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

Guidance/guidelines by source category: Source categories in Part III of Annex C

Part III Source category (a): Open burning of waste, including burning of landfill sites

Supplemented to reflect the South Africa Development Community (SADC) Region

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(The list of illustrations from the original guideline was removed from here)

GLOSSARY

(Developed as part of the guidance for the SADC region)

4R policy: Reduction, Reuse, Recycle and Recover of waste

Agricultural waste: is solid waste that is generated by the rearing or harvesting of animals, or the producing or harvesting of crops or trees (definitions.uslegal.com)

APCS: Air Pollution Control Systems

ASEAN: Association of South-East Asian Nations

Basel Convention: The Basel Convention is a multilateral environmental agreement. Its aim is to protect human health and the environment against the adverse effects of Transboundary Movements of Hazardous Wastes and their Disposal.

BAT: Best AvailableTechniques; often understood ad technical devices

BEP: Best Environmental Practices; often understood as management or operational solutions

CO: Carbon Monoxide: is a colorless, odorless, and tasteless toxic gas that with slightly lower density than air.

CO_2: Carbon dioxide is a colorless, odorless gas found in our atmosphere

Construction waste: anything generated as a result of construction and then abandoned, regardless of whether it has been processed or stockpiled

Dumpsite: A deposit of waste that does not have advanced measures to prevent or reduce spreading of environmentally hazard leachate water, dust, or air emissions (as opposed to "sanitary landfill", see below). In the text on the SADC region "municipal dumpsite" is used about a dumpsite that is designated by relevant authorities for deposition of waste, whereas "informal dumpsite" is not authorized.

Demolition waste: waste debris from destruction of buildings, roads, bridges, or other structures

EIA: Environmental Impact Assessment

EVA: ethylene-vinyl acetate copolymer (a plastic type)

E-waste; describes discarded electrical or electronic devices

Hazardous (or Toxic) waste; is waste that has substantial or potential threats to public health or the environment; typically defined as containing specified hazardous chemicals.

HDPE: High-density polyethylene (a plastic type)

Industrial Waste; is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process

Medical (or health-care) waste: is any kind of waste that contains infectious material (or material that's potentially infectious).

Medical/health-care waste incinerator: A device that eliminates the pathogenicity of medical waste by thermal decomposition (incineration) while markedly reducing its volume.

Municipal Solid Waste (MSW); Municipal waste covers household waste and waste similar in nature and composition to household waste; it typically also includes waste from shops, offices and public institutions.

Oil spill: an accidental release of oil into a body of water, as from a tanker, offshore drilling rig, or underwater pipeline, often presenting a hazard to marine life and the environment

PAH: Polycyclic Aromatic Hydrocarbons (carcinogenic chemicals formed in incomplete combustion)

Polychlorinated dibenzo-p-dioxins (PCDD), dibenzofurans (PCDF):Polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofuranes (PCDF) and polychlorinated biphenyls (PCB) are types of persistent and bioaccumulating organic pollutants (POPs) with enhanced chronic toxicity and carcinogenic properties.

POPs: Persistent Organic Pollutants

PVC: Poly Vinyl Chloride: PVC is a plastic material that is used for many purposes, for example to make clothing or shoes or to cover chairs;

REDISA: Recycling and Economic Development Initiative of South Africa

SADC: Southern Africa Developing Community

Sanitary landfill: A deposit of waste that has advanced measures, such as lining, ventilation pipes and top coverage, to prevent or reduce spreading of environmentally hazard leachate water, dust, or air emissions (as opposed to "dumpsite", see above).

SO_2 : Sulphur Dioxide is a colorless, extremely irritating gas or liquid

Stockholm Convention: The Stockholm Convention on Persistent Organic Pollutants is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment.

TEQ: Toxic equivalency factor (TEF) expresses the toxicity of dioxins, furans and PCBs in terms of the most toxic form of dioxin

UNEP Toolkit: Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs

VOCs: Volatile Organic Compounds

WACS: Waste Analysis and Characterization Study; sometimes also called "wastes characterization".

VI.A Open burning of waste, including burning of landfill sites

Summary

Open burning is an environmentally unacceptable process that generates chemicals listed in Annex C of the Stockholm Convention and numerous other pollutant products of incomplete combustion. Consistent with Annex C, Part V, section A, subparagraph (f) of the Stockholm Convention, the best guidance is to reduce the amount of material disposed of via this method with the goal of elimination altogether.

Other techniques which may effect improvement include, with respect to the materials burned: avoid including non-combustible materials, such as glass and bulk metals, wet waste and materials of low combustibility; avoid waste loads containing high chlorine content, whether inorganic chloride such as salt, or chlorinated organics such as PVC; and avoid materials containing catalytic metals such as copper, iron, chromium and aluminum, even in small amounts. Materials to be burned should be dry, homogeneous or well blended, and of low density, such as non-compacted waste.

With respect to the burning process, aims should include: supply sufficient air; maintain steady burning or rate of mass loss; minimize smouldering, possibly with direct extinguishment; and limit burning to small, actively turned, well-ventilated fires, rather than large poorly ventilated dumps or containers.

Specifically for the SADC region, open burning of waste is widespread and can be observed at backyards of households, in places where waste is illegally dumped and at municipal dumpsites. This may be a result of insufficient coverage or effectiveness of collection services and social issues (low-income people do not pay for collection and do not receive the service). Implementation of best practices has the potential for massively reducing the open burning activities in the region.

Among the major aims are improvement of the collection services, enhanced policies on waste fees (amount of fee and fee collection options) to achieve full payment from households, and recycling activities to reduce the volumes of waste to be dumped at dumpsites/landfills.

At municipal dumpsites, positive involvement and inclusion of waste pickers: their organization, education and management, could massively reduce the open waste burning in the region and would improve their working conditions and job opportunities.

Small medical waste incinerators used in the region often need improved operation and maintenance and could benefit from being periodically checking to ensure that POPs generated during combustion are destroyed.

1 General guidance

Open burning covers a wide range of different uncontrolled waste combustion practices, including dump fires, pit burning, fires on plain soil and barrel burning. For people in many parts of the world, open burning is the cheapest, easiest, most sanitary means of volume reduction and disposal of combustible materials. This is especially true for people with no access to organized waste handling and who have been left to their own devices for materials disposal.

1.1 Public health threats of open burning

Current research indicates that open burning is a more serious threat to public health and the environment than previously thought. The low temperature burning and smouldering conditions typical of open burning promote the formation of many toxic and potentially harmful chemicals, including chemicals listed in Annex C of the Stockholm Convention. These compounds may form during open burning regardless of the composition of the

material being burned. The compounds produced from sources of open burning can travel long distances and deposit on soil, plants, and in water.

The remaining ash in the burn pile also contains pollutants, which can spread into the soil and water. Animals and fish ingest the pollutants and accumulate them in their tissues, while plants can absorb them through their leaf surfaces. When this contaminated food is eaten, the pollutants are passed on to humans. Additionally, smoke and particulates from open burning sources can trigger respiratory health problems, particularly among children, the elderly, and people with asthma or other respiratory diseases, and those with chronic heart or lung disease.

1.2 Status of open burning

While this document provides guidance for open burning practices, it recognizes the environmental harm resulting from open burning, and should not be taken as licence to continue the practice, which should be minimized and eliminated as soon as possible and wherever feasible. Open burning may still be a last resort where there are no alternative disposal or recovery methods due to inadequate infrastructure; where sanitary disposal is required to control disease or pests; or in the case of disaster or other emergency (Great Lakes Binational Toxics Strategy 2004). However, household wastes should never be burned in indoor residential combustion devices such as stoves, fireplaces or furnaces (see section VI.C of the present guidelines).

Open burning of waste, including burning at landfill sites for volume reduction, is listed as an inadvertent source of persistent organic pollutants in Annex C, Part III of the Stockholm Convention. Most importantly, subparagraph (f) of Annex C, Part V, section A refers aspirationally to "… the aim of cessation of open and other uncontrolled burning of wastes, including the burning of landfill sites".

Although the Stockholm Convention is concerned with persistent organic pollutants such as polychlorinated dibenzo-*p*-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), polychlorinated biphenyls (PCB) and hexachlorobenzene (HCB) as products of incomplete combustion, open burning is responsible for generation of toxic by-products of combustion well beyond the named chemicals. Other by-products include polycyclic aromatic hydrocarbons, particulate matter, benzene and carbon monoxide. Regardless of specific chemistry, smoke and unpleasant odours always accompany open burning, and are at best a nuisance and at worst a health hazard. Elimination of the persistent organic pollutants listed in the Stockholm Convention would not sufficiently improve the emissions from open burning to make it an environmentally preferred means of waste disposal. It is imperative that the focus of implementation of the Stockholm Convention be on establishing alternatives to open burning rather than simply trying to improve a bad practice. Provision of this guidance should not be construed as acceptance or justification.

Efforts to reduce open burning should be promoted and such efforts should focus on government, private sector and civil society support of alternative end-of-life and waste management options. Government agencies in charge of public health policy and education should be as deeply involved as those responsible for waste policy. The Basel Convention Technical Guidelines offer basic guidance on alternatives to open burning and how to implement them (Basel Convention Secretariat 1994).

Countries should work diligently to establish and implement sound waste management practices, including resource use reduction, reuse, recycling, composting, modern sanitary landfilling and incineration using best available techniques. The Convention's implementation efforts and its financial mechanism could be used to support the establishment of model waste management systems as alternatives to open burning. In addition, educational programmes and materials designed to educate target audiences (e.g. the public, waste handlers) about the risks to human health and the environment occasioned by open burning should be considered as part of an overall effort towards continuous minimization (Canadian Centre for Pollution Prevention 2006; EPA 2006).

Many countries have formulated regulations and prohibitions covering various open burning practices (Government of New Zealand 2006). A number of these regulations contain specific guidance on categories mentioned in this section, including tyres and waste oil. Enforcement of such provisions depends on the public having access to acceptable waste collection and disposal options.

In this part of the guidance, a number of specific types of open burning are considered in generic categories, typically because means of reducing emissions of persistent organic pollutants in each category are similar (Lemieux, Lutes and Santoianni 2004). Accidental fires and intentional combustion of non-waste materials are not considered; however, they may also be sources of persistent organic pollutants. Parties to the Convention are urged to take steps to reduce accidental biomass burning of all types as well as accidental fires in residences, automobiles and places of business. Parties may wish to consider restrictions on fireworks or other recreational open combustion.

1.3 Scientific basis and general considerations

Waste composition varies by source. Domestic waste may contain more organic material; industrial waste may contain more metals and possibly organic chemicals. Some of the waste itself – even domestic waste such as clothing or leather – may contain persistent organic pollutants (UNEP 2003). Sections III.C (i) and (ii) of the present guidelines describe formation mechanisms of persistent organic pollutants and their relationship to materials that might be contained in waste. Subsection 1.3.1 below contains general guidance on materials and processes; subsections 2–4 contain further information on material composition for different types of waste.

Waste composition also varies among countries, and over time. Accurate waste composition data from each country will aid in overall waste management, increase the amount of material available for recycling or reuse and reduce the amount that is open burned.

Figure 1. Animals grazing near open burning

Figure 1Grazing animals may be adversely affected by open burning and may ingest harmful substances. Photo: Kenya POPs office

There are few data regarding generation of persistent organic pollutants from uncontrolled waste combustion. Most experimentation has been conducted on so-called barrel burning, but there are limited or no data on dump fires, open burning in pits or waste burning on soil.

The UNEP *Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases* (UNEP 2003)[1] provides a sound basis for calculating emissions of dioxins and furans. A number of parties who have completed their dioxin and furan inventories using the toolkit have found that open burning of waste is one of the four largest sources of dioxins and furans.

[1] The Toolkit has been updated in 2012.

1.3.1 Burning process

In the short term, where there are not realistic means to eliminate all open burning, the best guidance is to reduce the amount of material disposed of via this method. This is consistent with the convention and its goal of elimination.

Other techniques that may affect improvement include the following (Gullett 2003):

With respect to the materials burned:

- Avoid including non-combustible materials, such as glass and bulk metals, wet waste and materials of low combustibility;
- Avoid waste loads containing high chlorine and/or bromine content, whether inorganic such as salts, or halogenated organics such as PVC (Lemieux et al. 2003);[2]
- Avoid materials containing catalytic metals such as copper, iron, chromium and aluminium, even in small amounts;
- Materials to be burned should be dry, homogeneous or well blended and of low density (e.g. non-compacted waste).

With respect to the burning process:

- Supply sufficient air;
- Maintain steady burning or rate of mass loss;
- Minimize smouldering, possibly with direct extinguishment. Smouldering is the phase of burning associated with the largest production of persistent organic pollutants (Lemieux et al. 2003);
- Limit burning to small, actively turned, well-ventilated fires, rather than fires in large poorly ventilated dumps or containers.

Figure 2. Typical mode of disposal of mixed waste through open burning

Potentially explosive items (e.g. aerosol cans, partially full containers of flammable liquids) and hazardous materials should be removed, especially those that should be destroyed using best available techniques described in other parts of the guidance (see section V.A (i), subsection 2.2 of the present guidelines).

[2] "No distinction is observed in log (TEQ) for inorganic (7% Cl in $CaCl_2$) versus organic Cl sources (7% Cl in PVC)" (Lemieux et al. 2003).

