and Management

Ash is a by-product of the waste incineration process and may be classified as bottom ash and fly ash. For incineration processes, approximately 230-280 kg of ashes are produced per ton of municipal solid wastes incinerated (ISWA, 2006), with 80-90% of the ashes being bottom ash and the remaining 10-20% consisting of fly ash and air pollution control residues (Lynn et al., 2017). Both bottom and fly ash may consist of heavy metals and as such, may be classified as being hazardous. Nonetheless, fly ash is more hazardous since it may contain dioxins as well as a higher concentration of heavy metals (Lam et al, 2010). Considering the hazardous nature of fly ash, this must be properly managed in an environmentally sound manner so as to minimise any environmental and health impacts.

Fly ash must therefore be subjected to suitable treatments prior to utilisation or disposal. Some of these treatment methods have been reviewed by Lam et al. (2010). As for bottom ash, it has been commonly used as aggregate in concrete or as road base (Lam et al, 2010). However, it must be ensured that the bottom ash passes leachability tests and comply with existing standards for use as aggregates or construction materials.

For more guidance on the setting-up and operation of a waste incineration plant, refer to document by The World Bank (1999).

7.3.5 Biofuels (Gasification and Pyrolysis)

Gasification and pyrolysis are two thermo-chemical WTE processes that are used for biofuel production from biomass or waste materials. Gasification is the thermal conversion of carbonaceous waste materials in sub-stoichiometric amount of O_2 into syngas (CO, H_2 and CH_4) and a solid residue. The syngas can be combusted to produce energy while the solid residue must be managed in an environmentally safe and sound manner.

Pyrolysis is the thermal decomposition of organic matter in an oxygen-free environment to produce gaseous, liquid and solid fraction. Pyrolysis may be sub-classified as slow pyrolysis or fast (or flash) pyrolysis. Slow pyrolysis results in a higher solid fraction (char) while fast pyrolysis results in a higher liquid fraction (bio-oil). Both fractions can be combusted to produce energy but the solid residue produced as a result of the char combustion must be managed in an environmentally safe and sound manner.

7.3.5.1 Suitability of Gasification and Pyrolysis Processes

Gasification and pyrolysis are not suitable for processing commingled household wastes due to their heterogeneous nature. As such, it is not recommended to treat commingled household waste via either the gasification or pyrolysis processes. Nonetheless, these two processes may be used for treatment of the homogenous fractions of the household waste stream if this is sorted at source.

7.4 Project Cycle

Implementation of any composting or WTE facilities has to go through a project cycle consisting of primarily a feasibility phase, a project preparation phase and a project implementation phase (Rand et al., 2000; The World Bank, 1999). These 3 phases are essential for any new projects to ensure that, once implemented and operated, the project is successful.

7.4.1 Feasibility Study

A feasibility study is an important prerequisite to the setting-up of any large-scale facility as it helps assess the potential success or failure of a project. A pre-feasibility study may be carried out prior to an in-depth feasibility study to perform a preliminary evaluation of the project viability. However, a pre-feasibility study should not be a substitute for an in-depth feasibility study and even if a pre-feasibility study is carried out, a proper feasibility study is required which consists of at least the following components:

7.4.2 Quantification of Household Waste Streams

The amount of household wastes available to be subjected to the composting or WTE process is fundamental to the setting-up of composting or WTE facility. A critical mass is required to make any such system economically viable. If no data is available on the amount of household waste that is generated, estimates may be used as an indicative measure but these need to be refined when carrying out a feasibility study. A survey may be carried out over a sampled number of households and the waste generation rate may be determined accordingly. This data may then be used to calculate the total amount of wastes generated over a selected region. Alternatively, if all wastes are directed to a particular disposal site, the amount of wastes disposed may be determined via the use of weighbridge systems at the entrance of the disposal site.

7.4.3 Composition of Household Waste Streams

The waste composition is another factor that is primordial prior to deciding on the recovery or treatment option to be implemented. A waste with high organic matter content is better suited to the composting or anaerobic digestion process while a waste with a higher fraction of paper or plastics is better suited to a thermo-chemical WTE process. For countries not having a proper composition of the household waste stream, it is recommended that such a study be commissioned. The waste composition of unsorted household waste may be determined as per ASTM D5231.

7.4.4 Characteristics of Household Waste Stream

Similar to the composition, the characteristics of a waste stream also decides the option to be taken with regards to the treatment or recovery technique. Often, the composition of the waste stream dictates the characteristics. For instance, a waste stream consisting of high amount of organics tend to have a high moisture content and lower calorific value. Likewise, a waste stream consisting of high amount of plastics will have a lower moisture content and higher calorific value. The characteristics of the waste are important to the choice of the treatment technique since it is not viable to subject a waste with low calorific value (or low energy content) to WTE. Some of the analyses that are required prior to choosing a particular treatment technology are:

- Moisture content (after determining total solids content): ASTM E1756.
- C:N ratio (applicable for composting and anaerobic digestion): Determine organic carbon content (C) as per the Walkley-Black method and nitrogen content (N) by the Kjeldahl method.
- Calorific value (applicable for thermo-chemical WTE): ASTM D5468

- **Choice of technology** based on composition and characteristics of the household wastes (composting plant or biogas plant or thermo-chemical WTE plant).
- **Choice of system for the chosen technology** (e.g. composting: windrows composting, aerated static pile or in-vessel composting; anaerobic digestion: low vs. high solids, mesophilic vs. thermophilic, etc.; thermo-chemical WTE: incineration (mass-burn, fluidised bed, etc.), gasification (ultra-high temperature) or pyrolysis (slow or fast)).
- **Preliminary sizing and conceptual design** of the facility and of its unit operations based on the amount of household waste to be processed.
- **Cost-benefit analysis** of setting-up and operation of the facility.
- Capital and operating costs of the plant.
- Market for sale of compost, biogas or electricity and revenues derived therein.
- Any other costs or revenues (tipping fees for waste disposal) to ensure that the project is financially sustainable.
- **Financing mechanism:** Design-Build-Own-Operate (DBOO), Build-Operate-Transfer (BOT), Build-Own-Operate (BOO), etc.
- For more details on financing, refer to **Module 2**.
- **Siting of the facility:** When siting any such facility, it must be ensured that the distance of waste transportation is minimised while environmental and social aspects of the project are considered.
- **Environmental Impact Assessment:** To evaluate any bearing that the project might have on the environment through a consultative process with stakeholders.

7.4.5 Project Preparation Phase

Once the feasibility study has been carried out and the project is deemed viable, the project may then move to the preparation phase which consists of the following (Rand et al., 2000):

7.4.5.1 Setting-up of an Institutional Framework

An institutional framework consisting of all relevant authorities involved in the project needs to be established to oversee implementation of the project. This framework shall consist of, but not limited to, the following:

- Waste Management department: For waste supply agreement
- Energy department (wherever applicable): For power purchase agreement
- Environment department: For environmental impact assessment
- Finance department: For financial aspects
- Non-governmental organisations: For assisting in the evaluation of social impacts

For more information on the institutional framework, refer to **MODULE 1**.

7.4.5.2 Setting-up of a Regulatory/Legislative Framework

The setting-up of a regulatory framework is essential for ensuring that the facility is operating within a legal boundary. This framework shall ensure that the required legislations are in place within the host country and may include the following:

- Standards for compost quality
- Standards for air emissions from WTE plants

Refer to **MODULE 1** for more details on regulatory/legislative framework.

7.4.6 Preparation of Bidding Documents

Expression of interests may be launched to evaluate the market interest for investing in any waste recovery or treatment facility. The expression of interest may also be limited to only WTE processes.

Subsequently, request for proposals are then sent to a list of shortlisted bidders (from the Expression of Interest exercise) and the bids are then evaluated.

7.4.7 Project Implementation Phase

Once the bids have been evaluated, the Contract is then awarded to the successful bidder. This shall then initiate the detailed design and construction works of the composting or WTE facility which can be a lengthy process depending on the choice of technology. Following completion of the construction works, the whole plant is then commissioned and the process is started (start-up).

7.5 Conclusions

There is no standalone or single solution for household waste management and this should rather be an integrated system consisting of recycling, composting and energy recovery. Based on the waste management hierarchy, recycling should be favoured followed by composting, anaerobic digestion and thermal WTE solutions. For household wastes having a high fraction of organics, composting and anaerobic digestion are the more suitable recovery and treatment processes. Likewise, for wastes having a low moisture content and high calorific value, thermal WTE represent the most suitable solutions. Nonetheless, prior to large-scale implementation of any such facility, several steps need to be followed. A feasibility study is primordial prior to embarking on the implementation of a composting plant or WTE facility. Additionally, the necessary frameworks need to be established to ensure the smooth and efficient implementation and operation of the selected technology.

Module 8 - Environmentally Sound Final disposal of household waste

8. Introduction

This Module covers the least preferable waste management option in the waste hierarchy – incineration (with or without low energy recovery) and landfill disposal of waste. The waste hierarchy prioritises waste prevention, reduction, reuse, and recycle, so that only the residual fraction remains for final disposal. However, in many places landfilling is the only waste management option. There is regular leakage and occasional collapse at poorly managed non-engineered waste deposit sites. Therefore, transitioning to a well-managed engineered landfilling and improvement in management and operation of existing landfills is crucial.

