Women in Informal Employment Globalizing and Organizing

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Waste Incineration and Informal Livelihoods: A Technical Guide on Waste-to-Energy Initiatives

Jeroen IJgosse

WIEGO Technical Briefs

The global research-policy-action network Women in Informal Employment: Globalizing and Organizing (WIEGO) Technical Briefs provide guides for both specialized and nonspecialized audiences. These are designed to strengthen understanding and analysis of the situation of those working in the informal economy as well as of the policy environment and policy options.

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Cover photo: Waste pickers working at the Kpone Landfill in Tema, Ghana face the threat of losing access to waste for recycling. Photo: Dean Saffron

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Foreword

In the face of climate crisis, improving the final disposal of waste has become a major concern. Across the global South, cities are modernizing their municipal solid waste systems. In the search for efficient services, many opt to outsource waste management to big corporations and/or establish waste-to-energy initiatives such as incineration. Uncontrolled waste-to-energy technologies, however, generate high levels of pollution. In addition, there has been a shift from open or controlled dumps to sanitary landfills, which are considered more environmentally friendly.

These developments impact the livelihoods of waste pickers who play a critical role in municipal waste management and climate change mitigation. Existing assessments of waste-to-energy technologies focus on environmental impacts and provide guidelines on how to measure risks and economic feasibility. So far, very little attention has been paid to the impact on livelihoods.

In this publication, WIEGO aims to provide waste picker organizations, policymakers and practitioners with information about waste-to-energy initiatives. This is with a view to strengthen solid waste management models true to an inclusive circular economy. This includes zero waste strategies, waste minimization, reuse and reduction, and environmentally-friendly, decentralized technologies for disposal that are suited for local contexts and which include livelihood protection.

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Abbreviations

CAG — Comptroller Auditor General
CWG — Collaborative Working Group: solid waste management in low-and middle-income countries
EfW — Energy from Waste
EU — European Union
GAIA — Global Alliance for Incinerator Alternatives
GiZ — Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
ISWA — International Solid Waste Association
Ktpa — kilo ton per annum (year)
MJ — Meja Joules
MNES — Ministry of Non-Conventional Energy Sources (of India)
MSW — Municipal Solid Waste
MSWM — Municipal Solid Waste Management
MW — Megawatts
NGO — Non-Governmental Organization
USA — United States of America
WEC — World Energy Council
WtE — Waste-to-Energy

1. Introduction

The waste-to-energy (WtE) discussion is a recurrent topic around the world. The outcome of these discussions and the decisions made affect a large array of stakeholders, from politicians, civil servants and commerce, to neighbourhood communities and informal waste workers.

To be able to participate in and contribute to this discussion, it is important to understand the complexity of the different technologies, their impacts, and who is advocating for the technology. WtE can at times be portrayed as a simple solution to all of a municipality's waste and energy problems: those selling the technology continuously promote WtE projects as an answer to depleting fossil fuel resources, as a renewable energy source or an opportunity for acquiring carbon credits within the framework of greenhouse gas emission reduction. Local politicians might be tempted to believe that it is the easy option to consider when faced with open dumps that need to be closed while the amount of waste collected continues to rise.

The term "waste-to-energy" refers to a range of technologies that treat waste to recover energy in the form of heat, electricity or alternative fuels such as biogas. These technologies can be applied at different scales and with varying complexity: the production of cooking gas in household digesters from organic waste, collection of methane gas from landfills, thermal treatment of waste in large scale incineration plants at the municipal level (often referred to as utility size), and co-processing of refuse derived fuel in cement plants or gasification.

The main literature distinguishes five main types of WtE technologies, also commonly known as conversion technologies, used for treating (municipal) waste internationally: a) incineration, b) co-processing, c) anaerobic digestion, d) landfill gas collection e) pyrolysis and gasification. These five technologies are applied to different waste streams and have different functions and characteristics and will impact the livelihoods of informal waste workers in different ways. This technical brief will focus primarily[1] on the impact that incineration has on the livelihoods of informal waste workers.

This brief also looks specifically at the use of waste-to-energy systems in several countries in Europe. Significant changes in waste management policies in Europe have resulted in a scaling down of demand for incineration, which has led those companies selling WtE technology to shift their attention to developing economies, to sell facilities under the guise of development.

For those advocating for waste management alternatives that do not include incineration and who are supporting the active involvement of the informal waste sector, it is essential to understand how WtE initiatives have been implemented in industrialized countries and why they have failed in developing and in emerging economies. One recurring topic emphasized in the literature, and often overlooked by those advocating for WtE technology, are the framework conditions, which in most developing and emerging countries are essentially (structurally) different to those that have seen the rise of WtE projects in industrialized countries, where large waste-to-energy plants are an integral part of the waste management infrastructure.