1.3.1.1 Burning process in the SADC region

Several types of wastes are burned in the SADC region; Municipal Solid Waste (MSW) and agricultural waste are the most observed, while e-waste combustion is the most dangerous.

1.3.1.1.1 Burning of MSW

MSW in the SADC region can contain hazardous, industrial and e-waste. This may be due to absence of separation of hazardous waste at the source, as well as absence of waste deposits suited for environmentally sound disposal of hazardous waste. The presence of hazardous materials in MSW increases the risk of emission of POPs, as well as mercury and other pollutants, from open burning.

Waste classification

Solid waste is categorized according to standards into:

- *Municipal Solid Waste (MSW) covers household waste and waste similar in nature and composition to household waste (for example from offices, shops and public institutions).*
- *Industrial waste is the waste produced by industrial activity which include any material that is considered useless during a manufacturing process*
- *Hazardous waste) is waste that include hazardous chemicals or other hazardous material that can be a threat to public health or the environment (hazardous waste is defined specifically in the regulation of some countries).*
- *Medical waste (also called health-care) waste: is any kind of waste that contains infectious material (or material that's potentially infectious).*
- *Agricultural waste: is solid waste that is generated by the rearing or harvesting of animals, or the producing or harvesting of crops or trees*

Open burning of MSW waste has been observed in the following situations:

- *Informally in backyards:*
- *Informally at Illegal dumps: .*
- *On municipal dumpsites/landfills;*

Causes of open burning of waste at municipal dumpsites can be:

- *Unauthorized burning of waste to reduce volume and to extend the lifetime of dumpsite.*
- *Waste pickers setting fire to the waste to sort out metal and other valuables.*
- *Spontaneous ignition due to generation of heat (aerobic decomposition process) and formation of easily flammable methane. It can generate deep fires which are difficult to extinguish and can last for weeks.*

Figure 3 Burning of waste at a dumpsite

The issue of burning of mixed waste is dealt with in more detail in section 3.1.

1.3.1.1.2 Burning of industrial waste

Industrial waste can be burned when dumped together with MSW. Burning of textile discards is often observed in the region as the garment sector is widespread in many countries.

1.3.1.1.3 Burning of e-waste with MSW

E-waste such as cables and electronic circuit boards are found at dumpsites and are burned by waste pickers to recover copper and other precious metals. The content of e-waste in MSW is increasing with the use of electric and electronic appliances. Separate collection of e-waste has not yet taken place in some countries of the SADC region; therefore, e-waste is normally mixed with MSW.

1.3.1.1.4 Burning of medical waste

Medical waste (health-care waste) is normally segregated from other waste and delivered to small incinerators to be combusted (or to be treated in so-called autoclaves with no combustion). Its combustion can be classified as controlled burning.

***Cables burning**: The burning of cables and other e-waste is a common practice when waste pickers' activities are not controlled. According to international standards on emission of POPs (UNEP dioxins/furans Toolkit) this practice is one of the most dangerous because of the amounts of emitted POPs. The Toolkit gives a reference Emission Factor of 40,000 micrograms TEQ/ton of burned cables, compared to a value of 400 micrograms TEQ/ton for fires at waste dumps. It must therefore be assumed as one of the most critical habits to be discouraged that could be given priority in the implementation of policies to reduce open burning*

1.3.1.2 Measures to reduce open burning of waste in the SADC region

As the volumes of waste generated in the SADC region is rapidly increasing, the reduction of the volume of waste lead to dumpsites through increased recycling activities and separation of e-waste are the most viable solutions.

1.3.1.2.1 Reduction of the volume by segregation at source of recyclables

Segregation at source by recovering paper, plastics, metals, e-waste and glass, can reduce the waste amounts dumped with 20% to 50%, thus reducing the risks and volumes of open burning. In addition, removal of combustible materials such as plastic and paper results in lower risks of combustion at municipal dumpsites and lower POPs emissions from plastics with chlorine contents.

***Segregation at source of recyclables**: Inciting or requiring households to separate recyclables from other waste (two bins system) can be a low-cost and effective means of reducing waste volumes dumped and burned. Recyclables have a market and can be sold. The incomes from the sale can cover the extra costs to organize the segregation at source and collect the two fractions. Recent studies have demonstrated that the economics of a door to door segregation of recyclables material is better than traditional collection systems. Segregation at source reduces the content of valuables at dumpsite and discourages unregulated activities of waste pickers at the sites.*

1.3.1.2.2 Reduction of the volume by composting of organic material

The fraction of organic material in MSW in the SADC region vary and can range up to 70% depending on social economics and traditional habits of people. High contents of organic material results in generation of odors, flammable gases, proliferation of vermin and production of leachate with consequent potential for contamination of groundwaters. Segregation at source of organic material is viable for vegetable markets and restaurants and can provide un-contaminated material to be converted into fertilizers and sold to farmers.

In cases where kitchen waste (organic material) may be contaminated by other materials such as solvents, drugs and toxic compounds making it unsuitable for production of fertilizers, it can be treated in

Figure 24 composting activities by a dumpsite

mechanical-biological treatment plants to reduce its water content (and final volume), and the dried organic output material can be used as coverage for landfills.

1.3.1.2.3 Ban of burning activities at dumpsites

Banning of open burning of waste is already implemented in the regulations of countries the SADC region, but can be enforced more rigorously. This policy can be implemented at moderate costs and can bring substantial reductions of uPOPs formation with benefits to health and environment. Municipalities have an important role in enforcement of the ban of any open burning activity, including by management of waste pickers and of municipal dumpsites.

1.3.1.2.4 Improved dumpsite/landfill management and planning

Dumping management: The practice of open waste burning by waste pickers can be eliminated or reduced by concentrating the activities of waste pickers in a small area of the dumpsite, where sorting is easier and more profitable and there is therefore no need to burn. This can be achieved by organizing restricted areas for the dumping of waste and picking activities within the dumpsite. Trucks should be instructed to offload the waste in that area only, where waste pickers can be able to easily sort the recyclables. Once waste pickers have recovered the recyclables, what remains can be moved to its final place. At the same time, the populations of birds and vermin can be reduced. Final coverage of waste with soil is also recommended to reduce odors and spontaneous ignition.

Figure 35 Dumping in a dedicated, restricted area

Spontaneous fires fighting: Measures to extinguish spontaneous fires should be taken by municipalities as soon as smoke is detected, to avoid the extension of the fire to wider areas of dumpsite and the establishment of deep-seated fires, which are difficult to extinguish.

1.3.1.2.5 *Awareness raising*

Awareness raising campaigns addressed to all stakeholders should be periodically conducted to educate on stopping open burning activities paralleled by education campaigns to schools.

1.3.2 Handling after burning

Before burned waste can be handled or covered, it must be completely extinguished. Failure to do this can potentially ignite uncontrolled burning over large areas or allow ongoing smouldering. Ash from mixed waste burning should be kept from forage areas and landfilled rather than land spread.

1.3.2.1 Handling after burning in the SADC region

The following after-burning situations have been observed in the SADC region:

Use of ash as fertilizers: Ash generated at dumpsites is sometimes used as fertilizer; this habit occurs in countries where people are looking for cheap fertilizers. As a result, POPs in the ash are transferred to soil and then to the food chain. Use of the ash from backyard burning of waste as fertilizer for vegetable gardens has been observed as well.

Ash from waste ingested by animals: Grazing of animals (cows, goats and chicken) in not surveilled, not fenced dumpsites is widespread; animals eat everything edible, including residues from combustion of waste. It results in ingestion of POPs and consequent transmission to humans through the food chain. Moreover, the animals can die or be otherwise affected.

Inadequate disposal of ash: Ash from incinerators of medical waste, with high POPs content, is sometimes disposed of at MSW dumpsites with no safety measures. Un-covered ash can be blown away and contaminate the surrounding fields, or leach to the groundwater.

Contamination from fires in illegal dumps: People living in the area set fires to illegally dumped waste to reduce volume, odors, vermin, etc.; the ash generated may blow away causing local effects, and may contribute to pollution of groundwater.

1.3.2.2 Measures to reduce exposure to uPOPs in after-burning situations in the SADC region

The following measures are recommended to reduce the exposure to uPOPs in after burning situations:

- *Surveillance: As open burning is widely spread in the SADC region, the ban of burning activities at dumpsites, and associated enforcement, remains the major measure to be implemented to reduce after burning situations. Surveillance and fencing of municipal dumpsites are suggested to also avoid animals grazing in the area. If this is not possible because of the great extent of a dumping area and the limited finances, awareness raising to breeders on risks associated to this practice is recommended.*

- *Extinguish smoldering and deep-seated fires as soon as detected;*

- *Ban the use of ash produced from open burning as fertilizer and raise awareness of farmers and garden owners on risks and alternatives;*

- *Safely dispose of ash from medical waste incinerators. In case ash is dumped in municipal dumpsites designed for MSW, confine and fence a small area of dumpsite and dump the ash only there, assuring coverage with soil to avoid dispersion of ashes by the wind.*

Figure 46 Smouldering at a dumpsite

- *Take measures to reduce buildup of illegally dumped waste, (while educating people to stop informal dumping); extinguish the fires as soon as they are detected;*

- *Widen the collection service to the districts where backyard/ barrel/street burning is detected. If lack of finance does not allow it, improve the efficiency of the ongoing collection services and organize collection centers for recyclables close to the areas where backyard burning is practiced;*

- *If open burning cannot be fully stopped, people should be asked to dispose the ash in the garbage bin (after it has got cold);*

1.3.3 Health and safety considerations

In addition to the aforementioned guidance, steps should be taken to mitigate exposure routes to dioxins and furans. As is widely recognized, most human exposure comes through the food chain. Thus, necessary burning sites should be located away from production of plants and animals for food. It is also good practice to locate combustion sites remote from the population or at the very least downwind of residential areas.

In addition to isolating citizens from the odor, nuisance and potential toxics exposure of open burning, in all cases, whether in a landfill or at a secluded facility, personnel tending the fires should position themselves upwind from any burning waste and be clear of the burning waste. Protective clothing such as gloves, boots and overalls, together with smoke masks and goggles, are advisable where possible.

1.3.3.1 Health and safety considerations in the SACD region

In addition to the mentioned risks from direct exposure from smoke and wind-blown ash dust, and the indirect exposure through grazing of domestic animals in dumpsites and other areas polluted by ashes, the following should be mentioned in the SADC region context:

Not only dioxins, furans and other uPOPs pose health risks from open burning; also other toxic chemicals can be formed by, or released from, burning processes. These include, among others, volatile organic compounds (VOC),

polycyclic aromatic hydrocarbons (PAH), mercury, black carbon (soot), dust with heavy metals contents, CO, CO2, etc.

Health risks to waste pickers from the handling of sharp waste, hazardous materials and exposure to smoke and generated biogas.
Huge landfills can be overloaded; mountains of waste can be accumulated without any safety consideration. and become a threat for waste pickers. During the rainy season, the slopes can collapse. Many accidents with fatalities have occurred in huge dumpsites.

Normally sanitary landfills, when properly managed, are safer and risks to health are normally low. However, insufficient management, for example dumping without a site development and maintenance plan, waste not periodically covered, un-regulated waste pickers activity, etc., can lead to increased exposure risks for both waste pickers and other workers, local population and the global environment. Lack of control to monitoring wells can lead to pollution of groundwaters; generation of biogas that is not flared in torches (or used for controlled purposes) increases the emissions of greenhouse gases and deep-seated spontaneous fires,

1.3.3.2 Measures to reduce health and safety problems in SADC region

Health problems which affect the informal recycling sector and the waste picker activities at dumpsites can be reduced with effective waste management practices. At dumpsites, safety measures need enforcement to avoid dangerous situations from open burning and collapsing of waste build-up.

Figure 57 waste pickers at a dumpsite

Waste pickers can be involved positively and managed with good results by municipalities and organized to sort the waste without burning (for example by organizing restricted dumping areas where they can pick). This can lead to significant reductions of both local and global exposures from open burning; see Annex1 for details on management of waste pickers.

Fires control teams can be organized at dumpsites enabling rapid extinguishing of spontaneous fires; see Annex 2 for details on dumpsite fires.

1.3.4 Intermediate burning technologies and practices

Combustion devices, sometimes called “incinerators” by vendors, are sold for the purpose of burning refuse. In some cases these devices may be as simple as steel drums or barrels that contain the waste but do not constitute a best available technique for incineration. For the purposes of this guidance, open burning includes any form of combustion for waste disposal, whether in unconfined piles or confined in metal barrels or burners, that does not meet the standards for incineration (using best available techniques) of municipal, medical or hazardous waste, as defined by a Party.

Utility of these intermediate burning devices is limited by lack of data on generation of persistent organic pollutants. It is strongly recommended that manufacturers of these devices supply such data, specific to the waste for which they are intended.

1.3.4.1 Intermediate burning technologies and practices in the SADC region

Data for intermediate burning technologies, data is now available from UNEP Toolkit.

In the SADC region, such "intermediate burning practices" are used in the incineration of medical waste, where inadequate burning operations often lead to low combustion temperatures and consequent generation of POPs. Incinerators are normally located by the main hospitals and by municipal dumpsites. The capacity is normally small (500-1000 kg/day) and the operation is batchwise (daily).

Incineration of MSW in large high-tech incinerators is not yet implemented in the region.