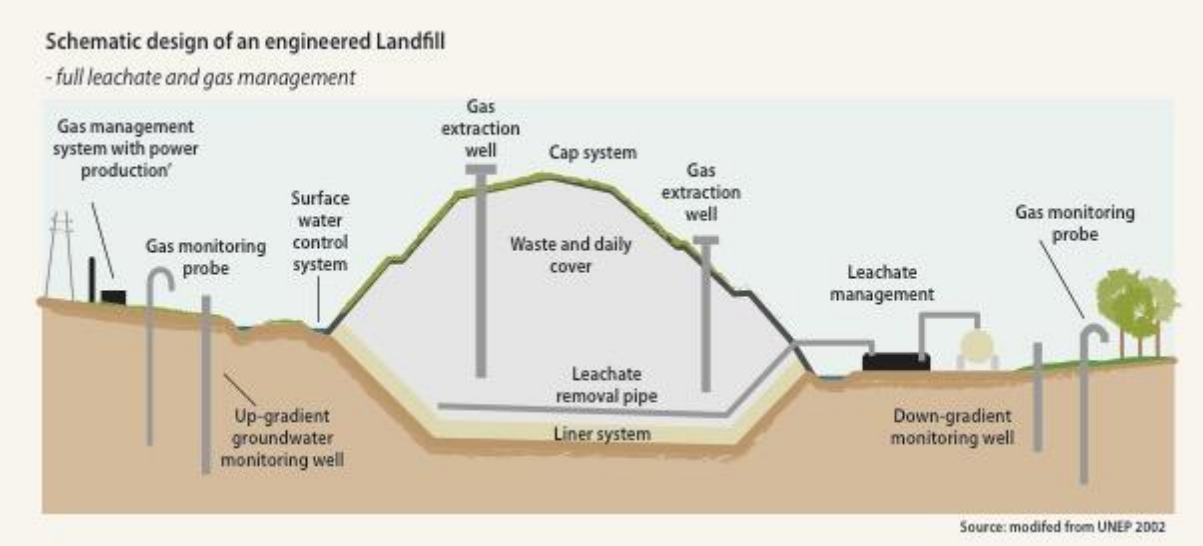
8.1 Environmentally Sound landfill (Basel Convention Annex IV (a) including compartmentalization to deal with different waste streams as well as landfill site aftercare, monitoring and surveillance)

Landfill waste disposal presents a potential pollution threat. The Basel Convention has produced technical guidelines on specially engineered landfill (Basel Convention 2019). Developing a landfill, regardless of community size or the quantity of waste handled, requires that the best practically feasible environmental option, based on appropriate and affordable technology, is chosen. Landfills should not be located at sites where they will have high visual or environmental impact. Avoiding contaminating surface and ground water sources is particularly important, therefore nonpoint discharges must be avoided and any discharged leachate needs to be treated to meet appropriate water quality standards.

Residue waste should be disposed at an engineered landfill (also referred to as a sanitary landfill) in a manner that results in an adequate compaction and air-space utilisation. The following will be key aspects to consider in this regard:

- Waste should be deposited in thin layers for good compaction;
- Cells should be fenced temporarily to collect litter during waste deposition;
- Daily working area should be kept as small as possible in order to minimise the area of waste material exposed during the operating day;
- Each layer of waste deposited should be compacted to reduce the likelihood of instability and settlement problems in future, and to give the best density.
- To avoid creating large voids within the waste disposal site, bulky waste such as old furniture, baskets, cages, packaging etc. should be crushed before compacting and spreading;
- Final cover should be applied to all surfaces where the final approved elevation has been reached and on all surfaces when the waste disposal operation is closed.

Where cells are used for depositing wastes, temporary bund walls are built up to provide sides and an end to each cell. The bunds are constructed of spoil or other inert waste. The initial bund should be of fairly low permeability material in order to prevent surface water infiltrating into the cell.



8.1.1 Upgrading of Existing sites

There are a number of waste disposal sites that do not meet the environmentally sound management criteria and therefore would need to be upgraded or closed. This would likely be done in a phased gradual approach so as not to impact negatively on the overall waste management operations in an area.

While upgrading an existing waste disposal site into an improved waste disposal site may be the most suitable option for a government or local authority, the phased closure of an existing site might be the environmentally sound appropriate decision to make mainly because of poor location.

To upgrade an existing waste disposal site, similar criteria would be applied as to a new disposal site. Upgrading a site should also only be considered if the lifespan of an existing site after the upgrade would be extended for a comparable period of years. If then the site is suitable after all environmental, technical and social aspects have been made, planning and design should be done as if it was a new site.

While the planning and designing are going on so as to upgrade the site to an environmentally sound, a number of actions can be made in the short term on the existing site. The following are important:

- Site drainage improvement so as to divert runoff around the site
- Extinguishing all fires that may be on site by making a trench around them. The use of water should be avoided as this would contribute to the creation of more leachate and groundwater pollution
- Levelling so as to stabilize the waste but also promote storm water drainage
- Cover material should continuously be applied especially to sites that would not use moving forward and this would also help in managing vectors on the site
- Fencing the site if it's not already fenced ensures that there is no further encroachment on the land, the control of windblown litter and management of what comes on the site. Any locally appropriate fencing material may be used as a fence including bamboo or brick mortar

Successful closure of waste dumps and construction and operation of engineered landfill

Mauritius is an island off the east coast of the continent of Africa with a population of 1.4 million people. Through concerted effort by the Local authorities, the waste management industry and the general public, Mauritius has made significant strides in managing its solid waste. A decision was made in 1994 by the Mauritian Government to:

- Close all open waste dumps in the country
- Construct sanitary landfills
- Construct additional transfer stations and upgrading of existing ones
- Increase the collection, coverage and frequency of waste
- Dispose specific types of solid hazardous waste in specially designed cells
- Increase public awareness on waste management

In 1990, there were 21 open waste dumps spread over the island, representing not only an eyesore but also an environmental and a public health nuisance. In May 2009, an agreement for a landfill gas to energy project was signed between the private sector represented by the operator of the Mare Chicose landfill and the Government of Mauritius. The agreement entailed the:

- Enhancing the capture of Landfill Gas (LFG)
- Using the Clean Development Mechanism (CDM) provisions of the Kyoto Protocol to sell Certified Emission Reductions (CER's) acquired through the project;
- Use of gas by the landfill operator to produce electricity through generators (instead of flaring) and sale of electricity through a Power Purchase Agreement (PPA)

The project was a success because the policy, legal and institutional framework combined with the national solid waste management plan ensured the mobilization of resources. The biggest obstacle was securing land for the engineered landfill. A key driver towards the development of the landfill gas project was the strong private-public partnership relationship.

Sound management of a non-engineered waste disposal site

Dhankuta, with a population of 50,000 in 2019, is a small municipality located in the hills of eastern Nepal covering 42.81 square kilometres. The municipality has made progress towards improved waste management with limited resources and despite having a non- engineered waste disposal site. Dhankuta has introduced a system of household waste separation into biodegradable and non-biodegradable waste fractions. Non-degradable waste is carried to the landfill site by the municipality, while biodegradable waste is used as animal fodder and agricultural manure. In city areas, the manure is used for kitchen garden and rooftop farming. So as to avoid harmful health effects of landfill site on its employees, municipality has adopted safety measures. Employees are undergone periodic medical check-ups and are insured.
Dhankuta's landfill site is situated nearby by a dense city settlement and just 150-300 meters away from human settlement, nobody has spoken against it. Dhankuta has successfully

turned the decommissioned part of landfill site into a beautiful park. More than 40 species of flowers are planted in this site. No foul smell is felt in the surrounding area because of fragrance emitted by a variety of flowers. Every day more than hundred city dwellers visit this place. The municipality charges an entrance fee of 5000 rupees (US$ 45) and earns around Rs 4 million from the sale of old wires, paper, iron, zinc sheets, glass and plastic disposed by households every year. The landfill site has become a national model and the city has been recognised by the Nepalese Government for its cleanliness.

8.2 Landfill site restoration and aftercare

Landfill site restoration and aftercare, including monitoring and surveillance are important final processes in the management of waste[60]. Environmentally sound restored landfill sites can be used to the benefit of the local community. Sites can serve as open spaces for sports and recreational purposes. Structures should not be built on formerly closed landfill sites until complete stabilisation has taken place and this process can take several decades. Legislation is certain countries does not allow any structures to be built on restored sites even when stabilization has taken place because of the potential landfill gas generation. It is therefore critical that activities are restricted to those that do not pose a hazard. The closure plan that is approved as part of the original environmental impact assessment process should cover:

1. Final shaping and landscaping;
2. Final waste disposal cover or cap design;
3. Permanent storm water diversion measures and runoff control
4. Anti-erosion measures; and
5. Infrastructure relating to the selected end-use.

Aftercare is required once the operation of a landfill site has ceased. National policy should spell out the minimum time a landfill site needs to be subjected to aftercare. Generally, the larger the site, the longer the aftercare requirements. The operating procedure and maintenance manual of a landfill site, agreed upon with the regulator of the landfill site, should provide details of the specific aftercare requirements and procedures to be followed. This ensures liability for restoration and aftercare is in place.

8.3 Monitoring and Surveillance

Monitoring and surveillance is importance as it ensures that the final state of the site is environmentally safe, especially as it relates to any surrounding water bodies, final cover, capping, top soil application and vegetation. Surveillance requires substantial financial and technical resources and these would have been accounted for at design stage and controls like monitoring bore-holes and sampling points to monitor the quality of groundwater installed at site preparation stage.

Restricting the amount of water getting to the landfill impacts the amount of leachate produced and affects the rate and level of degradation of wastes and the final stabilisation of

[60] https://www.epa.vic.gov.au/~/media/Publications/788%203.pdf

the landfill site. Thus, measures have to be taken to reduce the amount of leachate generation from a design point of view. Such designs may include the placement and compaction of adequate final cover, the selection of suitable vegetation types and effective drainage. Managing the surface run-off is equally critical not only in reducing the amount of leachate but also the possible flooding which could de-stabilise slopes and cause slips.

Gas is inevitable generated as waste decompose and this process would continue for decades after the site is closed. The gas may migrate for long distances away from the site in a waste disposal site as wastes decompose. Gas will start to be given off within a few weeks of wastes being deposited, and may be generated for many decades after the site is closed. Waste disposal gas can migrate considerable distances from the landfill site. The methane gas produced may pose a big hazard and flaring it would have greenhouse gas implications.

The final closure and rehabilitation plan that would have been integrated into the site plan and design to ensure that the waste has stabilised physically and chemically before the final cover is applied. It would be after a complete audit of the site is done by authorities using an approved system or criteria that monitoring and surveillance would cease.

8.4 Environmentally sound incineration for final disposal of household waste

Incineration is a high temperature dry oxidation process that reduces the volume and weight of waste. This process should be selected to treat household waste that cannot be recycled, reused, or disposed of in a landfill or for purposes of energy recovery. Incineration would also need to meet the applicable local legislation including standards related to air pollution and planning authorities.