This technical brief does not pretend to provide all the answers, but rather a brief and systematic overview of the impacts WtE initiatives and especially incineration (can) have. Further, it seeks to assist decision makers, advocates and representatives of the informal waste sector, non-government organizations, and community and neighbourhood organizations in assessing the limits and risks of the various WtE technologies for effective planning, efficient investments in waste management, as well as where to look for further support and insight.

[1] The other four technologies will be briefly described in the glossary.

Textbox 1: A brief guide on the key characteristics of incineration

Municipal solid waste incineration is the burning of mixed and (often) untreated waste from households, commerce (and certain) industries in a controlled process within a specific facility (called an incinerator) that has been designed and built for this purpose. Several (technical) key issues are crucial to understanding the impact of municipal solid waste (MSW) incineration systems.

First, the primary goal of incineration is to reduce the volume and mass of MSW. Although a reduction in volume and a mass of 75 per cent can normally be achieved, it is the remaining 25 per cent left over that is of concern and requires specialized attention. The left-over ashes in the form of slag (bottom ash) and fly ash require further treatment. This is especially true in the case of hazardous (toxic) fly ash, which are fine particulates in exhaust gases created during incineration that must be removed from the gases vented through the plant's chimneys to avoid air pollution. One option for fly ash is to collect it in a sanitary landfill with secure cells appropriate for hazardous substances, although these are often not available in developing economies.

Secondly, the combustion (burning) of waste generates energy and heat, but the waste does not burn by itself. The combustible materials in waste only burn when they reach a specific temperature (the necessary ignition temperature) and come into contact with oxygen — thus undergoing an oxidation reaction. This (so-called) reaction temperature is between 850 and 1450ºC. The combustion process takes place in the gas and solid phase, simultaneously releasing heat energy. Waste materials require a minimum calorific value (energy content, or how well it burns) to enable a thermal chain reaction and self-supporting combustion (so-called autothermic combustion). If this minimum value is not met, additional fuels are required to initiate (and continue) the incineration process. This means that there should be a continuous and large supply (feedstock) of waste to be burned and this feedstock should have enough materials with high calorific values (i.e. paper, cardboard, plastics and textile content). If this is not guaranteed on a permanent and long-term basis, the additional fuel consumption will lead to (unforeseen) high operational costs to avoid the ovens having to be shut down.

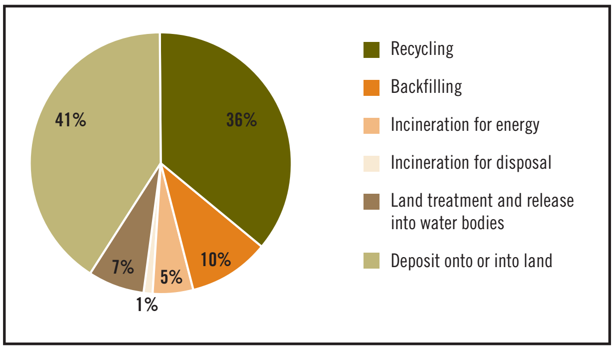
Thirdly, although energy and heat are generated during the burning process, converting that into electricity and thermal power depends largely on how efficient the selected technology is. The demand for the electricity and the thermal power will have significant influence on the revenues generated.

2. Development of waste-to-energy initiatives

The first incineration plants were built at the end of the 19th century in Europe, and there was an important increase in their use after 1960 in highly industrialized European countries. The main driver for using incineration was to control diseases (typhus and cholera) and to reduce the volume and mass of waste generated in the fast-growing urban areas, especially in those countries where finding new sites for (sanitary) landfills in densely populated (urban) areas proved more difficult.

In 2012, there were over 1,200 WtE plants in operation in more than 40 countries (ISWA 2012), which would also include plants with landfill gas recovery facilities, anaerobic digestion plants and plants using pyrolysis or gasification technology. Of the estimated 122 million metric tons of waste incinerated worldwide in 2016 (WEC 2016), over 99 per cent was treated in high-income countries in Europe, but also in Japan and the United States of America.