Figure 68 Evidence of bad combustion of medical waste

***Incineration** of MSW is a quite widespread practice in developed countries and it is considered one of the best ways to safely handle MSW. Incinerators have high capacities, are equipped with sophisticated combustion system and APCS (Air Pollution Control Devices) which keep emissions within very strict standards. The economics of MSW incinerators is guaranteed by the fees that municipalities pay to incinerate the waste and by the generation of electricity and sometimes of heat from the combustion energy. The high investment, operation and maintenance costs, the need for skilled personnel to guarantee the proper functioning of the furnace and of filtering system have so far discouraged their application in the SADC region. Small incinerators of medical waste are on the other hand quite widespread, but, as investments and operation and maintenance (O&M) costs cannot be retrieved, they are a burden for the municipal finances.*

Medical (health-care) waste incinerators: The safe combustion of medical waste is achieved by keeping high temperatures (more than 900° C) in the combustion chamber to reach the core of the waste bags, and by keeping the temperature of the exhaust gases to more than 850°C-900 °C for more than 2 seconds before the release to air.

1.3.4.2 Measures to reduce emissions from intermediate burning

Medical (health-care) waste incinerators: The safe combustion of medical waste is achieved by keeping high temperatures (more than 900° C) in the combustion chamber to reach the core of the waste bags, and by keeping the temperature of the exhaust gases to more than 850°C-900 °C for more than 2 seconds before the release to air.

Some medical waste incinerators have shown lack of operation and maintenance. As a result, temperatures in the furnace are kept below the minimum requested for a safe combustion, the afterburner often does not work or is kept off to save fuel, the feeding system is out of service and waste is improperly loaded from the front door. As a result, high levels of POPs are generated and emitted to air.

The potential generation of POPs from a medical waste incinerator can be visually controlled by:

- *Visually checking the smoke at stack; if color is black (like that in the picture) it indicates bad combustion; checking of the main burner and the afterburner and checking that there is an excess of air in the afterburner are recommended.*

Figure 79 Evidence of not fully incinerated residue of medical waste

- *Checking the appearance of the ash produced after combustion; the presence of syringes and other solid materials is an indication of not good combustion (low temperatures); check of the combustion system to ensure to get high temperatures in the core of medical waste is recommended. Additional details on proper*

> ***Operation of medical (health-care) waste incinerators***
> *The incineration of medical waste in incinerators must be conducted by strictly following the operating instruction provided by manufacturers, with reference to:*
> - *Excess air: must be kept within the limits indicated by manufacturer: high excess air reduces the temperatures of furnace and exhausted gases; low excess air results in poor combustion and generation of carbon monoxide and risk of explosions and shall be kept in the primary chamber only;*
> - *Combustion temperatures: medical waste must be input only when furnace has reached the working temperature stated by manufacturer. The combustion time must stick to what has been prescribed by manufacturer;*
> - *Proper functioning of post combustor (afterburner) to destroy the POPs generated during the combustion. The post combustor must be kept operating and temperature gauges must be controlled to check that the prescribed by the manufacturer is reached;*
> - *Periodic maintenance of burners, temperature gauges, feeding system and filters;*
> - *Proper input of medical waste through the provided waste feeding device;*
> - *Proper installation and functioning of APCs (Air Pollution Control Systems). Often small incinerators are equipped with a bag filter only. The filter must be periodically checked and cleaned. The fly ash generated from operation and cleaning must be properly managed (not dumped to dumpsite, unless in a confined area that is well protected and regularly covered with soil to prevent dust from spreading).*

operation of medical waste incinerators can be found in Annex 3.

2 Intentional biomass burning

2.1 Agricultural/crop residue and land clearing debris

2.1.1 Material composition

In general, this material is biomass: wood, grass and other vegetation. Depending on locality the material may include sisal, coffee husks, corn (maize) cobs and stalks, sugar cane or rice husks. The material may be composed of living plants, deadfalls or plant material that has been cut and dried. Intentional burning does not constitute well-controlled combustion despite the fact that the geographical boundaries of the material to be burned may be well defined.

Biomass materials will vary in water content (live versus harvested material; wet versus dry season; low versus high humidity), fuel density (mass per hectare and degree of compaction or other measure) and species. Biomass materials vary naturally in chloride content and may have been treated with chemicals (chlorinated pesticides or fertilizers), metals capable of catalysing formation of persistent organic pollutants (copper, for example as copper chromium arsenate-treated wood) or inhibitors (sulphur, nitrogen-containing materials), all of which may impact generation of persistent organic pollutants, particularly dioxin and furans, during uncontrolled combustion (see subsection 1.3 above on general process considerations). Some research on large-scale biomass burning has been published (Lobert et al. 1999; Nussbaumer and Hasler 1998; Gullett and Touati 2003; Gullett and Touati 2002).

2.1.1.1 Material composition in the SADC region

Many agricultural residues such as cereals' straw are burned after harvesting in the SADC region.
Some residues such as those from sugar cane and palm oil cultivations are often burned to support the production processes (bagasse). The heat for the production process is obtained from the combustion of the residues in special grate boilers (controlled combustion). This type of combustion is safer as it can be controlled; combustion is optimized, temperatures are kept high, filters before the stack reduce the emission of particulate matter to air.

By way of example, in Madagascar in the process of treating sugar cane, two methods are used for cutting: a mechanized cut and a manual cut that requires burning of the cane stems. Two sites in Madagascar still use manual cutting and burn cane stems before cutting. Note that the burned parts represent about 10% of the cane.

The ash produced from the combustion, which contains POPs, is sometimes sent back to the fields/plantations and spread as fertilizer. As a result of this habit, every cycle increases the content of dioxins in the soil and in the product.

Logging of virgin forest is implemented at small scale in some SADC countries as a mean to produce charcoal for cooking. The extensive implementation of this traditional habit has resulted in open burning and deforestation of large areas. Virgin forests are also cut to be replaced by fruits plantation such as bananas, pineapples, mangos, or palm oil. In addition to logging, also forest fires contribute to uPOPs formation. They may be ignited due to draught or by illegal activities.

2.1.2 Barriers to elimination; remedies or policy to remove barriers

Prescribed burning may be permitted by government for perceived economic benefit (cost reduction), perceived agricultural benefit (ash as soil adjuvant), risk prevention (e.g. to minimize bushfires in Australia), termite, reptile or other pest control, convenience or recreation. In each of these cases the government has the power to remove permission for such burning and to educate the public regarding the health risks of open burning, especially if it is conducted on a large scale. In some cases, as for termite control, open burning of biomass may be the least environmentally problematic approach. Cost and availability of alternative means of disposal or environmental management can be an overarching issue.

2.1.2.1 Barriers to elimination; remedies or policy to remove barriers in the SADC region

The use of ash as fertilizer in sugarcane and palm oil plantation could be banned to avoid concentration of POPs, in the produced products, but habits and economic consideration (how and where ash should be disposed of) hinder it. A ban of virgin forests logging cannot be enforced if alternate sources of energy for cooking, such as affordable LPG, are not available to people.

2.1.3 Strategies and policy instruments to avoid, reduce or divert waste

Where possible, machine harvesting paired with alternative, non-destructive uses for harvested materials can reduce the need for wholesale burning. In areas of livestock cultivation materials may be harvested for silage. Grass may be dried for hay; other crop waste may be processed for fodder, fermented, allowed to decompose in situ or composted; wood of sufficient quality may be harvested for timber; yard waste can be composted and utilized as soil amendment; some non-traditional biomass can be used as a raw material for paper. In most cases, these alternatives also require markets and infrastructure for economic feasibility.

Beneficial results can be obtained if agricultural vegetation residues are composted, especially in areas with poor soil. Zero burning techniques, as outlined by the Association of South-East Asian Nations, should be applied where applicable to the region and the crops (ASEAN Secretariat 2003). Reduction and elimination of persistent organic pollutants from open burning may provide an opportunity to reform agricultural practices.

2.1.3.1 Strategies and policies to avoid, reduce or divert waste in the SADC region

The use of residues from crops cultivation as energy for industrial food processes is one solution to reduce open burning and divert agricultural waste, but cost-benefits analysis is needed as the economics can limit the use of residues for energy generation.

Figure 8~~10~~ Biomass ready to feed an industrial boiler

Due to their low energy content and consequent low value, agricultural residues cannot be economically transported for long distances. Receiving plants should be located within 30-40km from the fields where residues are generated. Moreover, this solution needs the presence of industrial sectors (e.g. food production factories) available to use the residues close to generation area.

Where economically feasible, in-field chipping, plowing down and composting of straw and other crop residues can irmprove the soil quality (crop waste gives both structure and act as fertiliser). This approach is widely used in developed countries.

Rotational logging of non-virgin forests can be implemented in some areas to preserve virgin forests and keep open burning activities under control. For example, residues from logging which are normally burned can be shredded to be then converted into fuels (pellets). Saw dust can be used in the furniture sector (fiberboards). Rotational logging can provide the material to produce charcoal without affecting biodiversity of virgin forests.

A strategy may be needed to sustainably make the best use of biomass while securing reduced emissions of uPOPs from combustion.

2.1.4 Alternatives, barriers to use and policy instruments to remove barriers

Alternatives vary by situation. Barriers include lack of education, lack of government will to reduce dependence upon open burning to accomplish goals, and lack of alternative machinery or processes whereby open burning is an integral part of local agriculture. The sometimes high cost of alternatives in any form may be a barrier and, as with any reforms, economic instruments may be necessary or desirable to induce change. Demonstration projects and research in the regions may help understanding of the feasibility of alternatives.

2.1.4.1 Alternatives, barriers to use and policy instruments to remove barriers in the SADC region

Lack of potential users of agricultural residues can hinder the use as energy sources. Lack of policies to influence traditional habits, which result in deforestation activities, can hamper efforts to reduce open burning.

2.1.5 Burning techniques and attributes, and means of improvement

Where open burning of biomass is permitted by government policy the process improvements noted in the general guidance should be implemented. Careful planning of prescribed burns modulated by weather conditions will allow greater control and the potential exposure of air pollutants to downwind populations should be minimized. After the fires, residue management may be an issue.

Application of chemicals in agriculture and forestry should be minimized consistent with local needs and good management. Where mechanical clearing and alternative use of harvested material is possible, incidental burns can be avoided; however, in certain local situations prescribed small burns may have a place in an overall land management scheme if used to prevent more devastating inadvertent burning with concomitant larger emissions of persistent organic pollutants. Recognizing that control of prescribed burns can be lost, fire abatement procedures (training, equipment, planning), infrastructure (access, roads) and management planning are all reasonable secondary support measures.

2.1.5.1 Burning techniques and attributes, and means of improvement in the SADC region

Biomass can be burned in several ways. The best techniques are those that use the biomass as fuel for boilers/furnaces; the heat released is used for production processes such as sugar, palm oil, and thereby substitute for fossil fuels and reduce climate impact. High-tech boilers ensure the optimal combustion of biomass and reduction of the POPs associated with its combustion. Biomass furnaces are equipped with grates where biomass is loaded and ignited. The heat produced is transferred to the boiler section, where water is transformed into steam, which is used for the production process. Boilers are equipped with exhaust gas filters to collect ash and non-combusted particles before the stack.

Figure ~~9~~11 Combustion of biomass to produce palm oil

Other techniques include small stoves and fireplaces for cooking which are less efficient and release more pollutants.

Composting of biomass such as mulching can also be implemented to reduce the open burning.

3 Open burning of mixed consumer waste

3.1 Household waste, landfill/dump fires, industrial non-hazardous waste

3.1.1 Material composition

Household waste and the composition of landfills and dumps may be qualitatively very similar. They differ importantly where modulated by programmes (such as recycling, scavenging, composting or other segregation) that remove specific streams from waste between collection point and repository. Non-hazardous waste may arise from commercial establishments such as shops, restaurants and light manufacturing. It will differ according to the exact commercial source but may contain many of the same materials found in household waste.

Open burning of waste has been the topic of significant study (Lemieux et al. 2003). However, there seem to be very few data regarding dump fires and persistent organic pollutants (Lemieux, Lutes and Santoianni 2004). Waste composition studies show variation in waste among countries and especially between developed and developing countries. In developing countries as much as 50% of waste composition may be putrescibles such as kitchen waste. In developed countries, more convenience packaging and electronics may be found unless these materials have been removed by other end-of-life systems. Significant differences may also exist between urban and rural waste and among wastes from different regions, regardless of development. In general, household waste streams and landfill waste will contain paper, plastic, organics such as food refuse, glass, metal, wood, leather and miscellaneous other materials. Under poorly controlled conditions, household hazardous waste such as cleaners, paints and solvents may find its way into a non-hazardous-rated landfill or dump.

Moreover, negative management approaches will change the composition and performance of a landfill or dump. In a modern, compartmentalized landfill, daily cover consisting of soil or clay will be added to the refuse to reduce not only the moisture content of the landfill but also the likelihood of spontaneous ignition. A traditional dump, by comparison, is rarely well organized and is more likely to burn spontaneously.

All disposal sites will generate some combustible gas (e.g. methane) from anaerobic degradation of organic materials contained within. Unless this gas is controlled it constitutes a highly combustible fuel for either spontaneous or illicit anthropogenic ignition. It is also a potent greenhouse gas. Methane collection systems have been designed and implemented as part of modern landfill technology, both for reasons of safety and potential energy recovery.