Household waste with the following characteristics is not recommended for incineration:

- Pressurized gas containers
- Reactive chemical wastes
- Silver salts and photographic or radioactive waste
- Halogenated plastics such as polyvinyl chloride
- Waste with high mercury or cadmium content, such as broken thermometers, used batteries and lead-lined wooden panels

Typically, household wastes to be incinerated would have the following characteristics:

- Low heating value
- Content of combustible matter above 60%
- Moisture content below 30%
- Content of non-combustible fines below 20%
- Content of non-combustible solids below 5%

The use of incinerators for the disposal of household waste can be a good option particularly if it’s used with energy recovery in mind. However, the use of an incinerator, its maintenance and management can be a challenge if the construction, siting, operation and management of these units is not up to standard. These deficiencies can result in poor performance of the incinerator, e.g. low temperatures, incomplete waste destruction, inappropriate ash disposal, high smoke emissions, fugitive emissions, etc. The use of an incinerator in the disposal of

household waste may be the preferable option if unsecured pits or landfills, or (uncontrolled) burning in drums or pits is the alternative. However, the combustion of household waste can form particulate matter, dioxins, furans and other toxic air pollutants that needs to be considered before incineration is adopted as an option.

It is in view of the foregoing, incineration should only be considered when environmental sound disposal is guaranteed and there will be adequate emission control, reduced occupational exposure and other hazards. This will entail adherence to the following key elements:

- Effective waste reduction and waste segregation, ensuring that only the smallest quantity of appropriate waste types is incinerated.
- An engineered design, ensuring that combustion conditions are appropriate, e.g., sufficient residence time and temperatures to minimize products of incomplete combustion.
- Siting incinerators away from populated areas or where food is grown, thus minimizing exposures and risks.
- Construction following detailed drawings, thus avoiding flaws that can lead to incomplete destruction of waste, higher emissions, and premature failures of the incinerator.
- Proper operation, critical to achieving the desired combustion conditions and emissions, e.g., appropriate start-up and cool-down procedures; achievement and maintenance of a minimum temperature before waste is burned, use of appropriate loading/charging rates (both fuel and waste) to maintain appropriate temperatures, proper disposal of ash, and various actions and equipment to safeguard workers.
- Periodic maintenance to replace or repair defective components, e.g., including inspection, spare parts inventory, record keeping, etc.
- Enhanced training and management, possibly promoted by certification and inspection programs for operators, the availability of an operating and maintenance manual, management oversight, and maintenance programs.

8.4.1 Safe handling of Ash

Some of the treatment technologies employed for the household waste treatment such as Incineration with and without energy recovery do produce some of the residual waste e.g. incineration ash that needs to be safely disposed. All ash from incineration of household waste shall be considered hazardous and disposed off appropriately.

- The ash processing system shall involve stabilizing the ash product with lime and cement so that it can safely be land filled or used in construction as fill material or construction blocks.
- Ash handling and processing shall be kept away from water courses to avoid water pollution or being offensive to the surrounding prior to disposal.
- Incinerator ash and residues shall be disposed of in a special cell within the landfill.
- Volatile organic compounds in ash shall not be more than 0.01%.
- Wastewater from gas washing and quenching of ashes shall be neutralized to permissible statutory limits before being discharged.

Module 9 - Awareness raising and communication

9. Introduction

If household waste is not stored, separated, collected, and disposed of properly there can be threats to public health and the environment. It is therefore important to promote the best practices for the Environmental Sound Management (ESM) of household waste with the target audiences through awareness raising and communication. Therefore, effective communications are paramount and need to be tailored to suit different stakeholder groups and their different behaviors and motivations.

The implementation of successful awareness campaigns that promote proper environmental behaviour in the field of waste management is a challenge, particularly as it seeks to change the population behaviours and habits. The population consists of different groups, which can be defined according to criteria of age, gender, education, occupation, income, among many other factors that require to plan communication and direct it to specific target groups, with different messages and appropriate media to each one of them.
In addition, any awareness campaign will contribute to avoid any type of public reaction or opposition from different parties.

The present module provides guidance on the design and implementation of an appropriate awareness raising and communication campaign to promote the best practices for the Environmental Sound Management (ESM) of household waste with the target audiences.

9.1 Communication strategy aim and objectives

The overall aim is to be persuasive, comprehensive and robust in the communication of the household waste management practices, in a manner that is palatable for the wide cross section of target groups.

The main objectives include:

(i) To promote awareness on the guidance document on ESM of household waste,
(ii) To generate awareness about the health and environmental impacts of improper management of household waste among
(iii) To educate and exchange information on good practices for the management of household waste with the target audience through different channels (traditional media and digital/innovative channels).
(iv) To influence behaviour towards improved household waste management

This is enabled through the availability of a guidance which contains modules on the ESM of household waste. It begins with 'The Waste Journey' which takes the audience no matter stage they are at, by taking them through a simplified and easy way to use checklist that asks the rights questions and directs them to the most appropriate, useful and beneficial answers/strategies. The checklist makes it easy and straightforward for the stakeholders to actively use the modules contained within the guidance.

9.2 Audience

Improper household waste management affects a wide cross section of stakeholders. As such, in order to achieve the aim of improved behaviour a wide range of groups need to be engaged. These include parties to the Basel Convention, businesses (including manufacturers and retailers), decision-makers (including practitioners, municipalities, policy makers) and household members (including adults with purchasing and disposal responsibilities and children).

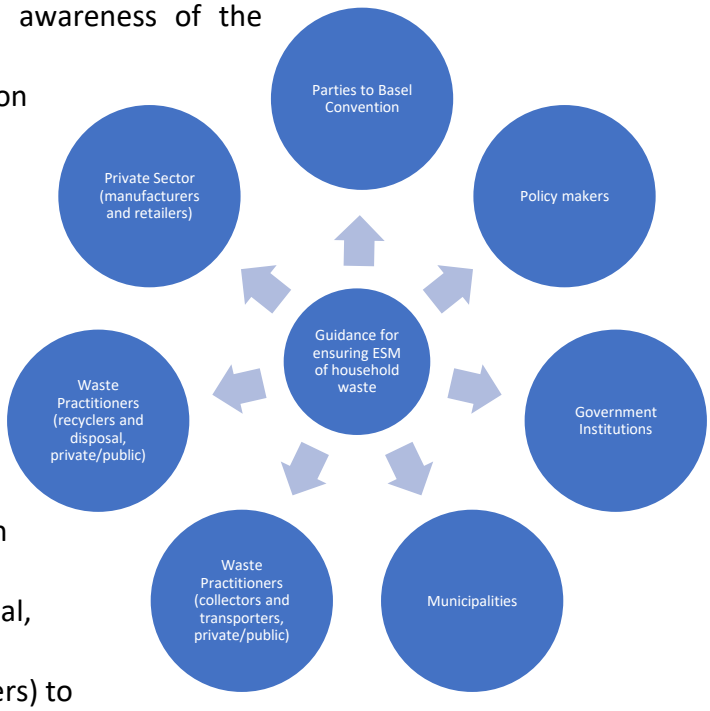
9.2.1 Target Audience

In order to successfully target specific groups, it is important that we segment residents. This can be achieved based on the following factors: • Age • Type of accommodation • Ethnicity • Gender • Language • Level of interest/participation in recycling and waste prevention • Whether they are covered by estate or kerbside collection rounds. In addition to residents, it is also important to consider and identify our wider stakeholders to ensure that communication and joint working opportunities are maximised. These can be categorised as internal and external stakeholders.

9.2.1.1 Primary Target Audience

The primary target audiences will be engaged primarily in order to present, promote and communicate the ESM guidance document and supplementary information to support the best practices on household waste management (e.g. websites).

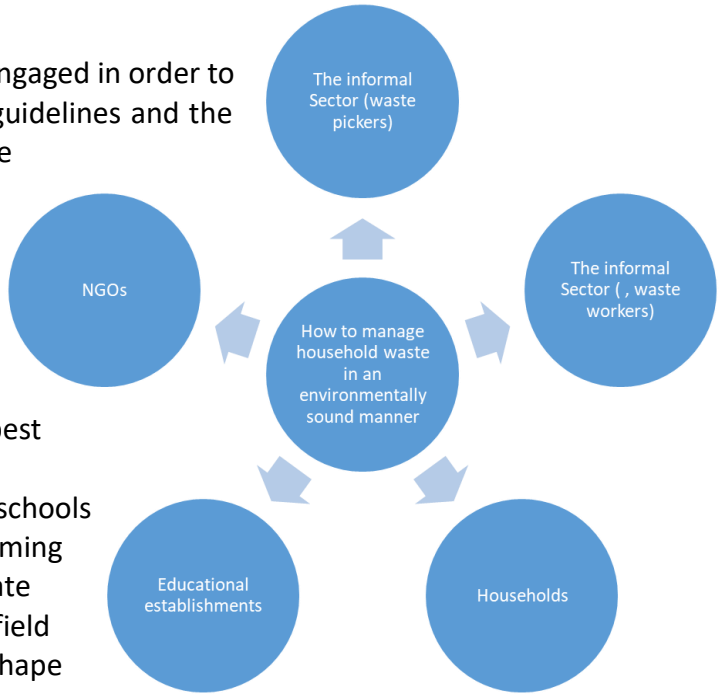
- Parties to Basel Convention – general awareness of the guidance and website etc.
- Policy makers – to inform for consideration developing policies, making decisions, designing plans, investing or making legislation
- Government Institutions (waste management authorities and other government agencies) – to guide on best practices
- Municipalities - – to guide on best practices
- Waste Practitioners (collectors and transporters, private/public) - to guide on best practices
- Waste Practitioners (recyclers and disposal, private/public) to guide on best practices
- Private Sector (Manufacturers and retailers) to guide on best practices



9.2.1.2 Secondary Target Audience

The secondary target audience will be engaged in order to translate the key messages of the EM guidelines and the focus will be to enable behaviour change

- The informal Sector (waste pickers, waste workers) – Health and Safety
- Households – to communicate the direct impacts of improper household waste management and improve awareness on the best management practices
- Educational establishments e.g. schools and colleges (these are the upcoming generations who will also generate waste and potentially enter the field of waste management in some shape or form themselves in years to come.
- NGOs – to support and promote the awareness and communication campaign



9.3 Communications Channels

The checklist will appear electronically (via the internet) as an interface to users, to allow a user-friendly way to access and complete the checklist.
The checklist enables easy navigation of the questions that best relate to the stakeholders questions and enquiries.