Figure 1: Waste treatment methods used in 28 European Union member states in 2014



Source: Eurostat (accessed May 2019)

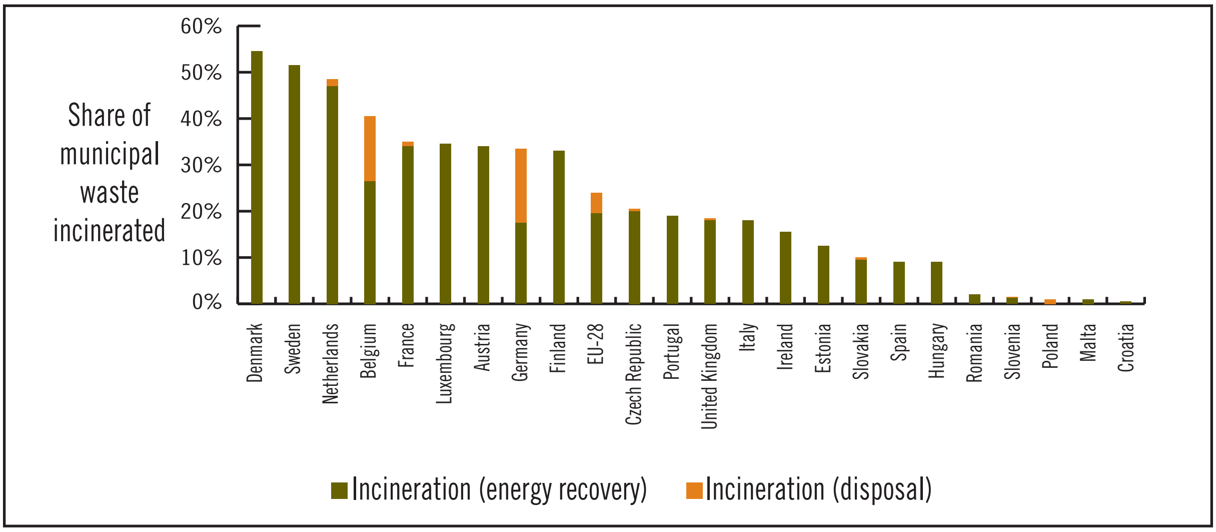
Although there are 400 incinerators in Europe, incinerating only plays a minor role. Figure 1 shows the main waste treatment methods used in 2014 for treating the approximate 2.6 billion metric tons of waste generated in the 28 EU member states. Final disposal (48 per cent) and recycling (36 per cent) remain the main two methods used, while other forms of recovery (10 per cent for backfilling) and incineration (6 per cent) play a secondary role.

All EU member states have developed systems to comply with the objectives of the EU waste policy (Waste Framework Directive) and the waste (management) hierarchy, which favours (in order of preference) prevention, reuse and recycling over incineration with energy recovery — leaving landfilling or incineration without energy recovery as a last resort. Six countries[2] have developed a system built on comprehensive waste collection systems in which less than 5 per cent of their waste goes to the landfill. In order to accomplish this, all these countries have well-developed recycling systems based on separation-at-source collection, generation of green jobs, and adequate treatment capacity (including for biodegradable waste), and they mix legal, administrative and economic instruments to good effect in their waste management policies.

An example of these instruments in practice is the EU's target for municipal waste: by the year 2030, 65 per cent of all municipal waste needs to be reused or recycled, with a maximum of 10 per cent to be landfilled. Only the remainder can be considered for incineration for energy recovery. This 65 per cent target forms part of the new vision for the circular economy implemented in all the member states, and this mandate has led to a significant reduction in incineration. It shows clearly that, as the management systems develop over time and public health and environmental concerns are overcome, the primary focus remains on material recovery through recycling options and creation of green jobs through recycling and reuse. Energy recovery driven technology initiatives only remain a secondary option and can only function within waste management systems that are mature enough to receive and accommodate them. In the Netherlands, for instance, WtE facilities are only planned and licenced to receive waste that cannot be recycled (technically) or in a currently economically feasible manner.

[2] Austria (AT), Belgium (BE), Denmark (DK), Germany (DE), the Netherlands (NL) and Sweden (SE).

Figure 2: Percentage of municipal waste incinerated in 28 European Union member states in 2012



Source: Eurostat (accessed May 2019)

These policy developments have an impact in Europe, but also affect those companies that manufacture, implement and operate WtE technologies. As the European demand for incineration scales down, the market for selling WtE technology becomes saturated in Europe, especially in those countries where incineration plays an important role, such as Denmark, Sweden and the Netherlands (see Figure 2). As such, a new driver emerges, the free market driver, where WtE technology companies move away from Europe in search of countries where legislation standards and waste management policy targets are less restrictive (or even non-existent) — and where the informal waste sector, which often plays a pivotal role at both municipal and national levels, can become an inconvenient obstacle to their goal.