3.1.1.1 Material composition in the SADC region

Open burning is affected by composition of waste. Composition of MSW in the SADC region has varies significantly among countries, mainly depending on traditional habits and culture. Where the kitchen (organic)

waste is traditionally used for animal feed, no organic material is found at dumpsites. Some countries instead show very high contents of organic matter.

Waste characterization

Municipal Waste (MSW): Waste characterization is an important factor in the planning of efficient collection services. Composition of waste differs according to culture and habits of people and leads to different management policies.

The main components of the MSW are:

- *Organic material: Kitchen waste and garden trimmings*
- *Recyclables: Paper, plastics, glass, metals, etc.*
- *Non-recyclable material: What is left from the two above categories;*

The content of organic material can range from 0% to 70%. In some SADC countries kitchen (organic) waste is traditionally used to feed animals and is not discarded to the waste bin. As a result, no organic material is found in the MSW stream to dumpsites .

Composition of waste at individual sources (households, commercials and institutions) may differ from composition at dumpsite because it is affected by the structure of the town (composition of households, commercials, and institutions) and by the welfare of people. Depending on local characteristics and presence of local sources, dumped waste may include industrial and hazardous waste.

***Composition of waste is quite** variable in the SADC region .In Madagascar and Mozambique the content of kitchen (organic) waste and other organic material from household is very high, from 60% to 70%. In Eswatini the content of organic material in the waste is around 40%. In Lesotho is 0%. Recyclables are also quite variable among countries; the content of recyclables in the MSW is high in Lesotho and Eswatini (from 50% to 90%) and low in Madagascar (less than 30%) .*

Industrial waste: Composition of industrial waste is a result of the production process; different production processes generate different discards. As few landfills for industrial waste exist in the SADC region, otherwise MSW and industrial waste are dumped at the same places, which can result in increased emissions of POPs from open burning. As textile industry is widespread in the SADC region, thanks to special international agreements, textile discards is the a common kind of industrial waste. Textile discards are either disposed of at municipal waste dumpsites or burned.

Guidance on material composition study

To better manage waste, its composition must be analyzed by conducting WACS (Waste Analysis and Characterization Study). This analysis is important for planning a sound management of the waste; often WACS are missing in municipalities that do not plan actions to reuse, reduce, recover, recycle the waste (4R policy). The comparisons between two WACS (one at source and one at dumpsite) can provide information on presence of informal recycling, on contribution of each sector to waste generation, and on content of industrial and hazardous waste.

With the outcomes from WACS, adequate management of waste can be planned. If the content of recyclables is high, their recovery should be planned. Segregation at source of recyclables is highly recommended as it provides clean, more valuable materials and reduces the volume of waste to be disposed of. Industrial waste can be reused/recycled. Scrap metals are normally recovered and sold to recyclers.

Industrial activities such as production of granules from recycled plastic can improve the economics of the recycling cycle and provide job opportunities. Recycling activities can be extended to both production of handicrafts from recycled materials, which has very low investment costs, and to production of goods, such as home appliances from plastic granules, to be sold locally and generate a circular economy.

If the content of organic matter in waste is high, policies to compost it into fertilizers could be evaluated. The economic sustainability of composting is more challenging than recovery of recyclables; high quality fertilizers offer better business chances. Organization of separate collection of organic material from vegetable markets and restaurants will result in high quality input material to composting plants.

For additional details on WACS, see Annex 4.

Recycling activities in the SADC region

The following recycling activities have been observed in the SADC region

- *Segregation of plastics, paper, glass, metals: Activities are located by dumpsites/landfills; the material is segregated and delivered to buyers in South Africa;*
- *Recycling of plastics: done by foreign companies (mainly from China); recycled plastic is either converted into granules to be sold or used to produce goods (plastic bags, carpets, home appliances) to be exported;*
- *Secondary aluminum recycling: Aluminum discards are melted to produce pots to be sold locally;*
- *Plastic bricks production: Plastic discards are melted with clay to produce bricks for the local market;*
- *Beer bottles recycling (reuse): Beer bottles are collected and returned to breweries which buy them back (Extended Producer Responsibility);*
- *Production of bricks from recycled glass: glass is grinded and mixed with cement to produce bricks to be sold locally;*
- *Production of handicrafts from recycled materials;*
- *Composting: organic material is separated from waste and composted to produce fertilizers;*

Figure 1012 production of handicrafts from recycled plastics

Figure 1213 Production of goods from recycled plastics

Figure 1314 Production of granules from recycled plastic

Figure 1115 Production of pots from secondary aluminium

Figure 16 Production of bricks from recycled plastic

Figure 1517 Production of blocks from recycled glass

Figure 1418 Paper recycling

3.1.1.1.1 Guidance on recycling of textile discards

Textile discards should be properly managed to avoid burning and reduce the footprint on environment .Suggested BAT/BEP practices are:

- *Locally recycle the discards to produce industrial products such as insulation material for construction, furniture and automotive sectors.*
- *Involve companies who import the garments to support recycling of textile discards (Extended Producer Responsibility) .*
- *Return the discards to buyers (western countries), when the raw materials are supplied by them;*

Figure 1619 Textile discards at a MSW dumpsite

Figure 1720 Products from textile discards

3.1.2 Barriers to elimination; remedies or policy to remove barriers

3.1.2.1 Household waste

Household waste will be burned in the open where cost, convenience or local custom and social acceptability make that option attractive to individuals or groups of citizens. In cases where people live far outside municipal governance, options for waste disposal will undoubtedly be *ad hoc*. Without appropriate systems in place waste disposal may be *ad hoc* even within municipal governance.

In order to eliminate open burning, reasonable alternatives must exist and the public must be educated regarding their availability as well as the consequences of open burning.

Figure 21. Centralized sorting of waste for reuse and recycle

At-source or centralized collection, recycling, transport or another disposal must be made affordable, convenient and effective. Landfills must be designed and operated according to modern standards (Hickman and Eldredge 2004). If combustion is to be used, incineration using best available techniques, with energy recovery, is strongly preferable.

Governments must accept responsibility to create waste reclamation and disposal systems as a public utility or service. Countries and municipalities must then have the will to mandate an end to waste burning and accept the responsibility for enforcement of those laws. Additionally, where modern landfilling is an option, waste management plans and regulations must include provisions for establishing new landfills so as to maintain disposal capacity.

Simply accepting the responsibility for providing waste management systems may not in itself mean the end of open burning. Waste could be collected and deposited in landfills or dumps, which can themselves be sites for open burning. Policies and practices must be developed and applied to these centralized services. Spontaneous ignition and combustion can be reduced by collection of landfill gas or regulations requiring modern landfill construction techniques along with the permanent closing of obsolete dumps.

3.1.2.1.1 Household waste management in the SADC region

The management of household waste is a major challenge in the SADC region, and municipalities are facing this challenge on a daily basis.

Barriers to a sound management of household waste in the region include:

Lack of funds to organize effective collection services, which makes it difficult municipalities to organize the collection service for all households. In many cities/villages only downtown, medium- high income wards are

served while suburban areas do not receive it and households must burn the waste in the backyards. The lack of fund may be associated to collection service inefficiencies.

Inefficiencies of collection service: Inefficiencies increase the collection costs and leave more areas of the municipality not serviced. The presence of a waste management plan is important for achieving effective collection service. Checking by the municipalities if contracts with private companies are carried out effectively is important, as ineffective collection may result in dissatisfied customers with the risk that the customers do not pay their bills – a vicious circle that can lead to increasingly lower waste collection rates.

It is also important to make sure that the waste collection means (trucks, etc.) provided by private companies are appropriate for the service that is contracted.

Figure 1822 Tractor used for collection of MSW

Challenges in urban planning: The region has many informal settlements with little urban planning. Additionally, many big cities, towns and villages with inadequate urban planning have narrow streets and areas not accessible to waste collection trucks, requiring more manual labour. If suburban districts do not receive waste collection services, the households must burn the waste in the backyards or abandon it along the streets and in informal dumps.

Waste fee: Setting up a waste fee policy that suits the local situation is important to ensure the incomes for the payment of collection and disposal of waste. Fee policies in the SADC region are different, depending on local settings. The way waste fees are organized and cashed has a direct effect on the efficiency of the collection and disposal system. The main policies applied, and their pros and cons, are presented in Annex 5.

Capacity and management of landfills/dumpsites
Different types of landfills and dumpsites exist in the SADC region. Informal and inadequately controlled dumpsites are common and sanitary landfills are few. In capitals and big cities there are challenges with the organization of sanitary landfills to enable the management of the high volumes of waste that are dumped daily. Inadequate management of municipal dumpsites/landfills often results in un-regulated waste picking activities including open burning of waste. Many dumpsites of small/medium towns and villages are organized without control/enforcement and not fenced, nor equipped with a weighting bridge.

Long distance between dumpsite and town (above15-20 km)
If a dumpsite is far from town, transportation costs are high and may affect the economic sustainability of the waste service (also resulting in less trips/day, low collection frequency). It has been observed that private collection companies sometimes illegally dump waste to reduce transportation costs;

Non-availability of landfills/dumpsites
The availability of land for new landfills/dumpsites has turned out to be a real problem in some SADC countries. Municipalities plan new modern landfills but are not able to get the land. As a result, the existing landfill/dumpsite become overloaded, and their management becomes more challenging;

Waste fee at dumpsites
Privatized landfills/dumpsites may ask for a fee to dump the waste in their site. As a result, private companies sometimes deposit heir waste in vacant lots or along roads to save money;

Types of waste collection:
- *Roadside collection: waste left on the roadsides, where is collected according to collection schedule;*
- *Collection points: Containers are placed where citizens can bring the waste, containers are periodically emptied;*
- *Summoning: the collection truck comes around on specific times/days of the week. When it arrives, it hoots its horn to summon the people to bring their waste for disposal.*
- *Door to door collection: collection companies directly collect the waste house by house*

3.1.2.1.2 Guidance to elimination of open burning; remedies or policies to remove barriers in the SADC region.

The lack of fund to cover collection services costs can be partially overcome by optimizing the collection and disposal services, for example by linking the contracts to the actual quantities of waste that is collected and disposed of. A weighing bridge installed at the municipal dumpsite gate can assist to keep waste services under control. Weighing bridges are found at large landfills, where the huge quantities of waste received justify its installation, but often not at small municipal dumpsites.

Small towns which cannot afford the investment for a weighing bridge, can benefit from focusing on the reduction of volume of waste through the organizing of waste segregation at source of recyclables and composting of organic material. Less waste to be disposed of at dumpsites means lower collection and disposal costs, potential for more sustainable services, and lower risks of open waste burning.

Inefficiencies in waste collection can be addressed by regular checks of the activities of collection companies to ensure that quality of service is matching what has been contracted (served areas and collection frequencies).

Open burning caused by inadequate urban planning can be reduced by organizing collection centers close to the non-served areas, to encourage citizens to bring waste and recyclables. Collection centers will receive the recyclables and compensate the people. This practice will remove the recyclables from the waste stream to dumpsite (generally, 20 to 50% of waste is recyclables). The revenues from the sale of recyclables can be used to cover the cost of compensations and to improve the collection service.

The waste fee policy should be carefully analyzed as it is imperative to get an efficient collection and disposal service at prices accepted by the population. Collection of waste fees through the electricity (or water) bill is very efficient as can reach most households and guarantee the payments, although commissions to utility companies must be carefully negotiated. Direct payment of the waste fee to collection companies ensures the control of waste generation, but can result in open burning activities from the households that do not pay and do not get their waste collected.

Regarding landfills and municipal dumpsites, barriers originating in lack of funds can be reduced by reducing the volumes of waste dumped through segregation of recyclables and by composting. Keeping the activities of waste pickers under control us very important for the reduction of open burning.

3.1.2.2 Accidental anthropogenic combustion

Accidental anthropogenic combustion in dumps can be reduced by prohibiting, licensing or limiting access to landfills and dumps. In many cases fires are set by waste pickers living and working in these areas. Fires, accidental or intentional, can ignite discarded materials or landfill gas. Authorities must accept responsibility and enact regulations organizing scavenging activities, providing safe conditions for workers and limiting access to and overt residence on landfills.

3.1.2.2.1 Accidental anthropogenic combustion in the SADC region

Accidental anthropogenic combustion has been observed at:
Dumpsites (non-sanitary landfills): Open burning can be caused by spontaneous ignition of waste, leading to emissions of POPs;
Sanitary landfills; normally sanitary landfills do not show open burning activities, but when waste is not properly covered with soil and vented, spontaneous ignition can occur as well;

3.1.2.3 Intentional anthropogenic combustion

Intentional anthropogenic combustion, that is, burning dump contents for volume reduction, must be prohibited by authorities. In order to avoid the need for dump burning sufficient planning must be given to landfill size, space, location and management, as well as to waste reduction and elimination programmes so as to obviate the need.

Waste management is a system. Where the system works to make final disposal of true waste a collective responsibility rather than an individual responsibility, direct economic costs may rise, but in general environmental costs and impacts will fall.

3.1.2.3.1 Intentional anthropogenic combustion in the SADC region

Intentional anthropogenic combustion can be found at:

Backyards: Waste burning by households that do not receive regular collection service results in generation of POPs at close distance from people living in the houses. It is traditionally practiced in the SADC region and is difficult to eradicate if alternatives are not offered. Households burn waste in the backyard when:

- *Collection service is lacking*
- *Collection serviced is implemented but household cannot pay the waste fee (low income areas)*

Informal dumps and roadsides: Where people burn the waste to get rid of it and to reduce the odors

Municipal dumpsites (non-sanitary landfills): Emissions of POPs are generated by waste picker activities.