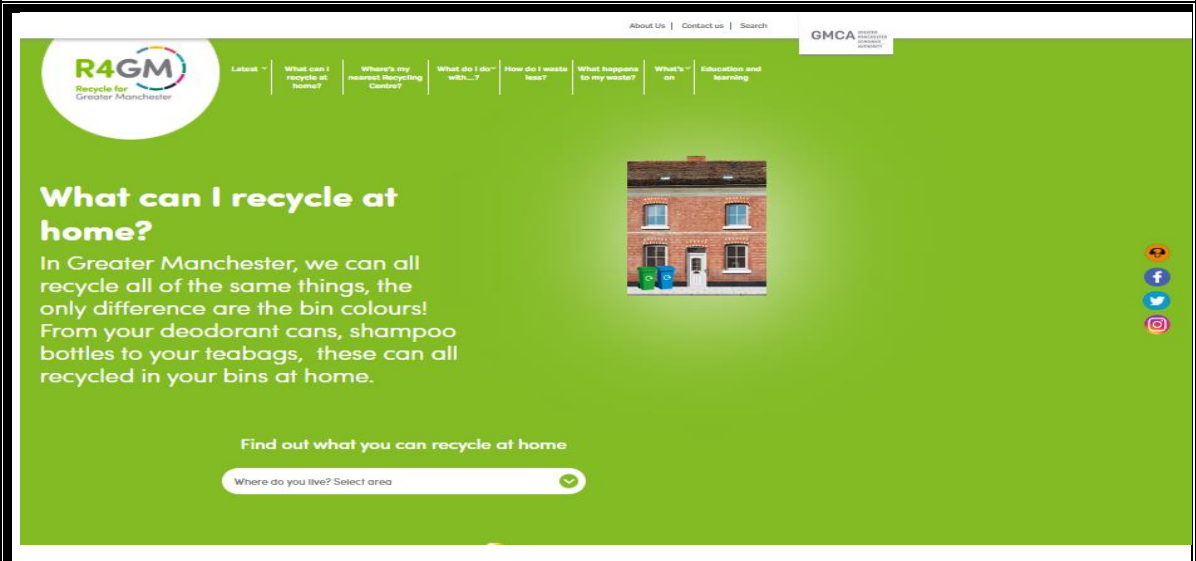
9.4 Communication Tools

9.4.1 The HW Website

(i) UN, BRS, Stakeholders, business advice sites and portals e.g. government, chamber of commerce, tax/HMRC, waste management, recycling, vehicles and technologies for the waste industry, press and media.

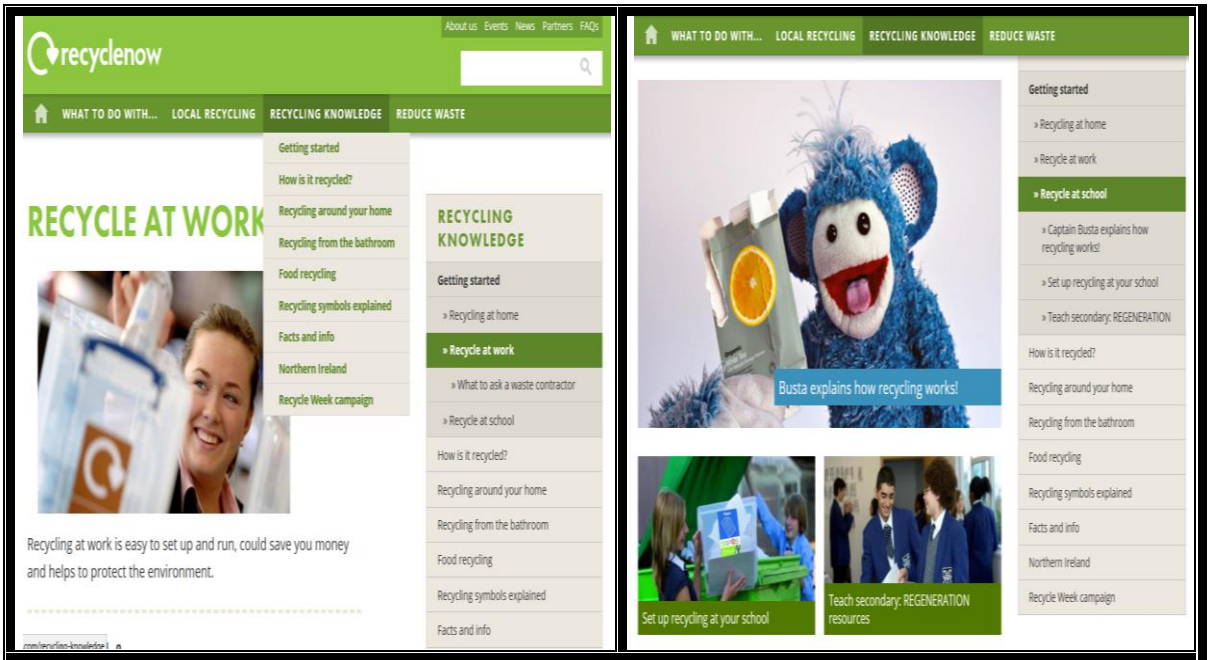
(ii) A section on the website to include Social Media coverage of events that we are hosting and inks to events that our target audience are hosting in terms of ESM of Household waste and education of other audiences.

(iii) We are to either host or recommend that our target audiences host web pages that help to educate and empower certain audiences like work places and schools on areas like recycling (even reduce and reuse) and capturing what can be collected for ESM. A section on the website to include the education and awareness material and messages.



The use of a website to provide best practice on household waste in Greater Manchester, England

Source: https://recycleforgreatermanchester.com/community/

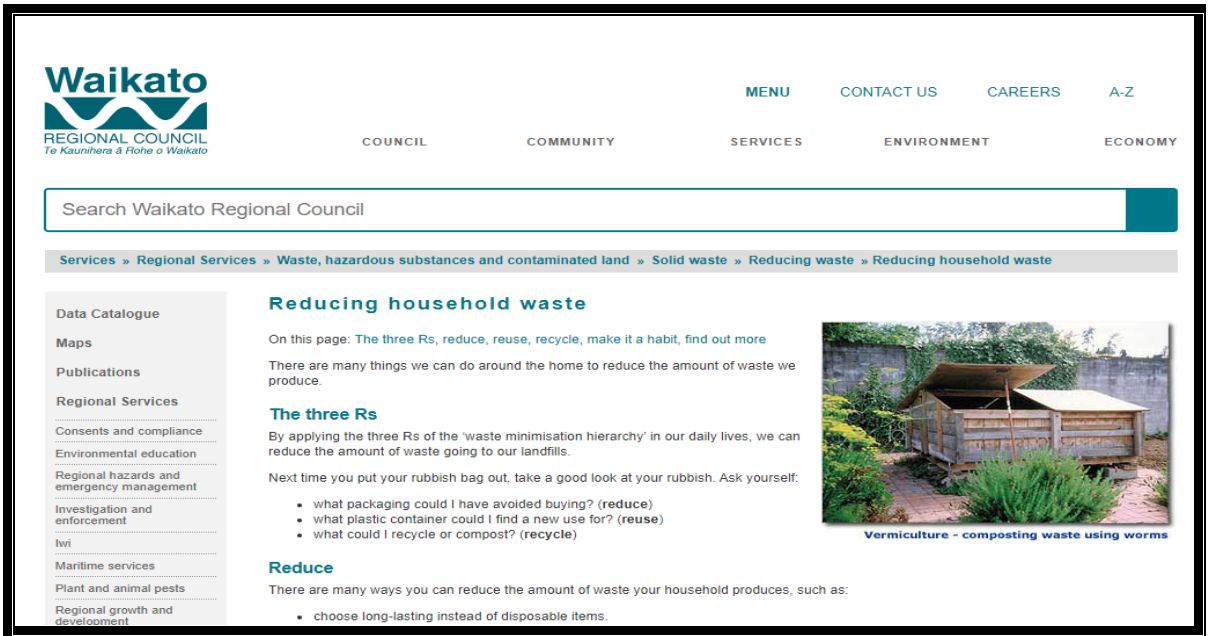


The use of a website to provide best practice on household waste at work and school - Recycle Now in England

Source: https://www.recyclenow.com/recycling-knowledge/getting-started/recycling-at-work and https://www.recyclenow.com/recycling-knowledge/getting-started/recycling-at-school

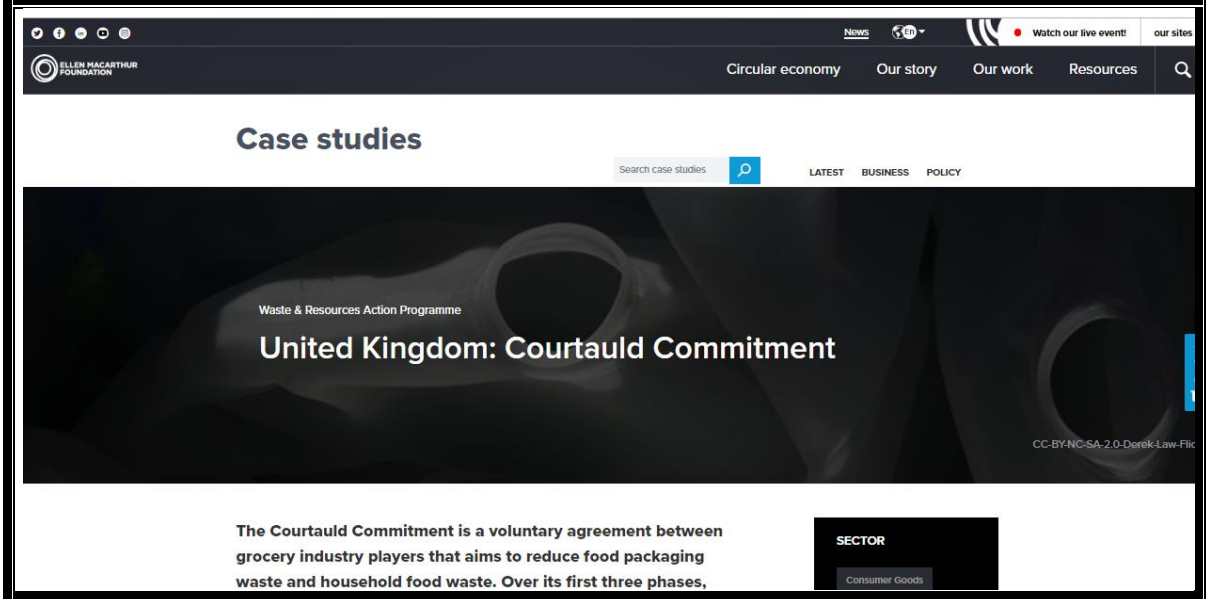
(iv) Create a section on our key website specifically for our key target audiences and call it 'Partners' which hosts further case studies, photographs, communications collateral/materials for use in communications that would normally require the target audience a great deal of time and money. Thus, pulling in the key audiences towards the guidance and its use. They would have to register with us for use and allow us to hold their details and make future contact.