As a result, it has become important for stakeholders in the cities in these emerging economies to better understand the details of WtE technologies and see beyond the “magic wand” promises of making the waste disappear and providing “free” energy in return. There is also a desire to grasp the impacts WtE technology can have on the environment, economy and livelihoods of the urban (and rural) areas receiving them, and also to understand what alternatives to WtE can be explored to address the continuing growth of solid waste in urban settings.

However, it is precisely because WtE companies have shifted to countries where the informal waste sector has significant presence that advocates of the informal sector need to proceed with caution. Those who seek to safeguard the informal sector’s interests should be prepared to understand the vantage point of those who sit on the other side of the table and who seek to promote and sell WtE technologies. This is a necessary step in order to help the public understand the implications behind the “dumping” of WtE technologies in developing countries. An article published in the July 2018 edition of Energy Source (Smith 2018) illustrates the rationale behind the “dumping” of WtE technologies as it discusses the growing opportunities that exist across Africa for the development of WtE facilities and what needs to be done by the public sector to make such projects deliverable and, more relevantly, financially feasible. It highlights issues such as:

> “a) the more favourable regulatory environment in African countries towards thermal treatment of waste (compared, for example, to the EU which has focused on waste reduction); b) The reality is that many Energy from Waste (EfW) facilities are not currently affordable or bankable, as they are based entirely on the revenues from the sale of the power generated (regardless of whether the facility also produces heat). This is largely due to the cost of electricity produced in this manner being higher than the cost of producing electricity using other technologies; c) Most large-scale, successful EfW projects have relied heavily on the revenue arising from their waste disposal activities,

typically charged based on a "gate fee" or "tipping fee" per metric tonne of waste. These fees will also be payable by the relevant municipal authority responsible for the disposal of waste; and d) The legal frameworks across several African countries are also still developing and do not have the same standard of transparency and rule of law as in developed countries. This means less certainty to funders and other parties involved with respect to any conflicts."

Textbox 2: Developments in waste-to-energy projects in emerging economies

China: The Chinese government has set a target of disposing nearly a third of the country's waste with waste-to-energy plants by 2030 and numerous plants are in the process of being constructed. Currently, 28 WtE plants are operating in China using CFB[3] technology, the largest (built in 2012) processes 800 metric tons of waste/day. Vendors of Chinese WtE technology have also expanded their horizons to include international markets (WEC 2016).

India: Driven by international programmes such as Cleaner Development Mechanism, more than 30 WtE projects have asked for funding since 2012, with mixed success (Chintan 2012).

Singapore: Tuas South Incineration Plant, Singapore processes 3,000 metric tons/day of mixed MSW (NEA 2018).

Thailand: In 1999, the country´s first WtE plant began its municipal solid waste disposal service for 18 localities in Phuket Province with a 250 metric tons/day capacity, generating 2.5 MW[4] of electricity (Vanapruk 2011).

United Arab Emirates: Construction for the first WtE facility in the United Arab Emirates started in 2017. The expectation is that, by 2020, it will receive approximately 300,000 metric tons of MSW a year and convert it into 30 MW of power (Ramboll 2017).

Ethiopia, Ghana, Kenya, Uganda, Senegal, South Africa and Zambia: different proposals and projects ranging from a 1,400 metric ton/day incinerator plant in Ethiopia, implemented in 2017, to a proposal for a landfill gas recovery project in Johannesburg, to the Ketu Ikosi Biogas Project in Lagos, Nigeria (Smith 2018).

[3] CFB — circulating fluidized bed technology.