Sanitary landfills; Normally sanitary landfills, do not show open burning activities although un-controlled scavenging activities have been observed.

3.1.2.3.2 Guidance to anthropogenic combustion in the SADC region

Awareness raising campaigns can reduce the burning activities at backyards, but alternatives must be offered to households that are not served by the collection service. Collection center for recyclables are a solution as they divert the recyclables from backyard (barrel) burning. House composters can assist to reduce the burning of kitchen waste.

Waste pickers' activities, need to be controlled by municipalities. Waste pickers can be organized, registered, given an identification card and PPE (Personal Protective Equipment) for a safer sorting of recyclables. The sorting of recyclables can be permitted to registered waste pickers only (see also Annex 1).

This practice has been implemented with success in some landfills and can be replicated in similar situations as costs are limited. Its adoption needs surveillance personnel at the entrance gate to control the access to the landfill and possibly the fencing of the landfill to avoid illegal intrusions. When the dumpsite has no gate and fencing, waste pickers control can be difficult to implement.

The example of Matsapha landfill (Eswatini)
The landfill has successfully implemented waste pickers control policies. Pickers are registered and given a card and PPE. Only registered waste pickers can enter the landfill. Trucks dump the waste only in the areas that have been indicated by management; waste pickers collect most of recyclable in that areas before the waste is finally disposed of by dozers. The sorted materials are taken away from the landfill to be sold to recyclers.

3.1.3 Strategies and policy instruments to avoid, reduce or divert waste

3.1.3.1 Source reduction

Careful study of local waste composition may lead to specific programmes for reduction of large volume streams. As an example, in certain cases bulk purchase of products can reduce the need for individual product packaging. This and other strategies may be modulated by population density.

3.1.3.1.1 Source reduction in the SADC region

Most of municipal solid waste generated is made of packaging (glass, plastics, paper, metals). So far, policies to reduce packaging of products at origin in the SADC region are hard to implement, considering that most goods are imported and come with their own package. Legislative tools have been prepared and issued in most of

countries in the region in the framework of general policies to reduce the waste generation and improve waste management, but the enforcement is challenging. Efforts have been done to reduce/ban the use of thin plastic bags (shoppers), which have been banned in some countries.

Reduction of waste at source can be achieved by implementing segregation of recyclables and composting.

3.1.3.2 Composting

Where significant fractions of household waste will biodegrade, and where the population density will allow it, municipalities should provide education on cost- and space-effective composting. Included in this strategy is appropriate diversion of organic waste to animal feed or other similar productive use, modulated by a concern for spread of disease. Education must include means for vermin and disease vector control. Some organic wastes may contain persistent organic pollutants or materials that could be converted to persistent organic pollutants under composting conditions, and they should be treated separately in order to guarantee high-quality compost with low content of such pollutants (EPA 2005). In some cases, composting can be enhanced by substitution of certain biodegradable materials for alternatives.

3.1.3.2.1 Composting in the SADC region

Composting activities are traditionally implemented at small scale in the households, that use kitchen waste as fertilizer for vegetable gardens. Activities at large scale are at a very early stage in the region as their economic sustainability can be challenging. Composting to produce fertilizers needs segregation of the organic material from other waste, which can only be achieved in a safe manner by doing it at source.

Organic materials shall be stored in separate containers and delivered to composting facilities in separate trucks or truck compartments. Only selected sources, such as vegetable markets and restaurants, can be expected to provide clean organic material to produce fertilizers. Garden trimmings and agricultural waste are good materials as well. Kitchen waste can be polluted by foreign substances such as solvents and pathogens and should not be used unless special education campaigns are carried out to reduce the risks of contamination.

Using kitchen waste as animal feed, traditionally implemented in some countries, is a very good alternative way to reduce/eliminate the organic material from the waste cycle.
The use of organic material as fertilizer in tree nurseries and flower- growing has been observed, and this may be more tolerant to sub-standard waste segregation, if these crops are not eaten.

Composting facilities
Composting facilities are made of:
- *A receiving area where the organic material is downloaded*
- *A shredding area, to shred bulky material such as branches from garden trimmings*
- *A composting area, where material is organized in windrows and left for maturation. Windrows are periodically revolved by a turning machine*
- *A screening area where the matured compost (fertilizer), is screened to get the finest particles*
- *A bagging area, where the fertilizer is put into bags for its final deliver to customers*

In situations where the content of organic material is high, deviating it from dumpsites can really benefit the waste management and improve hygienic and health condition at dumpsite. Segregation of organic material from MSW is much more effective if done at source. Once organic waste is mixed with other waste, its separation is challenging and expensive. If central composting is planned, households should be requested to use three different bins: one for recyclables, one for organic material and one for other waste. The increase of collection costs can be covered by the revenues from the sale of recyclables and fertilizers, but its economic sustainability should be carefully checked. The extra collection costs could be difficult to be justified in situation where content of recyclables is low compared to the content of organic material. A cost benefit analysis is recommended in the planning steps. Turning organic materials into compost needs investments in composting facilities. As alternative, vermiculture can be implemented to produce high quality compost. Organic material from vegetable markets, restaurants, garden trimmings and agricultural discards can be used to produce fertilizers. The use of compost as fertilizer in tree nursery, gardening and flowers-growing can be a solution for potentially contaminated kitchen waste. Tree nurseries in countries with high deforestation rates, offer the possibility of organizing a circular economy aimed at improving re-forestation activities. Costs could be covered by international programs on reduction of greenhouse gases and nature conservation.

3.1.3.3 Reuse

Where parts or entire devices can be recovered, washed, repaired or reclaimed as fabricated articles the need for disposal can be reduced. In many cases, involvement of labour in such reclamation and value creation can be more cost-effective and economically beneficial than the purchase of new devices.

3.1.3.3.1 Reuse in the SADC region

While the reuse of products and materials is widespread in the region, once they have become waste the reuse is quite limited. The most interesting practice is the use of kitchen waste for animal feed in some countries. Reuse of some materials like plastic and paper has also been observed, but quantities are small and do not significantly affect the waste cycle; waste pickers sort what is sellable in street markets in small quantities. Sometimes tyres are reused for making furniture or shoe soles.

Reuse of some e-waste is practiced in the region. Old computers can be refurbished by improving software and some components, but this practice needs to be carefully controlled as it has been misused as a way to bypass the Basel Convention on waste trading: E-waste such as discarded computers are exported from developed countries to Africa as second-hand items, but instead of being reused, they are dismantled to recover metals. What remains, more than 95%, ends in dumpsites or is abandoned in the environment.

Basel Convention
Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal have the overall obligation to ensure that transboundary movements of hazardous and other wastes are minimized and that any transboundary movements are conducted in a manner which will protect human health and the environment.

3.1.3.4 Recycling

Many waste streams contain valuable, reclaimable items. Metals, glass, clean dry paper, corrugated board, cloth, plastics and wood are recyclable streams. Depending on the situation, centralized collection and recycling infrastructure can be cost effective. In other situations, simply providing a safe staging area at a disposal site and encouraging the development of markets for recycled materials can facilitate recovery by waste pickers. This can greatly support employment creation, conservation of resources and poverty reduction strategies.

3.1.3.4.1 Recycling in the SADC region

Informal recycling of some materials; paper, plastics, metal, glass, is widespread in the region. Small private companies buy recyclable materials from individuals, junk shops and waste pickers, segregate and sell them to buyers. More organized and formal recycling activities to produce products are also found.

Materials sorted from municipal waste(PE, PVC, etc.) are separated at junk shops and sold to

- *Local recyclers (plastics) who grind and wash plastics and produce granules which are sold to factories as raw material for the production of plastic items such as home appliances. Sometimes local factories produce plastic products themselves;*
- *Foreign buyers: paper, metals, cans are just baled and sold to foreign buyers who process the materials to produce recycled products. In the SADC region, buyers are in South Africa.*

3.1.3.5 Incineration

In some situations, incineration using best available techniques, especially with energy recovery, and open burning may coexist. Where they do, incineration is preferable to open burning, but may not be the only alternative. Authorities must take care to understand specific local barriers to the elimination of open burning in favour of less environmentally burdensome disposal, including source reduction, reuse, recycling and incineration using best available techniques. Collection and cost may be one such barrier; however, incineration using best available techniques, when coupled with energy recovery, may mitigate that cost and provide significant energy benefit.

Medical (health-care) waste Incineration

Medical waste incineration involves the burning of waste produced by hospitals, veterinary facilities, and medical research facilities. These wastes include both infectious "red bag" medical wastes as well as non-infectious, general housekeeping wastes. Three main types of incinerators are used: controlled air, excess air, and rotary kiln. Of the incinerators installed , the majority are controlled air type.

Combustion of waste in controlled air incinerators occurs in two stages. In the first stage, waste is fed into the primary, or lower, combustion chamber, which is operated with less than the stoichiometric amount of air required for combustion. Combustion air enters the primary (starved-air) chamber from beneath the incinerator (below the burning bed of waste). In the primary chamber, the low air-to-fuel ratio dries and facilitates volatilization of the waste, and most of the residual carbon in the ash burns. At these conditions, combustion gas temperatures are relatively low (760 to 980°C).

In the second stage, excess air is added to the volatile gases formed in the primary chamber to complete combustion. Secondary (upper) chamber temperatures are higher than primary chamber temperatures-typically 980 °C to 1,095°. Additional heat is provided by auxiliary burners (after burners) located at the entrance to the secondary chamber to maintain desired temperatures and destroy POPs that are generated at low temperatures. Small incinerators are equipped with bag filters to reduce emission of particulate matter (fly ash and non-combusted particles).

3.1.3.5.1 Incineration in the SADC region

Incineration techniques in the SADC region are confined to medical and hazardous waste. Incineration of MSW, largely practiced in developed countries as a means to eliminate municipal waste, is not implemented because of the high investment and operation and maintenance costs. Medical waste, for its high content of pathogens, cannot be dumped to dumpsites if scavenging activities are present. Incineration of medical/hazardous waste takes place in small batch incinerators (about 100-200 kg/batch) located by the hospitals or by landfills.

Figure 1923 Medical waste incinerator

Sound operation and maintenance of medical waste incinerators (BEP):

The combustion of medical waste in incinerators, which should guarantee the proper elimination of toxic compounds generated during combustion, can turn onto a relevant source of POPs emissions when operation and maintenance are not properly conducted. POPs like dioxins and furans are generated at low temperatures during combustion and can be destroyed only by maintaining high temperatures within the combustion chamber for some time. Incinerators burning at low temperatures become generators of POPs. More information on the characteristics and operation of medical (health care) waste is given in Annex 3.

Figure 2024 Bad practice-loading an incinerator from front door

Best Available Techniques for medical waste incinerators (BAT)

The following Best Available Techniques for medical (health-care) waste incineration are available:

Gasification of waste (pyrolysis) used for small plants. A two chambers plants are normally used in batch operation;

Rotary kilns: used for larger plants where other hazardous waste are incinerated;
Grate incinerators adapted to medical waste: grate incinerators are normally used for MSW, but can be adapted to incinerate medical waste as well:
Fluidized beds: used for incineration of homogenous waste (medical waste shall be pre-treated);

Safe combustion of medical waste
The safe combustion of medical waste in small two chambers incinerators is achieved by keeping high temperatures (more than 900 °C) inside the furnace and in the core of the waste pile and keeping the temperature of the exhaust gas to more than 900 °C for more than 2 seconds before exit.
Some incinerators in the SADC region have shown lack of proper operation and maintenance. As a result, temperatures in the furnace are kept below the minimum requested for a safe combustion, the after-burner does not work or is kept off to save fuel, the waste feeding system is out of service and waste is loaded from front door. Periodic checks of operating conditions of incinerators should be planned together with control of combustion. Training of operators is crucial.

Alternative techniques to incinerators
Sterilization: waste is exposed to saturated steam in a pressurized autoclave
Microwave disinfection: disinfection occurs through the action of moist heat and steam generated by microwave energy;
Dry heat sterilization: medical waste is exposed to heat for a time sufficient to ensure sterilization
Chemical disinfection/sterilization: waste is treated with chemical agents which possess antimicrobial activity.

3.1.3.6 Modern landfill

Given the differences between modern engineered landfills and unorganized dumps, modern landfill construction with collection of gas and leachate, and appropriate opportunity for recycling and reuse, is preferable to open burning. As noted above, authorities will need to accept that education and cost-effective waste disposal options must be provided if open burning is to be eliminated.

Modern landfills differ from dumps in many ways. As engineered constructions, they are typically safer, more sanitary and less prone to anthropogenic combustion. They also require active management and security measures to exclude unauthorized people (e.g. waste pickers) and may be relatively more expensive than open burning or low-tech dumping.

Policies that prohibit disposal of hazardous industrial and infectious wastes in the normal waste stream will enhance the safety of the municipal disposal system. Governments can encourage effective use of alternative methods listed above by implementing legal restrictions on open burning; mandates for composting, recycling or recovery; taxes on excessive waste placed into the disposal system; or institution of lower-cost and more convenient resource management systems.