(v) Collaborate with key environmental groups to get their backing (even accreditation) and piggyback on their comms e.g. Surfers against Sewage, Friends of the Earth (FOE), World Wildlife Fund (WWF), Ellen MacArthur Foundation…Ensure we have Search Engine Optimisation so that our websites come up top on any searches.



The use of a website to promote the management of household waste in the Waikato Regional, New Zealand

Source: https://www.waikatoregion.govt.nz/Services/Regional-services/Waste-hazardous-substances-and-contaminated-sites/Solid-waste/Reducing-waste/Reducing-household-waste/



The use of the ELLEN MACARTHUR FOUNDATION's website to promote the Courtauld Commitment- A voluntary agreement between grocery industry players that aims to reduce food packaging waste and household food waste

9.4.2 Traditional Media

- Press releases and photos
- Editorials in newspapers, magazines, trade journals…
- Posters, Billboards, Correx boards, Leaflets/Flyers, Pull-up banners

- Street advertising at key locations
- Paraphernalia e.g. key rings, pens made from sustainable wood, reusable bottle

	
Management of household waste on the newspaper the Waikato Regional, New Zealand Source https://www.bbc.com/news/uk-49280709	***The use of flyers to promote initiatives on best practice of household waste management*** Source: https://sutton.ca/en/services-to-citizens/public-works/waste-management/

9.4.3 Online communication tools

9.4.3.1 Audio visual tools

- Radio adverts (can we get these sponsored?) – consider Adopting Broadcast Media Sensitization Campaigns for Solid Waste Management https://pdfs.semanticscholar.org/9f90/fbc556dc13d03394e17193677eba1485613a.pdf
- Radio interview spots - The Role Of National Radio In Solid Waste Management In Juba: A Case Study Of South Sudan Radio By Garang Kuol Gabrielhttp://erepository.uonbi.ac.ke/bitstream/handle/11295/94426/Garang%20Gabriel%20Kuol_The%20role%20of%20National%20Radio%20in%20solid%20waste%20management%20in%20Jubao.pdf?sequence=1
- TV adverts (can we get these sponsored) - Influence of Broadcast Media Enlightenment Campaigns on Solid Waste Management in South-South of Nigeria http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1014.1817&rep=rep1&type=pdf
- TV interview spots on key programmes and inclusion in TV programmes - Public Awareness and Communication: A study on Role of Television in Waste Management

https://www.academia.edu/8604032/Public_Awareness_and_Communication_A_study_on_Role_of_Television_in_Waste_Management

TV programme series on waste management in India, supported by celebrity Aamir Khan

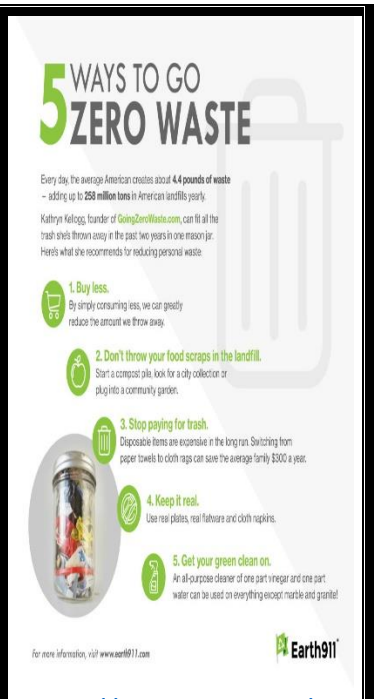
Source: https://youtu.be/lS0_FCBzI_w

9.4.3.2 Other Digital channels

- Blogs – Blogs which talk about being plastic-free, re use, repair based on information from the guidance and organisations that offer such services e.g. https://recycleforgreatermanchester.com/blogs/.
- Infographics and Digital content for social media (Twitter, Whatsapp, Linked In, Facebook and Instagram). Developing a hashtag(s).
- Web applications – guide on how to manage particular waste streams. There are 10 current applications to support household waste management : https://www.waste360.com/waste-reduction/10-innovative-and-informative-waste-and-recycling-apps/gallery?slide=10 & Recykle | A smart phone app to manage household waste responsibly https://www.climatecolab.org/contests/2016/waste-management/c/proposal/1331611
- Informative or interactive games such as Playing for the Planet- UN Environment online interactive games. Example & Case Study: Playing for the Planet: How video games can deliver for people and the environment.
- Videos/ YouTube content (case study – Kodaikanal- YouTube rap) - Where possible every month or at set periods highlight a particular way a member of the key audience is providing ESM of household waste by the successful use and implementation of the guidance e.g. this is based on the major contract for 9 authorities in Greater Manchester https://recycleforgreatermanchester.com/what-happens-to-my-waste/
- Social media influencers toolkit
- Emails and subscriptions
- Podcasts

https://addinfographic.com/tips-recycle-domestic-wastes-home/

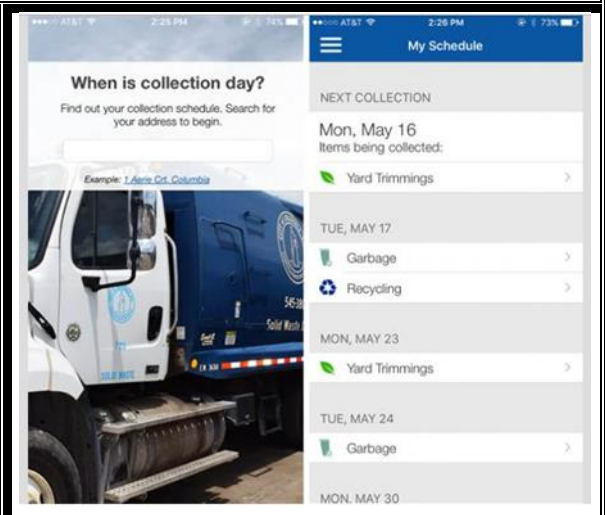
http://www.beginwiththebin.org/



https://earth911.com/living-well-being/infographic-go-zero-waste/

Examples of Infographics on household waste

There are 10 current applications to support household waste management : https://www.waste360.com/waste-reduction/10-innovative-and-informative-waste-and-recycling-apps/gallery?slide=10



https://youtu.be/80kjYZLNVtA -

https://blogs.worldbank.org/sustainablecities/five-ways-increase-citizen-participation-local-waste-services

9.4.4 Experiential Events

- Event stands
- Roadshows
- School assemblies, School and College Councils and Eco Group meeting

9.4.5 Interactive Educational Programmes

- Lessons and teaching plans (case study-UNESCO Upper Primary) - to be included as part of the primary and secondary school's curriculum.
- Other stakeholders can link in with national and international educational institutions and learning programmes such as Colleges, Universities, The Open University, Online courses, Workplace courses covering a range of subjects on Environmental Science, Environmental Management and Technology, Waste Management, Sustainability…e.g. In the UK the CIWM offer face to face and online courses which are accredited https://www.ciwm.co.uk/ciwm/training/waste-management-courses.aspx?hkey=95e241b6-a82d-4a99-aae0-a0f49b65d10b These days on many courses, study materials, access to online resources, community forums and tools are made available to learners. Campaigns they can consider:
- Offer free visits and tours to waste and recycling facilities that promote ESM of Household Waste to stakeholders.
- In the UK these are offered free to schools and community groups and they just have to pay for the travel. We sometimes run competitions for schools to have their transport

paid for by the council or sponsors. See following link https://recycleforgreatermanchester.com/education-centres/

- School Competitions: Zambia and South Africa:
  https://www.mpactrecycling.co.za/campaigns/schools-competition
  http://manjapamodzi.com/news/ZAMBIA
  https://www.mpactrecycling.co.za/campaigns/schools-competition

9.4.6 Training Workshops

- Host workshops on the guidance and help to educate and empower the stakeholders
- Ensure Sustainability

9.4.7 Launch of the Guidance

- Arrange for well-known identities to launch the guidance officially with stakeholders, press and media.
- The above both highly recommend and urge stakeholders to read, take on board and put into action the guidance as well as spreading it through their networks. Ask the stakeholders and network to share and use the guidance as well as forwarding their contributions, examples, best practices…
- They also encourage education establishments to discuss the guidance with their students and staff on how they can help enhance the guidance and consider careers in the field of waste management and resources.
- The above is shared on the UN websites and partnership websites, on Social Media including as a video. Along with press releases and photo shoots.
- Ask well known identities to be part of short videos with various stakeholders to raise awareness and encourage take-up of the guidance. The videos to be promoted on social media channels at different intervals over several months/year.
- Promote the guidance, web links and Social Media access on posters, correx boards, pull-up banners, leaflets, vehicle livery (belonging to stakeholders) in various locations e.g. at tipping and landfill sites, Household Waste Recycling Centres, sites where stakeholders are based and operate from, offices of municipalities, chamber of commerce, business and tax centres…
- Raise awareness through direct contact made with stakeholders through email and possible telephone calls. Invite them to local events launching the guidance and/or tie in with appropriate local events e.g. waste and recycling events, vehicle and new technologies showcasing events.
- Make contact with key influencers that can reach and help create word of mouth with key stakeholders.