3.1.3.6.1 Modern landfill in the SADC region

Most of sites where municipalities dump their waste can be classified as un-controlled. Some dumpsites are organized with guards (one man at entrance who controls if incoming trucks are authorized to dump). Few modern (or sanitary) landfills are available in the region. A sanitary landfill has high investment costs as it must be constructed with waterproof clay layers at bottom, with a bottom HDPE liner, leachate extraction pipes, monitoring wells, etc. Additionally, it needs proper fencing, and an entrance gate equipped with a weighting bridge to control incoming waste. Municipalities in the SADC region are often not able to allocate the funds necessary for a sanitary landfill and rely on simpler and less costly dumpsites. The new strategies implemented in developed countries (4R policies) are supporting recovery and recycle of waste and have banned the landfills in favour of

policies to reduce the volumes of waste. In the long perspective, investing in the reduction of waste instead on sanitary landfills is therefore recommended.

Types of landfills/dumpsites

Sanitary (engineered) landfills are designed to reduce spreading of environmentally unsafe effluents, dust and emissions. They are normally found in presence of high volumes of waste to be disposed of, as the investment cost is high. A sanitary landfill is organized with waterproof layers of clay and with a HDPE liner in the bottom to protect the groundwater from leachate leaks. It is fenced, equipped with a weighting bridge at entrance gate and guardiancy. Burning of waste is prohibited; waste pickers are organized by the municipality. Leachate extraction and monitoring wells are also in place. Extraction of biogas is organized with venting pipes. Once full, the landfill is covered with soil and reclaimed for other uses (green areas, recreational purposes, etc.). Waste-to-energy activities (extraction of biogas to produce electricity) can be organized but are not present in the region because of the high investment costs and the need for a intensive operation of the landfill.

Landfills for industrial and hazardous waste: these landfills are like the sanitary ones, but safety measures are stricter as the dispersion to environment of the hazardous material results in more risks to health and environment. They are rarely observed in the region.

Municipal dumpsites: Dumpsites designated by municipality for dumping of waste are common in the region. Normally dumpsites are not fenced, sometimes they have a guard to control the activities. Waste is disposed of with no rules; the leachate that is generated pollutes the groundwater; open burning happens either because of the activity of waste pickers or due to spontaneous fires. Sometimes municipalities are forced by circumstances to deliberately burn the waste to reduce its volume and to extend the lifetime of the dumpsite.

3.1.4 Alternatives, barriers to use and policy instruments to remove barriers

Strategies for waste reduction and available alternatives to open burning are largely the same.

3.1.4.1 Alternatives, barriers to use and policy instruments to remove barriers in the SADC region

Barriers to a sound management of waste are the lack of fund, the traditional habits of the people who are used to burn the waste in the backyard and social issues such as poverty, which do not allow municipalities to proper tune the cost of collection with the waste fees. The new strategies implemented in developed countries (4R policy) oriented to recovery and recycle of waste have banned the landfills in favor minimization of the volumes of waste and reuse. Investing on the reduction of waste instead than on sanitary landfills is cheaper and is a better alternative. Incineration of MSW can be considered an alternative to landfills as well, but investment costs are much higher than recycling. Policies to encourage to reduce, reuse, recovery and recycle the waste should therefore be implemented at central and local level.

3.1.5 Burning techniques and attributes, and means of improvement

Where none of the previously mentioned alternatives are feasible or when alternatives cannot be implemented in a timely fashion, governments may wish to educate citizens on ways to reduce the impacts of open burning. Those process improvements have been outlined in the general guidance.

3.1.5.1 Burning techniques and attributes, and means of improvement in the SADC region

In the SADC region citizens refer to local government about management of waste, as it is traditionally considered a burden of the state and already included in the tax system and general welfare. Citizens are therefore not prone to pay fees and to directly support local authorities to reduce/recycle waste. Education campaigns are not

regularly implemented. Recycling activities take place in all involved SADC countries, partly conducted through informal structures, partly through recycling companies; they generate business and job opportunities. Potentials for the improvement of waste management by, inter alia, educating citizens to implement the 4R policy (reduce, reuse, recover, recycle) in the region are high. Education campaigns addressed to schools and to the sectors which generate waste such as households, commercial and institutional activities are crucial to successfully implement new improved waste management policies such as recycling and zero-waste.

3.2 Construction, demolition and post-disaster debris

3.2.1 Material composition

3.2.1.1 Construction waste

Construction waste will consist of the usual materials of construction and potentially the packaging in which the materials are brought to the site (e.g. pallets and sacks). Materials of construction of buildings vary by size, type and geographical location. Types of buildings, whether commercial, office, or residential, will differ significantly between developed and developing countries and among regions. Common combustible materials of construction include wood, paper and other cellulosic, asphalt, paint and various plastics. Metal contamination of combustibles is not unknown.

For commercial buildings the contents will be representative of the business and will include furnishings and fibre similar to those in dwellings, as well as electronics and volumes of paper (offices) or concentrations of products for sale.

3.2.1.1.1 Construction waste in the SADC region

Construction waste mainly consist of soil and inert matter and can commonly be seen abandoned along the roads and in informal dumps. It includes rubble, earth, rock and wood displaced during construction. Fibers and plastics are not frequently found in the region.

3.2.1.2 Demolition waste

Demolition waste, particularly post-disaster debris, will contain other occupant belongings. These materials also vary with the type of building, geography and development of the economy. Partially burned remains of a fire in an industrial operation may also qualify as post-disaster debris or hazardous waste.

For dwellings, this similarity will be to household waste, and will be greater in developing countries; in developed countries there will be a greater proportion of fabric (clothes), foam (furniture), rigid plastics (appliances) and fiber (carpeting*)*.

3.2.1.2.1 Demolition waste in the SADC region

Demolition waste includes rubble, earth, rock, wood, plastics, metals, paper and other foreign materials generated from the demolition of buildings, roads and other construction jobs. Demolition material is sorted to recover valuable materials (paper, wood, plastics). What remains is often seen burned/abandoned along roads and in informal dumps Post disaster waste needs to be managed according to nature of disaster (earthquake, flooding, etc.) its composition and volumes; there are no common rules. In developed countries, after a disaster such as an earthquake, due to the high volumes of debris, special landfills are set up to store non-recyclables materials. Recyclables are recovered. In the SADC region those policies are difficult to implement due to lack of funds and organization; often post disaster debris are left in the place.

3.2.2 Barriers to elimination; remedies or policy to remove barriers

Intentional combustion of waste derived from construction or demolition is a matter of low cost and convenience at the job site. It is done due to sanitary needs, the cost of removal, the inconvenience of on-site burial or unavailability of alternatives. While it is a poor practice and should be avoided under any but the worst circumstances regarding public health, the intentional combustion of post-disaster debris is known due to

unavailability of alternatives, desire to avoid massive use of landfill space or for convenience in clearing areas after earthquake (Nakao et al. 1997). The issue, nominally, is cost, whether expressed as direct cost or the cost of development or use of another disposal means.

3.2.2.1 Barriers to elimination; remedies or policy to remove barriers in the SADC region

Cost of transport and of disposal are the main barriers for a sound management of construction and demolition waste and often result in informal abandoning along roads and in informal dumpsites. The lack of control of the stream from origin of materials to destination is a barrier for a sound management of construction waste.

3.2.3 Strategies and policy instruments to avoid, reduce or divert waste

Clean, uncontaminated construction waste can be collected and sorted with usable materials diverted to other construction, shredding for mulch and material recycling. Demolition, when done as disassembly, can yield many fixtures suitable for resale and reuse. Materials from demolition that cannot be reused or reprocessed can be separated and disposed of, much as construction wastes.

While in theory the strategies used for treatment of construction and demolition waste can also be used for post-disaster debris, the scale can be enormously different. After a disaster there may be no choice but to move material to a landfill site, allowing scavenging as usual or conducting recovery operations there. Landfilling without scavenging or incineration using best available techniques may be the best options in an emergency, depending on exact circumstances.

Governments can, and some do, prohibit the open burning of construction and demolition debris. Where there is poor waste management infrastructure, many of the same instruments used in the recovery of household waste may be useful for construction and demolition materials.

3.2.3.1 Strategies and policy instruments to avoid, reduce or divert waste in the SADC region

Reuse of construction and demolition materials is practiced in the region. What is reusable is recovered from the waste, but abandoning is frequently observed. Abandoning of construction and demolition waste can be avoided by reusing the inert matter for buildings foundation or as bottom bed for road construction and similar, but needs a proper logistic to match offer and demand (for example special dumpsite for construction waste where waste is crushed and then sold as road bed, embankment material, etc.). Construction and demolition materials can be conveniently used to cover the waste at dumpsites, but some constraints such as transportation cost to landfill/dumpsite must be properly managed.

The introduction of "Green Building" policies aimed at reducing the volumes of discards from construction activities can be a remedy to reduce the amount of construction/demolition waste. This involves the preparation and implementation of guidelines on construction activities. Construction costs may increase but can be compensated by the reduction of transportation and disposal costs.

About post-disaster waste, its burning should be allowed only for materials which have no or low POPs emission factors (wood, not painted wooden materials), while e-waste and materials with chlorine content, such as PVC, painted wood, should be recovered and reused. What is left can be delivered to landfills (or buried if landfills are not available)

Typical construction and demolition materials and potentials for reuse are **(Terramanzi group (pty) LTD, 2015)**

- *Bricks and concrete used for clean-fill*
- *Timber salvaged for new structural or material use; timber waste ground into mulch or compost*
- *Crushed concrete used for road-base*
- *Plasterboard crushed for soil conditioner or manufacture of new plasterboard*
- *Steel, aluminum and other metals for reuse in the manufacture of new*
- *metal products*
- *Foam insulation and packaging for new insulation or soft structural forms*
- *Pallets for reuse*
- *Clean plastic for packaging new packaging materials*
- *Carpet and ceiling tiles may be taken back for reconditioning/recycling byv the manufacturer*
- *Light fixtures for cleaning and reuse*
- *Furniture for refurbishing and reuse*
- *Crushed tiles for paving or landscape decoration*

3.2.4 Alternatives, barriers to use and policy instruments to remove barriers

As outlined above, the alternatives for waste disposal on construction and demolition sites are collection, separation, disassembly, resale, reuse and recycling. These processes can be economically viable or can be made so by changes in laws or regulations governing disposal of these materials. Such instruments include bans on open burning, removal of taxes and other financial barriers on landfill disposal of construction and demolition material, or economic instruments promoting recycling or reuse. In many cases, the resale of building fixtures is encouraged and economically viable; this is particularly true in developing countries.

Additionally, contracts for construction can be written to specify removal of debris as a responsibility of the contractor. Acceptable means of disposal can also be specified by contract.

recovery of household waste may be useful for construction and demolition materials.

3.2.4.1 Alternatives, barriers to use and policy instruments to remove barriers in the SADC region

Barriers are the lack of legislation and the cost of transportation. Policies to control the disposal of construction waste need to be implemented. Construction companies can be committed to produce the evidence of disposal of waste (i.e. receipt from landfill). This policy is difficult to implement in un-organized, un-surveilled dumpsites that are not equipped with weighng bridge, as it would not be possible to get dumping certificates. Alternatively, only certified (by municipalities) collection companies could be qualified to collect construction waste and dump to dumpsites.

3.2.5 Burning techniques and attributes, and means of improvement

For these materials the same general guidance holds as outlined elsewhere in the document. Open burning should be a last resort and should actively exclude materials that do not burn well or at all.

4 Open burning of specific materials and miscellaneous

4.1 Agricultural plastic

4.1.1 Material composition

Agricultural film is usually made from polyethylene due to cost but ethylene-vinyl acetate copolymer (EVA) is also often used. PVC has been used previously but appears to be less common today. Among other uses, agricultural film is used for covering fields in early season to warm the ground; as bale wrap; as bags for silage, fertilizer or agricultural chemicals; and as greenhouse film. Some specialty suppliers offer material specified to be degradable, though this requirement is not universal.

Rigid plastic containers of pesticides or other agricultural chemicals may be found as well. Bags are usually low-density polyethylene; bottles, drums and tubs are usually high-density polyethylene, a multilayer polyethylene, or a polyethylene container whose interior surface has been treated to reduce interaction with the product contents. One report discusses experiments burning bags containing residual pesticide but finds PCDD/PCDF only "at very low levels", and blanks for both air emissions and solid residual (Oberacker et al. 1992). Following published procedures for rinsing containers and treating the rinse water properly will significantly reduce this already low possibility.

4.1.1.1 Material composition in the SADC region

The use of plastic film in agriculture (greenhouses, walk-in, low tunnels, etc.) in the SADC region is quite limited compared to other countries like China (about 20,000 ha for Africa against 1,300,000 ha in China ((E. ESPI and others, 2008). More than 80% of worldwide market is comprised of film made from LDPE (Low Density Poly-Ethylene), which has no chlorine content. Other material such as EVA(Ethylene-Vinyl-Acetate) and EBA (Ethylene-Butyl-Acrylate) are also chlorine free. The use of PVC (Poly-Vinyl Chloride), for which burning results in emissions of POPs, is very limited.

4.1.2 Barriers to elimination; remedies or policy to remove barriers

Material located far from normal waste collection will be discarded using the lowest-cost and most convenient method. Burning could be reduced by institution of a collection scheme for the material, particularly if many farmers in an area use the same material. Governments can also institute education programmes and laws prohibiting burning, supporting recycling and developing economic instruments to support such initiatives.

4.1.2.1 Barriers to elimination; remedies or policy to remove barriers in the SADC region

Lack of policies to deal with recovery of plastic film from agriculture is a barrier in the region. Plastic films are sometimes intercepted by informal recycling and delivered to recycling system. Plastic film can be recycled at end of its life; the film is not mixed with other materials but is contaminated with soil and needs to be washed before being recycled. Transportation costs can be relevant if recycling plants are distant from sources; recycling plants are not very widespread in the region and are concentrated in big cities; recycled plastic bales have to travel 500-700 km to reach recycling plants in South Africa.

4.1.3 Strategies and policy instruments to avoid, reduce or divert waste

Agricultural film is recycled extensively in some countries. This is facilitated when material is collected explicitly. Where there is no opportunity for recycling other forms of disposal are utilized, including landfill. Use of additives such as UV-inhibitors can extend the life of greenhouse films and reduce the need for disposal. In the absence of specific programmes, materials used for wrapping bales or bagging compost is discarded in the same way as any packaging in a particular area. In some areas, film can be recycled explicitly, compounded into wood-plastic composites or processed into refuse-derived fuel for combustion in an incinerator using best available techniques. For plastic bottles, the World Health Organization recommends triple-rinsing, then puncturing and burying them (Rosendaal 1997, ch. 10).

4.1.3.1 Strategies and policy instruments to avoid, reduce or divert in an the SADC region

As greenhouses and tunnels are concentrated in specific areas, collection from farms can be suitable with the economic constraints of recycling cycles. Establishment of recycling plants close to source areas can improve business possibilities. Recycling plants where plastic film can be converted into products can be encouraged. Inventories on the quantities of plastic film annually disposed of by farmers in the areas where use of plastic films is widespread can provide the data to evaluate the economic sustainability and the type of recycling plants needed. Plastic containers of pesticides should be separately collected by different collectors as they are classified as hazardous waste and need proper disposal (incineration). In case separate collection of plastic containers is not possible because of costs, farmers should be educated to not burn containers for pesticides. The use of plastic film as a fuel is normally not possible in the region due to the lack of furnaces/boiler that can safely burn it. Combustion in furnaces/boilers that are not properly equipped should be discouraged.

4.1.4 Alternatives, barriers to use and policy instruments to remove barriers

Strategies for waste reduction and available alternatives to open burning are largely congruent.

4.1.5 Burning techniques and attributes, and means of improvement

Agricultural film, while combustible, because of the way it has been manufactured, will tend to melt and shrink. Proper incineration could depend on shredding to increase surface-to-volume ratio or relatively slow feeding of material. High-temperature, well-ventilated combustion is possible, but may be challenging on a large scale if film is the only material burned.

Bottles may not burn well due to their surface-to-mass ratio even if dry and combustible. Alternative fuel may be required and should be material consistent with the general guidance.

4.1.5.1 Burning techniques and attributes, and means of improvement in the SADC region.

Plastic films should recycled if possible, not burned, while containers for pesticides should be burned in incinerators for hazardous waste. Burning should occur in large furnaces, where high temperatures can be easily kept and the heat generated can be usefully recovered. Plastic film is a good fuel, as it is derived from oil. Emissions of POPs are low if chlorine-free plastic is burned. PVC films should be recycled and not burned due to their chlorine contents that form uPOPs when burned. In case of combustion, it should be conducted in incinerators only.

Collection of containers for pesticides can be challenging in large areas because of transportation costs. Moreover, a fee for their incineration could be collected from producers/importers to cover collection and incineration costs. Policies to provide free collection and incineration could be implemented locally to ensure proper disposal. A good practice to minimize costs should be to ask farmers to store the containers in a safe place and call for the collection only when reasonable quantities of containers are available.

4.2 Tyres

4.2.1 Material composition

Tyres are a composite of styrene-butadiene copolymer or natural rubber, chloroprene, polyamide, steel wire, carbon black and numerous other organic and inorganic additives. Tyres contain low concentrations of chlorine; they also contain significant sulphur, similar to that of medium sulphur coal, as a result of vulcanization. Sulphur inhibits formation of persistent organic pollutants in combustion; the probability for generation of chlorinated persistent organic pollutants in this waste is probably lower than for mixed waste. However, poor combustion of large volumes of tyres in open burning situations is a source of PCDD/PCDF and will certainly be a prodigious generator of other hazardous pollutants, including SO_2 and polycyclic aromatic hydrocarbons.

4.2.2 Barriers to elimination; remedies or policy to remove barriers

Ignition of tyre fires can be natural (lightning) or anthropogenic. Tyre dumps present a number of hazards, including culture of insect disease vectors. Additionally, they occupy large spaces. Anthropogenic burning of tyres can and has been undertaken to alleviate either of these problems.

4.2.2.1 Barriers to elimination; remedies or policy to remove barriers in the SADC region

Problems with disposal of/recycle of tyres have been reported in the region. The tyre market in Africa has seen growth in demand and consumption, especially in the passenger car tyre segment. Replacement accounts for the majority share in tyre market and this trend is anticipated to continue. Un-recycled tyres are burned to recover the steel, causing a massive air pollution and emission of POPs. Tyre recycling industry is present in South Africa only. Lack of organized collection of worn tyres is a cause of their abandonment in the environment. Dumping at dumpsites can result in spontaneous ignition. Lack of legislative measures for a sound management of worn tyres favors their abandoning and burning. Recycling of tyres can be hindered by logistic factors like the absence of a local market for the products from recycling (fabric, steel and rubber), and by the distance of cement kilns that can use the tyres as fuel.

4.2.3 Strategies and policy instruments to avoid, reduce or divert waste

Worn tyres can be retreaded and reused in many cases. Modern technology has extended the life of the average tyre by a factor of ten over the past thirty years. Utilizing tyres with the longest life minimizes the need for disposal. Alternatively, they may be recycled to various uses, either whole or as shredded material. Whole, or preferably shredded, tyres can be landfilled. However, whole tyres and similar articles like uncrushed bottles may tend to float to the surface of a dump. Collection of tyres in above-ground dumps constitutes an eyesore and a hazard for insect control and potential for uncontrolled combustion.

4.2.3.1 Strategies and policy instruments to avoid, reduce or divert waste in the SADC region

Establishment of a mandatory consortium among dealers and producers for the collection and recycle of scrap tyres can improve the recovery and massively reduce the impact to environment. The consortium should be given the task of collecting for free worn tyres from the source (tyre repairers, gas stations, etc.). A small tax on the sale of new tyres can cover the costs of collection and recycling, The sale of the products from recycling as secondary materials to factories is also a means to cover the collection costs Recycled rubber from tyres can be used as mats for sport activities, can be mixed to asphalt for road paving and used to produce different products.

4.2.4 Alternatives, barriers to use and policy instruments to remove barriers

Waste tyres may be reused whole, shredded or cryoground into powder. Processed tyres may be used in rubber-modified asphalt for road surfacing materials. Shredded and ground tyres have also been compressed and used in building materials. Shredded tyres are used as a cushioning material for playgrounds. Additionally, tyres may be pressed into service as materials for fabrication of articles including fencing, reef creation, soil erosion control, sandals, doorstops and waste bins, recognizing that as a composite, thermoset material recycled rubber is subject to certain processing constraints. Use of whole tyres above ground must take into consideration and mitigate their tendency to collect water and harbor insect infestation.

If shredded and whole tyres are to be combusted in cement kilns, it must be done under proper combustion conditions and operation corresponding to best available techniques as described in section V.B of the present guidelines. Thus, kiln should meet the PCDD/PCDF performance level in air emissions associated with best available techniques (< 0.1 ng I-TEQ/Nm^3). Releases of chemicals listed in Annex C via cement kiln dust and possibly clinker have been reported, however, and are currently under further investigation.

4.2.3.1 Alternatives, barriers to use and policy instruments to remove barriers in the SADC region

The best techniques to recycle tyres are:

- *Shredding and separation of materials (rubber, steel, fabric) and recycling for asphalt, rugs and mats, furniture , etc.*

- *Pyrolysis, which involves the thermal degradation in the absence of oxygen to produce a gas (or liquid) that can be converted to fuel. Char and low-grade carbon black are the solid outputs from the process.*
- *Combustion in cement kilns to replace fossil fuels (both shredded and non-shredded tyres).*
- *Production of handicrafts such as shoes from rubber.*

Further inspiration for the management of tyres, from South Africa, is given in Annex 6.

4.2.5 Burning techniques and attributes, and means of improvement

Open burning of tyres results in the formation and release of chemicals listed in Annex C. As a mass or in dumps there is virtually no way in which the open burning of tyres can be improved; in addition, extinguishment of large-scale fires is almost impossible, and they may burn for years.

4.2.5.1 Burning techniques and attributes, and means of improvement in the SADC region

Scrap tyres can be conveniently used as fuel in cement kilns to replace traditional fossil fuels such as coal and fuel oil. Scrap tyres can be fed to the kiln either as whole tyre or as shredded rubber (fabrics and steel have been taken away). Emissions of dioxins are very low and comparable to the fuels that are replaced. The dumping in dumpsites should be banned to reduce the risks of combustion and proliferation of mosquitos.

4.3 Oil spills and gas flares

4.3.1 Material composition

Crude oil, natural gas and associated gas consist largely of carbon and hydrogen with smaller constituent amounts of oxygen, sulphur and chlorine. As found in nature, or as a result of recovery techniques, they may also contain salt or salt water. Particularly of concern is combustion of oil spilled on ground that contains salt or other chlorinated materials, or on seawater, or combustion of oil contaminated by intrusion of water into wells drilled near a saline body of water. Spilled oil from pipeline breaks has been burned to mitigate potential contamination of a frozen river (Kruglov, Amirova and Loshkina 1996).

The open burning of oil from off-shore facilities under certain circumstances may be a significant emission source. For accidental spills of oil, biological remediation methods may be useful in some circumstances.

4.3.2 Barriers to elimination; remedies or policy to remove barriers

Barriers to elimination include considerations related to cost, convenience and safety, and lack of alternative recovery or disposal methods.

4.3.2.1 Barriers to elimination; remedies or policy to remove barriers in the SADC region

Oil exploration and production activities are found in some countries of the SADC region; Angola, Madagascar, Tanzania, Mozambique, Zambia. Oil and gas fields are characterized by continuous burning of gases in flares. The gas to the flares is a non-homogeneous and non-stable mix of several different gases.

Emissions from oil/gas sector can be divided into two categories:
- *Emissions from extraction/production activities (gas flares)*
- *Emissions from accidents (oil spills fires) from both extraction and transportation activities.*

Elimination of gas flares can be implemented by installing flare gas recovery systems. Most modern refineries have been equipped with flare gas recovery equipment. Reluctancy of oil companies to invest in reduction of emissions from extraction and refining activities can be a barrier to reduction of flaring. However, implementation of emissions reduction measures can be required in the environmental permits of the companies.

Regarding accidents (oil spills), barriers are the costs of the safety measures implemented by oil companies. Low safety means higher risk of accidents. Reluctancy of oi/gas companies to provide data on accidents can be a barrier to implementation of safety measures

4.3.3 Strategies and policy instruments to avoid, reduce or divert waste

Gas flaring is common. To the extent that this is a waste issue and not one of recovery from accident, better procedures for handling materials or recovery for sale may improve normal performance.

4.3.3.1 Strategies and policy instruments to avoid, reduce or divert waste in the SADC region

The safety and reliability of the oil/gas extraction equipment can be tested by accessing to the records on accidental spills. An EIA (Environmental Impact Assessment) should be enacted for the oil and gas sector, with special reference to reduction of risks of accidents.

Technologies to eliminate gas flaring are available and mature. An inventory of the situation of flares in the countries that include refineries and oil/gas fields could produce the information necessary to quantify the amounts of pollutants emitted by flaring activities and identify the techniques to reduce them.

Regarding accidents, decisions on improvement of the safety should be based on the processing of the data of recorded accidents, from risk analysis and from the evaluation of the pollutants emitted and of the consequent effects to environment. Interventions should be focused to prevent and reduce as much as possible the risk of occurrence of accident that result in oil spills with consequent risk of ignition and negative effects on health and environment).

Prevention at marine oil/gas platforms should therefore be focused on:
- *Reduction of risks of accidents;*
- *Prevent spills from reaching the shores;*
- *Reduce the impact on marine life;*

The burning of oil from oil spills could be implemented, as it is a cheap and fast measure to reduce the effects on marine life but it results in emissions of pollutants to air.

5 Annexes relevant to the SADC region

5.1 Annex 1: Involvement and regulation of waste pickers's activities

The management of waste pickers has become a social issue in the SADC region. Preventing waste pickers from sorting and selling the valuables collected at dumpsite is at odds with poverty, famine and survival. Often it is tolerated that waste pickers burn the waste in the municipal dumpsite, despite laws and regulations that ban this practice. The day to day survival prevails over medium/long term health concerns, so health risks are neglected, resulting, over the years, in chronical diseases and other serious health disorders. The emissions of dangerous substances also affect people living in the neighboring areas. Waste pickers are also sometimes supported by a religious organization which defends their right to sort and burn waste as a mean to survive.

If formalized and well controlled, waste pickers can make significant positive contributions to recycling of valuable material in waste. In many countries they are major actors in the recycling of materials such as metals and plastics. In the SADC region, as other in other developing counties, there are positive experiences with involving waste pickers actively, and in a formalized manner, in the waste management chain. Such organization can include training in safer practices, avoidance of open burning, reduction of health hazard risks, etc. It can also involve making personal protection equipment (PPE) such as dust masks and gloves available to the waste pickers, thus directly leading to improved health among these workers. Involving and organizing waste pickers may also increase the waste pickers' income and thereby improving the livelihood of some of the poorest people of the population.