9.4.8 Consideration to Ongoing Initiatives

- International Environmental Awareness campaigns (e.g. World Environment Day etc. Annex with listing- working)

- Acquire/create database of stakeholder contact information and inform them of the guidance and their agreement to be put on a circulation database for future updates. E.g. email, follow us on Social Media
- Ask them to be part of the Household Waste Partnership Group or contribute in anyway they can and spread information through their contacts and networks
- Ensure the Household Waste Partnership Group and other related groups spread and share the information and use their influence to get stakeholders to take on board the guidance
- Discuss with stakeholders e.g. municipalities for their help and involvement with promoting the guidance within their organisations and with stakeholders. For instance, in management and team meetings, internal communications (online and offline). Train up waste management & recycling teams, environment and trade enforcement teams to engage with stakeholders and schools about the guidance including as part of face to face engagement, events, roadshows, school assemblies, meetings with school councils and eco groups.

9.5 Behaviour Change

- Changing behaviour is also at the heart of the guidance, as this will ensure that stakeholders (including their colleagues, employees…) move effectively and successfully through their Waste Journey and become examples and success stories for others to follow.
- Therefore, education and two-way conversations play a key role for the guidance, if it is to be successful and to continue being a 'living' document that moves with the times and takes into account changes occurring in the world.
- Both online and offline communications on an ongoing basis will be key. But, not to overload either such as simple rules for Twitter don't post more than 3 to 5 times a week on the subject.
- Endeavour to have verbal and face to face contact with stakeholders even if only a call, skype, facetime is achievable to encourage take-up of the guidance but also to get feedback to further inform us of engagement techniques and how the guidance take up is going to understand challenges, barriers…
- Direct audiences to some hard-hitting videos from around the world on consequences of not managing waste properly and safely and seeing waste as resources. For example:
  https://www.youtube.com/watch?v=nSal-ms0vcI – Rap song on Mercury Awareness
- What if you could turn plastic trash into cash? Ted Talk which not only covers plastic recycling but also social plastic recycling, business enterprise for people, groups and organisations in developing and developed countries for recycling plastics.
- The Blue Planet series:
  https://www.youtube.com/results?search_query=the+blue+planet+1 – The Blue Planet I
  https://www.youtube.com/watch?v=_38JDGnr0vA – The Blue Planet II

9.6 Key Messages and Benefits

- Help is at hand on your journey to identify and address key challenges in moving towards Environmentally Sound Management of Household Waste, whilst making the most appropriate, beneficial and cost-effective decisions.
- A simple one stop place where you can access guidance which provides options and solutions through tools and strategies. It shares existing practical and concrete solutions with case studies from around the world to assist stakeholders in the ESM of Household Waste.
- Practical and sound advice is available no matter what part of the globe you are from.

9.6.1 Key messages on how to manage your household waste

Reducing Your Garbage

- Use cloth bags instead of plastic
- Buy food that has less packaging
- Do Composting
- Don't use bottled drinks unless you have to
- Reduce your paper usage
- Consider making your own household cleaners and detergents

Reusing and Recycling

- Donate items when possible.
- Reuse containers
- Follow your city's recycling policies
- Dispose of trash and hazardous waste properly

Composting

- Save your food scraps and yard cuttings from the trash
- Create a compost site

9.7 Results and Measures

- Create a feedback sheet for stakeholders taking on board the guidance.
- This will be key to understanding the success of the guidance, if stakeholders can effectively use and apply it, what challenges and barriers there are both in the communications/promotions and the actual guidance itself.
- Statistics can also be collated on stakeholders take-up, progress, registration to other programmes recommended like the UN Global Sustainability Compact etc.
- KAP Surveys

9.8 Messaging Considerations

In order to ensure that all sections of the population and communities are able to access clearly and easily communications and information relating to the ESM of household waste and the crucial part they play in ensuring we achieve a sustainable future. Is to ensure

stakeholders research and understand the population makeup and how the different population segments can access this information in a language, format, style they can understand and relate to, that that we can enable change of behaviour and the ability for them to take the action we need them to take.

There are a variety of options available that can aid in developing the most appropriate messages for the different audience considerations these include, using images/graphics/Infographics and less words (as images tend to be universally understood, take up less content space and as the saying goes 1 picture speaks a thousand words). Translating any information into key languages by using translation services that understand the language requirements and culture that successfully communicate the information.
For face to face engagement, the use of interpreters can also be beneficial e.g. dealing with different stakeholders e.g. small entities like scavengers who may have a mix of cultural and language backgrounds or when dealing with the general population e.g. door to door knocking campaigns. Good Interpreters can aid the communication process especially as they can help build trust and a good rapport.

What's important to remember is that having a diverse population also means that you have access to different perspectives and new ways, ideas and communications when it comes to Reducing, Reusing and Recycling our Waste and even Refusing plastic waste.
The following is a link to ESOL (English for Speakers of Other Languages) Resources used by a UK organisation https://recycleforgreatermanchester.com/education-and-learning/esol-resources/.

The following is an example of a translated leaflet about recycling in Urdu.

Hint & Tip: To help segment your audience and understand the diverse backgrounds, you should hopefully be able to approach such organisations like your local government office, municipality, National Statistics Office or Library for the information.
Hint & Tip: To find good interpretation and translation services you may want to consider approaching your municipality as many use such services. Looking for accredited organisations and even approaching your local colleges and universities language departments. The services will most likely come at a cost but will be worth it.
Hint & Tip: You may also find that within communities various community organisations are prepared to work with stakeholders to provide such services free of charge, they also have key insights into their communities and potentially successful ways of addressing those communities. E.g. Holding specific community events in community centres so that you address a particular group in one go (and where required with the use of an interpreter or member of staff who speaks that language).

9.8.1 Sex and Gender

Consider principles of Gender Responsive Communication when developing content. These will guide the development of messages to ensure equality for all genders, representation and guidance for the use of inclusive language.

1) Ensure that women and men are represented - eliminate gender inequalities and stereotypes. This means that all genders are represented equally in all forms of media.
2) Challenge Gender Stereotype - Ensuring that fair visibility for both men and women will assist in reducing the use of inaccurate representations. This means that communication material should not limit men and women to specific vocations or gender roles that have been previously associated with men or women.
3) Avoid Exclusionary Forms - These includes using the words “he” or “she” when referring to women and men. By using “they” gendered pronouns can be avoided.
4) Use equal forms of address - Especially for women, it is more suitable that the universal form of address, “Ms.” Is used. It is also important that the strategy avoids using stereotypes related to traits, behaviours, activities and appearances of women and men.
5) Create a Gender Balance - Avoid using generic nouns and pronouns. A neutral language is recommended
6) Promote Gender Equity throughout titles - Gender sensitive language should be used for more inclusive and equitable representations of both genders.

9.8.2 Age

All proposed communication tools features men, women and children in various roles.

9.8.3 Ethnicity

This allows socially constructed gender roles to be avoided and to encourage equal visibility through diversity. All proposed communication tools features men, women and children in various roles.

9.8.4 Religion

Give consideration to the role of religious and other social communities in supporting the public awareness initiatives/ programmes, particularly in countries where religion has strong influence in its social-cultural landscape and day-to-day activities of public life.

9.8.5 Persons with disabilities

- Use their name, make eye contact
- Always use accessible language
- Speak slowly and repeat verbal information multiple times if needed
- Use a respectful tone and volume
- Avoid jargon or long words that might be hard to understand.
- Use pictures, drawings, and gestures to go along with your words.
- Be prepared to use different communication tools
- Follow the lead of the person you're communicating with
- Go at their pace, check you have understood and be creative

- In communications materials use images and be aware of colour requirements for people with sight problems

9.8.6 Other Vulnerable Groups

Defined as: Any **group** or sector of society that is at higher risk of being subjected to discriminatory practices, violence, natural or environmental disasters, or economic hardship than other **groups** within the state; any **group** or sector of society (such as women, children or the elderly).

Groups of people who are disadvantaged in some way are considered **vulnerable populations**. **Examples** of **vulnerable populations** include children, people with schizophrenia, pregnant women, and homeless people. A **population** can be deemed **vulnerable** due to having a high level of physical, psychological, and/or social risk.

When communicating with vulnerable groups, ensure to take into account their communications needs and requirements.

To help you, you can approach various societies wo deal with such groups for their advice e.g. Society for the Blind, Disability Awareness Groups.

9.9 Important information about building and DIY waste

Any waste produced by tradespeople or builders you hired to carry out improvements, repair or alterations to your home is classed as business waste and can't be disposed of at any of our Recycling Centres. Always ask a tradesperson to include waste disposal in their quote. If you are recycling or disposing of business waste, visit the business waste page.

Host website pages that helps their audience like the public e.g. https://www.recyclenow.com/recycling-knowledge/getting-started/recycling-at-home

Make available advice and case studies like the following on communicating with the public e.g. http://www.wrap.org.uk/content/resources-local-authority-communications

9.10 Communications materials/wording:

For instance, add where appropriate to any literature for e.g. letters, correspondence wording such as 'Your items arrived in our plastic free bag which is made from Natureflex – a renewable and certified compostable film made from responsibly sourced wood pulp. PUT IT IN YOUR HOMECOMPOST BIN OR USE IT TO LINE YOUR FOOD CADDY. DO NOT PUT IT IN PLASTICS RECYCLING!

'Right Stuff Right Bin' style campaigns which are aimed at reducing contamination in recycling bins and trying to ensure residual (non-recyclable) bins only have items that cannot be recycled. See the attached link to a press release on the campaign and its success in the UK, Greater Manchester area, Rochdale borough http://www.mynewsdesk.com/uk/rochdale-

borough-council/pressreleases/prestigious-recycling-award-for-right-stuff-right-bin-campaign-1016621

What's good to see in the UK is how the public, private, charity, 3rd sector voluntary and community are trying to work in partnership when it comes to waste, recycling and resources with awareness raising being a key part of it. For example, Marks & Spencer Shwopping Scheme, where 'Your Shwopped items are resold, reused or recycled and allow Oxfam to fund all sorts of vital projects around the world' that also includes bra's by making recepticles available in various stores. See the following link https://www.marksandspencer.com/s/plan-a-shwopping

These Shwopping awareness raising campaigns and below can also be run in work places by linking in with the charities e.g. M&S/Oxfam.

Oxfam have recently started a new campaign called 'I'm doing Second Hand September'. Based on using your consumer power to go without new clothes for 30 days. They state that 'throwaway fashion is harming people and our planet. Over 11 million items of clothing go to UK landfill every week. Now there's something you and your friends can collectively do to help.' People can visit https://www.oxfam.org.uk/shop/second-hand-clothes to find out more and sign-up.