Unregulated waste picking is however among the most important causes of open waste burning. To avoid or minimize this, waste pickers' activities needs to be monitored and managed by the municipalities, including by issuing permits to waste pickers upon finalized training and only permitting registered waste pickers on the dumpsite. Sorting activities can be facilitated by the municipalities by organizing special sorting areas strictly forbidding waste burning. Waste pickers can be PPE (Personal Protective Equipment) for a safer sorting of recyclables.

The adoption of such initiatives may require fencing of the municipal dumpsites (also good for avoiding grazing animals) and the regular presence of surveillance personnel at the entrance gate and the dumping areas to control the access to the landfill and the activities taking place. If the dumpsite has no gate and fencing, waste pickers' control can be difficult to implement.

5.2 Annex 2: Fires at dumpsites

Two types of landfills fires are generally recognized on dumpsites: surface fires and deep-seated fires (smoldering). Surface fires typically occur in dumpsites that lack capacity to properly cover waste with inert matter. In landfills that do not cover their waste with soil or rubble, air intrusion provides the oxygen required for increased biological decomposition of organic material. This activity creates substantial heat and can cause material in the landfills to spontaneously ignite. In deeper layers, where conditions for the anaerobic process of organic material take place, methane gas is generated. Methane is lighter than air and moves to the surface, where it can generate spontaneous fires. Unchecked, spontaneous combustion fires tend to burn deeper into the waste mass, resulting in deep seated fires up to 5-6 meters deep quite difficult to extinguish. The use of water as extinguisher needs large quantities and results in production of leachate. Other extinguishers like CO2 and flame retardants, are more effective but more expensive and generally not available in the SADC region. Therefore, it is important to prevent the formation of conditions leading to fires, and to extinguish any fires as early as possible.

5.3 Annex 3: Operation of medical (health-care) waste incinerators

Medical waste incineration involves the burning of waste produced by hospitals, veterinary facilities, and medical research facilities. These wastes include both infectious "red bag" medical wastes as well as non-infectious, general housekeeping wastes. Three main types of incinerators are used: controlled air, excess air, and rotary kiln. Of the incinerators installed , the majority are controlled air type.

Combustion of waste in controlled air incinerators occurs in two stages. In the first stage, waste is fed into the primary, or lower, combustion chamber, which is operated with less than the stoichiometric amount of air required for combustion. Combustion air enters the primary (starved-air) chamber from beneath the incinerator (below the burning bed of waste). In the primary chamber, the low air-to-fuel ratio dries and facilitates volatilization of the waste, and most of the residual carbon in the ash burns. At these conditions, combustion gas temperatures are relatively low (760 to 980°C).

In the second stage, excess air is added to the volatile gases formed in the primary chamber to complete combustion. Secondary (upper) chamber temperatures are higher than primary chamber temperatures-typically 980 °C to 1,095°. Additional heat is provided by auxiliary burners (after burners) located at the entrance to the secondary chamber to maintain desired temperatures and destroy POPs that are generated at low temperatures. Small incinerators are equipped with bag filters to reduce emission of particulate matter (fly ash and non-combusted particles).

The incineration of medical waste in incinerators must be conducted by strictly following the operating instruction provided by manufacturers, with reference to:

- *Excess air: must be kept within the limits indicated by manufacturer: high excess air reduces the temperatures of furnace and exhausted gases; low excess air results in poor combustion and generation of carbon monoxide and risk of explosions and shall be kept in the primary chamber only;*
- *Combustion temperatures: medical waste must be input only when furnace has reached the working temperature stated by manufacturer. The combustion time must stick to what has been prescribed by manufacturer;*
- *Proper functioning of post combustor (afterburner) to destroy the POPs generated during the combustion. The post combustor must be kept operating and temperature gauges must be controlled to check that the prescribed by the manufacturer is reached;*
- *Periodic maintenance of burners, temperature gauges, feeding system and filters;*
- *Proper input of medical waste through the provided waste feeding device;*
- *Proper installation and functioning of APCs (Air Pollution Control Systems). Often small incinerators are equipped with a bag filter only. The filter must be periodically checked and cleaned. The fly ash generated from operation and cleaning must be properly managed (not dumped to dumpsite, unless in a confined area that is well protected and regularly covered with soil to prevent dust from spreading).*

5.4 Annex 4: WACS- Waste Analysis end Composition Study

A WACS allows municipality to better know the composition of the waste and manage it. It should be carried out at source for the different generation sources (households, commercials and institutional activities) and at dumpsites. The methodology envisages the following steps:

At source:

- *Select the sampling area and, within it, the number of households, commercials and institutions to be sampled .*
- *Organize sampling groups for each area.*
- *Collect the waste bins from each selected household/commercial/institution*

- *Segregate and weight the different types of waste (kitchen waste, paper, plastics, etc.) and organize the results in tables where each component of the waste is given its content.*

At dumpsite:

- *Download selected sample trucks; segregate and weight the different types of waste; organize the results in tables where each component of the waste is given its content*

5.5 Annex 5: Waste collection fee policies

Waste fee integrated in the general tax system: citizens do not pay a specific tax on waste, as it is included in the general tax system of the municipality (e.g.in the property tax). This system is efficient because there is no need to collect an extra tax. It also avoids discussions on tax fees, as it may be the understanding of the citizens that waste collection is the duty of the municipality and does not need payment of extra fees.
Pros: No burden to cash an extra tax for the municipality; waste collection becomes a social service and low-income people can benefit from it;
Cons: The tax collection system must be sound and have a basis relevant to the waste collection system (i.e. property tax linked to surface and number of people living in the house); if low income people do not pay taxes, they do not contribute to the payment for the waste collection services.

Waste fee is collected through the electricity and water bills: Electric and water utilities are asked to collect the waste fee together with payment of electricity/water bills. The system works when the majority of the households of the town is connected to electricity and water service. In non- connected areas, waste collection service is generally not provided. Less than expected incomes from this system have been reported by municipalities that do not exactly know how many households are connected to the grid (or water supply). Transparency is required from electricity/water companies;
Pros: The municipality outsource the fee collection service and the majority of households pay (due to their dependency on electricity/water), utility companies may take commission for the fee collection service, however;
Cons: Municipality does not exactly know how much the utility company is collecting; transparency tools are recommended; the system is not working in places where many households are not connected to grid/water supply;

Waste fee collected by municipality: The municipality can collect directly, going house by house, or collect by payment of monthly instalments. This system generates inefficiencies as many households do not pay, or delay the payments. In some countries citizens are taken to the court if do not pay the waste fee; it guarantees most of payments but is a burden for the social system.
Pros: Municipality can directly control the incomes and regulate the waste fee;
Cons; Some citizens do not pay or delay the payment of the fee, generating cash flow problems for the municipality.

Waste fee is directly collected by private collection companies: the appointed private collection companies are contracted by municipality directly collect the payment waste fees house by house according to the rule; no payment-no service.
The system is efficient as the company exactly knows who is paying and who is not but households that do not pay (and do not receive the service) use to burn the waste in the backyard or abandon it along the streets. Moreover, municipalities are not aware of the real situation (collection frequency, collected amounts) and are not able to manage the inefficiencies. If the dumpsite is far from the town, collection companies can illegally dump the waste in close areas to reduce transportation costs.
Pros: Direct control of payments by collection company; majority of households pay the fee; detailed records of households in the catching area;

Cons: No control on cash flow; no control on the quality of collection service; final destiny of waste generated by not payers result in open burning at backyards;

5.6 Annex 6: Management of tyres in South Africa

The South African tyre industry produces around 10 million - 200 000 metric tons – of used tyres each year (ref. 2016). Less than 5% are recycled. An estimated 60 million old tyres are today accumulating in the country's landfills. They are often stored informally or simply dumped somewhere. This unwanted waste represents a fire hazard and a considerable source of pollution because when it burns it emits POPs. These tyres are also a major threat to health since they help several species of mosquitoes to proliferate (Living circular , February 2016).

The Recycling and Economic Development Initiative of South Africa (REDISA) offers tyre manufacturers and importers the opportunity to pay and so delegate the collection and processing of their used tyres. This independent organization provides the necessary infrastructure to collect waste tyres across the country and distributes them to authorized recyclers; it supports initiatives to re-use (refurbish) or recycle used tyres. Specifically, the tyres are collected from storage places or in urban areas, and are taken to depots by transporters, stored and then transported to recyclers (living circular, February 2016). However, REDISA's model does not work anymore, as entrepreneurs are now giving priority to saving money and cutting costs, which results in decrease in jobs (Weibold, Feb. 20, 2018).

An example of tyre recycling as products: Sole Rebels' footwear is 100 percent made by hand using locally-sourced and recycled materials like old car tyres, discarded clothes and hand-loomed organic fabrics. It uses experienced and highly-skilled local craftsmen to transform these recycled products into world-class footwear products.
The eco-friendly brand of footwear now sells in more than 50 countries around the world, including the USA, Canada, Japan and Switzerland. A few years ago, Sole Rebels became the first footwear company in the world to be certified by the World Fair Trade Organization. By using local craftsmen, company has built a global brand and a hugely successful business that has created jobs and improved livelihoods in the local community.
Sole Rebels started in 2004 with less than $10,000 in capital. Today, the company has more than 100 employees and nearly 200 local raw material suppliers and has opened several standalone retail outlets in North America, Europe and Asia.

6 References

ASEAN Secretariat. 2003. *Guidelines for the Implementation of the ASEAN Policy on Zero Burning*. www.dec.org/pdf_docs/PNACU609.pdf.

Basel Convention Secretariat. 1994. *Technical Guidelines on Wastes Collected from Households*. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, UNEP, Geneva.

Canadian Centre for Pollution Prevention. 2006. *Great Lakes Trash and Open Burning Website*. www.c2p2online.com/main.php3?section=137&doc_id=289.

EPA (United States Environmental Protection Agency). 2005. *The Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States: The Year 2000 Update*. EPA/600/P-03/002A, Chapter 9. National Center for Environmental Assessment, Washington, D.C.

EPA (United States Environmental Protection Agency). 2006. *Backyard Burning.* www.epa.gov/msw/backyard/.

Government of New Zealand. 2006. *National Environmental Standards for Air Quality*. www.mfe.govt.nz/laws/standards/air-quality-standards.html.

Great Lakes Binational Toxics Strategy. 2004. *Strategy/Implementation Plan for Reducing the Prevalence of Household Garbage Burning (Barrel Burning) in Rural Areas of the Great Lakes*. Great Lakes Binational Toxics Strategy, Dioxins/Furans Workgroup, Burn Barrel Subgroup.

Gullett B.K. 2003. *PCDD/F from Uncontrolled Combustion*. First Session, Expert Group on Best Available Techniques and Best Environmental Practices.

Gullett B.K. and Touati A. 2002. "PCDD/F Emissions from Agricultural Field Burning." *Organohalogen Compd.* 56:135–138.

Gullett B.K. and Touati A. 2003. "PCDD/F Emissions from Forest Fire Simulations." *Atmospheric Environment* 37:803–813.

Hickman H.L. and Eldredge R.W. 2004. *A Brief History of Solid Waste Management in the US During the Last 50 Years.* www.forester.net/msw_0001_history.html.

Kruglov E.A., Amirova Z.K. and Loshkina E.A. 1996. "PCDDs and PCDFs in Snow Coat of an Industrial City as a Result of Oil Incineration at Accident Place." *Organohalogen Compd.* 28:228–231.

Lemieux P.M., Gullett B.K., Lutes C.C., Winterrowd C.K. and Winters D. 2003. "Variables Affecting Emissions of PCDD/F from Uncontrolled Combustion of Household Waste in Barrels." *J. Air & Waste Manage. Assoc.* 53:523–531.

Lemieux P.M., Lutes C.C. and Santoianni D. 2004. "Emissions of Organic Air Toxics from Open Burning: A Comprehensive Review." *Progress in Energy and Combustion Sci.* 30:1–32.

Lobert J., Keene W., Logan J. and Yevich R. 1999. "Global Chlorine Emissions from Biomass Burning: Reactive Chlorine Emissions Inventory." *J. Geophys. Res.* 104:8373–8389.

Nakao T., Aozasa O., Ohta S. and Miyata H. 1997. "Formation of Dioxin Analogues by Open Air Incineration of Waste Wood and Fire of Buildings and Houses Concerning to Hanshin Great Earthquake in Japan." *Organohalogen Compd.* 31:304–309.

Nussbaumer T. and Hasler P. 1998. *Emissions of PCDD/F from Biomass Combustion*. Biomass for Energy and Industry, 10th European Conference and Technology Exhibition.

Oberacker D.A., Lin P.C., Shaul G.M., Ferguson D.T., Engleman V.S., Jackson T.W., Chapman J.S., Evans J.D. and Martrano R.J. 1992. "Characterization of Emissions from Open Burning of Pesticide Bags." In: *ACS Symposium Series 510: Pesticide Waste Management.*

Rosendaal J.A. 1997. *Vector Control Methods for Use by Individuals and Communities*. World Health Organization, Geneva.

UNEP (United Nations Environment Programme). 2005. *Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases*. UNEP, Geneva. www.pops.int/documents/guidance/Toolkit_2005.pdf.