9.11 Connect to learning and qualification opportunities:

Early Years Education, Schools and Colleges encouraged to register with Eco Schools and The Pod (both work in partnership to empower children, teens…)
Eco-Schools is a global programme engaging 19.5 million children across 67 countries, making it the largest educational programme on the planet.
https://www.eco-schools.org.uk/
The Pod is an educational platform for teachers, community group leaders and children. It offers free lesson plans, activities, assemblies, films and games.
https://www.jointhepod.org/
Lesson Plans are available from UNESCO of waste and sustainability http://www.unesco.org/education/tlsf/mods/theme_a/mod05.html

Module 10 - Health and safety in waste management

10. Introduction

Waste management sector like any other sector inquires safe working environment. It is important that the working conditions provide a physical and mental health protection. The realities are often very different. In collection phase, labourers working with little or no protection are often directly exposed to waste loads. Bare-hand waste picking is a common practice.

Recycling sector is associated with technological aspects. Unsafe operations may cause injuries and fatalities. In US, recycling sector is reported to be with the higher injury rates than the average for all waste management and remediation services[61].

Informal waste pickers on landfills are greatly exported to toxic physical environment[62]. In addition, dumpsites in many cases around the world are often over their carrying capacity and are at risk to collapse. In general, working conditions and hazards associated with this work stigmatize the sector particularly in developing countries. It leads to violent and harassment acts.

Roles of women and men are polarized in the waste sector. Women are disproportionately affected by poor waste management. They face problems like lack of health and safety standards, they are not supported in terms of welfare.[63] According to UN Environment study, women are more exposed to hazardous waste. In addition, positions of women and men in waste sector are very polarized. If women are associated with “care taking” duties, men take responsibility of business part of it. Waste sector should provide equal opportunities for women and men at different stages of waste management hierarchy.

This module provides road to increased health and safety conditions in the waste sector, and create healthier gender culture.
Essential occupational health and safety measures include the following:

- Supporting legislation and soft laws
- provision of labourer protection gear for personal protection;
- supporting infrastructure
- proper training of workers;
- response to injury and exposure

[61] GAIA (2015). Sustainable ad Safe Recycling: Protecting Workers Who Protect the Planet. https://www.no-burn.org/wp-content/uploads/Safe-Recycling-Report.pdf
[62] ISWA (2015). Wasted health. The Tragic Case of Dumpsites. https://www.iswa.org/fileadmin/galleries/Task_Forces/THE_TRAGIC_CASE_OF_DUMPSITES.pdf
[63] Cynthia Ng, 2018,No Messing About With Women Of Waste. Available at: https://www.awanireview.com/articles/2019/01/02/news/no-messing-about-with-women-of-waste-561/

- establishment of an effective occupational health programme

10.1 Hazards

The exposure of solid waste workers in hazards is significant to all stages of waste handling, treatment and disposal. Worker are expose to risks that vary from contamination by biological or gaseous agents, physical injuries related to dust, noise, extreme temperatures, and pathogen from infectious waste such as syringes. In addition they are exposed to accidents during transportation, and unloading of waste at treatment and final disposal facilities as well as to fires, and/or explosions[64].

More specific, workers in the waste sector are often exported to following hazards:

- Hazardous wastes;
- Noise (e.g., in recycling facilities);
- Gas and dust emissions (e.g., emissions in landfills, emissions from open burning, emissions in recycling facilities (e.g. dust, microplastics));
- Vibration (e.g., recycling facilities);
- Physical collision (e.g., transport and machinery related accidents).

10.2 Supporting legislation and soft laws

Waste management is often shared between formal and informal sector. Workers in formal sector are usually more protected by domestic regulations than labourers in informal sector. Gender inequalities across the waste sector are widespread.

There are following supporting instruments that promotes safety in waste sector.

- Legislation dictating working conditions and social benefits (e.g., paternity leaves, access to childcare, equal remuneration, health support);
- Legislation stimulating organizational and economic supports (e.g., creating cooperatives, access to credits);
- Introducing voluntary concepts e.g., Corporate Social Responsibility (CSR).
- Legislation stimulating equal gender access to work places and opportunities.

The International Labour Organization promotes sustainable enterprises for innovation, growth, more and better jobs[65]. These conclusions are relevant to waste sector. In addition,

[64] MIDLANDS STATE UNIVERSITY, 2017, OCCUPATIONAL SAFETY AND HEALTH HAZARDS ASSOCIATED WITH SOLID WASTE MANAGEMENT IN BINDURA, Available at: ZIMBABWE.https://pdfs.semanticscholar.org/b2c4/71633458518aa918132b80b5bb03e4c3d279.pdf

[65] ILO (2007). Conclusions concerning the promotion of sustainable enterprises. International Labour Conference, June 2007.

the International Labour Organization has recommended general future action to its Member States, specifically focusing on e-waste management[66].

There are numbers of national guidelines developed by public and private sector which could serve as inspiration in increasing safety at work-place e.g., Health and Safety Issues in the Solid Waste and Resource Industry New Zealand[67].

10.3 Labourer protection gear

The type of protective clothing used will depend to an extent upon the risk associated with household waste management, but the following measures could increase safety at work place:

- It is strongly recommended that labourers working nearby moving traffic or machinery wear high visibility jackets to be visible to drivers and operators nearby.
- It is strongly recommended that labourers working nearby machinery and transportation wear protective headgear against possible injury.
- Where there is a risk of eye injury, eye protection is recommended.
- It is strongly recommended to wear ear protection gear against elevated noises.
- Where there is a risk of lung irritation from dust and odour, dust-masks are recommended.
- It is strongly recommended to put appropriate footwear.
- It is strongly recommended to use protective gloves to avoid hand injury.

10.4. Supporting infrastructure

Many waste workers are operating in difficult climatic environmental. With the climate changes the temperature is predicted to increase in urban structures. In addition, working places don't provide all necessary infrastructure such as sanitary facilities, access to portable water. It should be a requirement to provide necessary infrastructure to labourers at work place.

10.5 Safety - Health guidelines and rules

The associated waste management department/division must develop, maintain and publish guidelines for the management of household waste at all stages.

Also there must be provision and establish rules that would minimising hazards. For instance access to dumpsites is very easy in many countries. Unregulated dumpsites are dangerous to

[66] I LO (2019). Global Dialogue Forum on Decent Work in the Management of Electrical and Electronic Waste (e-waste).

[67] Department of Labour in Te Tari Mahi (N/A). Health and Safety Issues in the Solid Waste and Resource Industry. https://www.wasteminz.org.nz/wp-content/uploads/Health-and-Safety-Issues-in-the-Solid-Waste-and-Recoverable-Resources-Industry.pdf

humans, animals and environment. Access to unregulated places should be restricted. See Module 8.

10.6 Waste management training

The staff working in the waste management sector either on public, private or informal needs to receive training in handling and disposing of the waste. This may include:

- waste segregation;
- storage requirements;
- transportation requirements;
- labelling;
- emergency procedures;
- spill control; and
- awareness of all associated hazards.

10.7 Response to injury & exposure

Emergency planning and procedures deal with emergencies involving household waste have to be established in all stages of household waste management. The procedure could involve[68]:

- immediate first-aid measures,
- an immediate report of the incident to a designated responsible person;
- medical surveillance;
- recording of the incident;
- investigation of the incident, and identification and implementation of remedial action to prevent similar incidents in the future.

10.8 Occupational health programme

Establish an effective occupational health programme that includes immunization, post-exposure prophylactic treatment, and medical surveillance.

[68]Health and safety practices for health-care personnel and waste workers, Available at: https://www.who.int/water_sanitation_health/medicalwaste/140to144.pdf?ua=1

Appendix 1 Assessment and Decision-Making

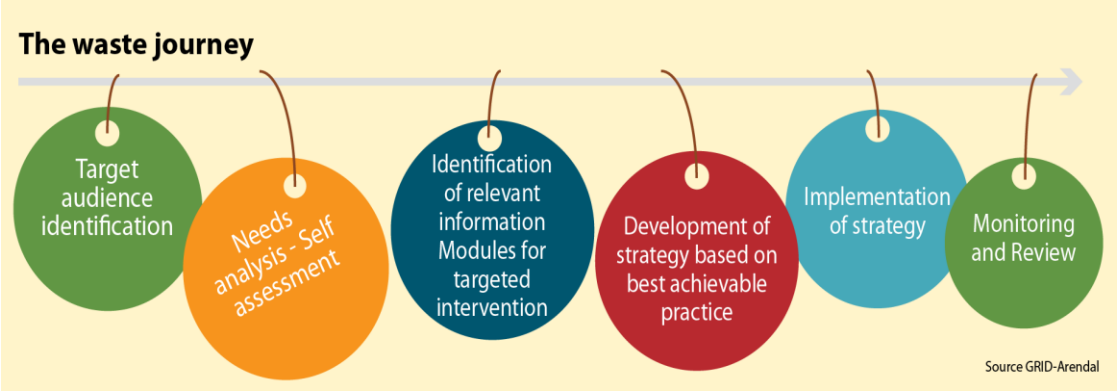
1. Introduction

Note: This Module will appear electronically (via the internet) as an Interface to users, to allow a user-friendly way to access and complete the checklist.

1. While most developed countries have introduced complex household waste management practices, many developing countries and countries with economies in transition are still struggling with sound management of the ever-increasing volume of household waste.

2. Municipalities and other relevant bodies involved in improving household waste management need to understand and assess current practices in order to identify and address the key challenges in moving towards ESM. An assessment checklist has been developed to help facilitate the policies and strategies required to deal effectively with household waste within an ESM framework.

3. To promote the ESM of household waste, including its prevention and minimization, managing authorities also need to understand how and where the generation of household waste is occurring and how it is handled by the public in their households.



2. Who should use this Checklist?

This checklist is aimed at helping the following target audiences:

(a) Government institutions
(b) Municipalities
(c) Practitioners (e.g. official or unofficial, licensed or unlicensed collectors, transporters, disposal operators, scavenger groups, etc.)

3. Why use this checklist?

This assessment and decision-making checklist will enable us to understand your requirements, help you to identify where you stand currently when it comes to managing waste, map out your needs through self-assessment and identify which guidance module to consult in order to help you achieve ESM of household waste.

Table 1. Profile of Audience

Completing Table 1 will enable us to:

(a) Understand who you are.
(b) Gather information to better develop our information and services to help you on your journey towards Environmentally Sound Management (ESM) of Household Waste.
(c) Gain feedback on your experience with this checklist.

Audience	Answer	Your Contact Details
Who are you?		
Are you a government institution?	Yes/No	
Are you a municipality?	Yes/No	
Are you a practitioner (e.g. official or unofficial, licensed or unlicensed, collector, transporter, disposal operator, scavenger…)?	Yes/No Please state what type of practitioner?	
Are you a private waste management company?	Yes/No	
Do you work in partnership with any other official or unofficial waste management organisations, enterprises…?	Yes/No	
Would you be happy for us to contact you to discuss any part of this checklist that you complete?	Yes/No If No, would you be able to explain why?	

Table 2. Status on Waste & Environment

Table 2 aims to:

(a) Enable you to confirm your waste management status.
(b) To provide information such as concepts, policies, strategies and initiatives on successful waste management and environmental areas for you to consider.

Status	Answer	Module to use
Are you aware of the Waste Hierarchy?	Yes/No	Guidance Document, Introduction section 4
Do you follow the Waste Hierarchy?	Yes/No	Guidance Document, Introduction section 4
What stage of the Waste Hierarchy do you feel you are at?	Explain	Guidance Document, Introduction section 4
Are you a Party to the Basel Convention?	Yes/No	Guidance Document, Introduction
Are you aware of the Circular Economy Concept?	Yes/No	Guidance Document, Introduction section 5

Is the Circular Economy part of your policies, decision-making and strategies?	Yes/No	Guidance Document, Introduction section 5
Have you signed up to the United Nations Sustainable Development Goals (SDG)?	Yes/No	Guidance Document, Introduction section 5
Do you have any environmental and sustainability policies? For example, Corporate Social Responsibility (CSR).	Yes/No	Module x or reference info that explains CSR.
Are you part of the United Nations Global Compact? (the most comprehensive global initiative on CSR).	Yes/No	Module x or reference info that shows info on UN Global Compact.

Table 3. Current Situation

Table 3 aims to:

(a) Help us understand where you are currently as a country in relation to various factors, such as physical characteristics, explained in the table.

(b) The above will enable us to develop further information and guidance on the various needs and requirements when it comes Environmentally Sound Management (ESM) of Household Waste.

Situation Analysis – Current Situation	**Answer**	**Further information**
Geography		
What continent are you on?		
Are you a landlocked country?		
Do you have coastal areas?		
Are you a small island development state (SID)?		
Is the area you are dealing with in an urban or rural setting?		
What is the terrain like for the area/setting?		
What is your climate e.g. a tropical, sub-tropical…?		
Economy		
Are you a highly developed mixed economy?	Yes/No Refer to Module or reference info that shows definition	
Are you a country in transition?	Yes/No	

	Refer to Module or reference info that shows definition	
Are you a developing economy?	Yes/No Refer to Module or reference info that shows definition	
Political		
What is the political nature of the country or area?	Refer to Module or reference info that shows definition	
Social		
How many and what languages are spoken in the country or area?		

Table 4. Current Situation/Baseline for managing household waste

Table 4 aims to:

(a) Help you understand and assess how you currently manage waste in terms of disposal and treatment of household waste.
(b) How you can ensure safe practices when it comes to managing household waste.
(c) You can answer the questions as many times as you want according to your country, region and locality.

Current Situation - Baseline	Answer	Module to use	Scoring
Disposal & Treatment of household waste:			
Burnt in open air in back yards?	Yes/No	Module 5 & 8	1 Very Poor
Burnt at uncontrolled official or unofficial dumping sites?	Official Y/N Unofficial Y/N	Module 5, 8, 9	1 Very Poor
Dumped and buried at official or unofficial dumping sites?	Official Y/N Unofficial Y/N	Module 5, 8, 9	1 Very Poor
Burnt at poorly engineered and unsanitary landfills?	Yes/No	Module 5, 8, 9	1 Very Poor
Burnt at poorly managed unsanitary landfills?	Yes/No	Module 5, 8, 9	1 Very Poor
Burnt at poorly managed sanitary landfills?	Yes/No	Module 5, 8, 9	2 Poor
Burnt at good engineered/sanitary landfills but poorly managed?	Yes/No	Module 5, 8, 9	3 Moderate

Burnt at good engineered/sanitary landfills and properly managed?	Yes/No	Module 5, 8, 9	4 Good
Do you deal with any Waste Electrical and Electronic Waste (WEEE)?	Yes/No Consider if disassembly is done safely?	Module 5, 8, 9	
Does energy recovery take place at the landfills?	Yes/No	Module 5, 8, 9	
Do you have any official or unofficial Transfer Loading Stations (TLS) that you deliver your waste into?	Yes/No	Module 5, 7, 8, 9	
Is the waste you collect or handle weighed in at any stage?	Yes/No	Module 5, 7, 8, 9	
Is the waste you collect or handle reported and documented officially?	Yes/No	Module 5, 7, 8, 9	
Is your waste inspected at any point once it is collected or delivered to a site?	Yes/No	Module 5, 7, 8, 9	
How is the waste treated?	Explain how the waste is treated.		

Table 5. Key functional elements of ESM of household waste

Theme	Questions	Possible situations	Possible needs	Module to use
WASTE GENERATION (Quantification)	Do you know how much waste you are generating?	Yes/No/Limited	Need to have quantification system to develop appropriate waste management system Methodology for data collection Quantify the waste being generated	Quantify the waste being generated Module 1

Theme	Questions	Possible situations	Possible needs	Module to use
	Do you have practices for prevention and minimization of waste?	Yes/No		Module 3 Module includes topic on recovery, reuse Currently the group has no participation from producers' side
	Do you have relevant financial system?	Yes/No		Module 2 See guidance on finance (to be developed)
	Do you have relevant legislation?	Yes/No		Module 1 includes topic on best practices
WASTE GENERATION (Characterization-determination of physico-chemical properties and radiological e.g. moisture content, ash content, calorific values: to identify appropriate treatment)	What types of waste do you have?	You don't know	Develop inventory	Inventory guidance Module 3 source separation Module 5 recycling
	How are you characterizing waste?	Not doing Using scientifically	Characterize waste so that the information can also be communicated to market/end users	
	Do you have waste list or codes for different types of waste?	Yes/No		

Theme	Questions	Possible situations	Possible needs	Module to use
	Do you have relevant financial system?	Yes/No		See guidance on finance (to be developed)
	Do you have relevant legislation?	Yes/No		Module 1 includes topic on best practices
WASTE GENERATION (Composition of waste for potential to recovery)	Do you know the composition of each types of waste?	Yes/No	Identify composition so that certain types of waste can be recycled	
	How frequently do you undertake waste composition analysis?	Not doing Doing periodically		
	Do you have relevant financial system?			See guidance on finance (to be developed)
	Do you have relevant legislation?			Module 1 includes topic on best practices
STORAGE (before collection, e.g. household waste stored in a bin, i.e. Household waste receptacles)	Do you have storage system for household waste before collection? (ESM?)			
	Do you have relevant financial system?	Yes/No		See guidance on finance (to be developed)
	Do you have relevant legislation?	Yes/No		Module 1 includes topic on best practices
COLLECTION	How are you collecting? Do you have			

Theme	Questions	Possible situations	Possible needs	Module to use
	centralized collection system?			
	How frequently you are collecting?			Module 3
	Do you do source segregation?			
	Do you have relevant financial system?	Yes/No		See guidance on finance (to be developed)
	Do you have relevant legislation?	Yes/No		Module 1 includes topic on best practices
TRANSFER AND TRANSPORT	How are you transporting waste?			
	Do you have finance system for transportation?			See guidance on finance (to be developed)
	Do you have transfer stations?			
	Do you have relevant financial system?	Yes/No		See guidance on finance (to be developed)
	Do you have relevant legislation?	Yes/No		Module 1 includes topic on best practices
PROCESSING AND RECOVERY	What infrastructure do you have for processing recovery?	Material recovery facility		
		Compost plant		
		Recycling plant		
		Waste energy plant		See guidance on finance

Theme	Questions	Possible situations	Possible needs	Module to use
				(to be developed)
	Do you have relevant financial system?	Yes/No		Module 1 includes topic on best practices
	Do you have relevant legislation?	Yes/No		National ESM capacity
DISPOSAL	What infrastructure do you have for disposal?	Sanitary landfill	Put appropriate infrastructure in place Develop national capacity	
		Open dumping		See guidance on finance (to be developed)
	Do you have relevant financial system?	Yes/No		Module 1 includes topic on best practices
	Do you have relevant legislation?	Yes/No		
CROSSCUTTING ELEMENTS				
LEGISLATION	Do you have policy or legislation framework?		Put appropriate legislation/target in place Develop national capacity	Module 1 policy and regulatory framework
	Do you have legislation for EPR?			
	Do you have challenges of enforcement of legislation?			
	Do you have control system put in place?			
	Do you have means to			

Theme	Questions	Possible situations	Possible needs	Module to use
	address informal workers?			
	Do you have illegal dumping?		Put sustainable financing in place	To be developed
STAKEHOLDERS	What is your policy for contracting? Is it transparent?			
INFRASTRUCTURE	Do you have appropriate infrastructure for ESM of household waste?			
	What equipment do you have?			
FINANCE	Do you have financing system?		Put financing system in place	
	Do you have PPP?		Put PPP in place	
	Do you have cost recovery mechanism?		Put cost recovery mechanism in place	
	Do you have sustainable financing		Put sustainable financing in place	To be developed
SOCIO-CULTURAL ASPECTS	How are you addressing socio cultural aspects in			
	How are you addressing gender			
AWARENESS	How high is the public awareness of household waste ESM		Education, dissemination of information	Factsheets developed by ESM EWG

Theme	Questions	Possible situations	Possible needs	Module to use
	How high is the awareness of the government personnel on household waste ESM			
	Seeing waste as resource?		Raise awareness as waste as resources	

Thank you for completing this checklist.

By working towards and achieving Environmentally Sound Management (ESM) of Household Waste you will see the results and benefits of a safe environment, eco-system, preservation of energy and natural resources, saving landfill space, save money, efficiencies, effectiveness, the creation of direct and indirect employment opportunities.