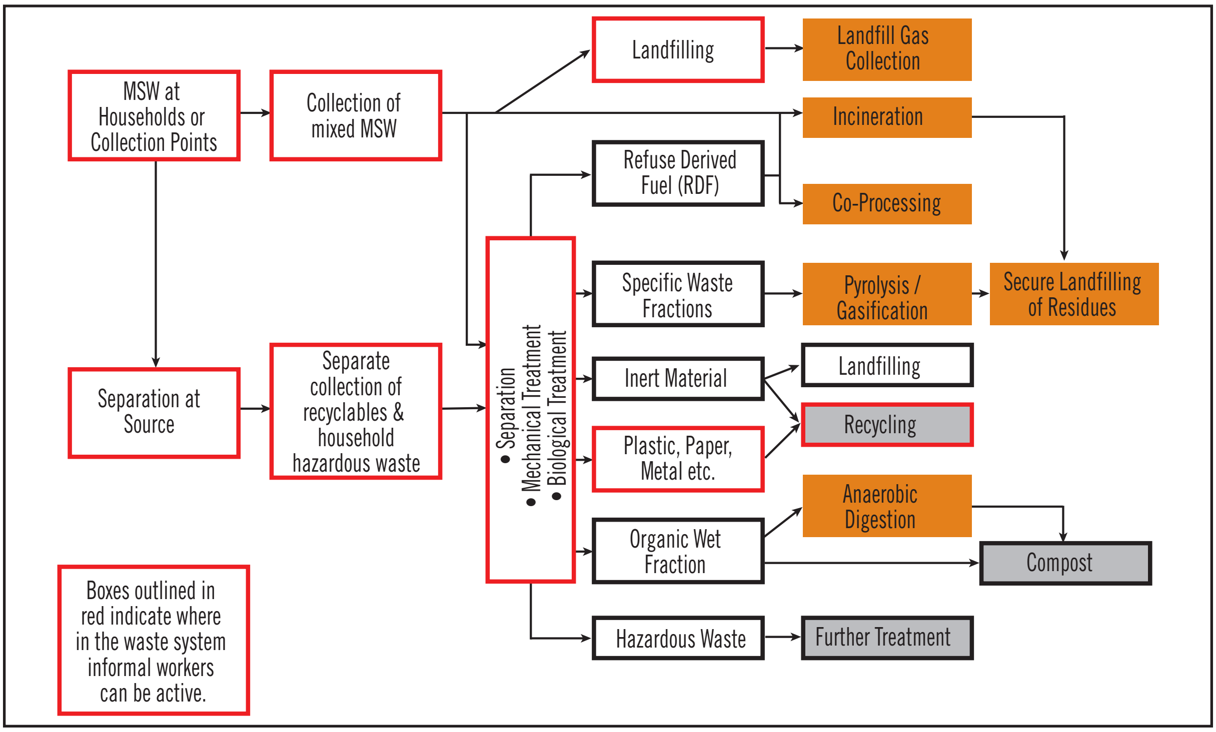
[4] MW = megawatts

3. Conflict between informal waste sector activities and waste-to-energy initiatives

To understand where conflict arises between WtE technology and the informal waste sector, it is essential to know how much, what type, and where waste is generated. The activities of the informal waste sector are concentrated mainly in the recycling chain, also known as the value-added chain.[5] There is, however, significant overlap in the materials the informal recycling sector collects and those sought for WtE initiatives. This section gives an overview of those materials, how the informal waste sector and WtE technology treat these, and where these two systems overlap.

To start, Figure 3 gives an overview of the different treatment options available for a municipal waste system and the parts or locations in the waste system where the informal waste sector can participate.

Figure 3: Overview of municipal solid waste treatment options



Source: Adapted from Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH —GiZ (2017)

As noted in Figure 3, the spaces where the informal waste sector can work, and the types of materials that have value, are quite specific. It involves the recovery of recyclable materials from the waste stream and selling them directly to the recycling industry or through intermediaries. For WtE technology, the process is much different.

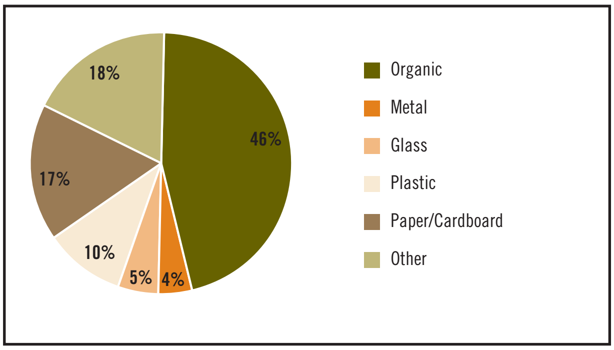
When considering or discarding WtE technology as an alternative, a key factor that should be analyzed is the nature (composition) and volume of the waste stream. A key parameter is the energy content of the waste (that is, how well it burns). This is called the lower calorific value (LCV) and is measured in Mega Joules/kg (MJ/kg). If the average LCV of the waste burned in an incinerator is below 7 MJ/kg over a one-year period,[6] then it should be discarded as an option.

[5] However, over the last few decades, there has also been a transition to the service chain where, in a number of countries, the (organized) informal waste sector is hired as service providers in municipal recycling systems (Bogota and more than 10 other cities in Colombia; Belo Horizonte and Itaúna, Brazil; Pune, India; Buenos Aires, Argentina).

[6] For comparison: The LCV of 1 kg fuel oil is about 40 MJ/kg.

Figure 4 illustrates the average composition of solid waste worldwide.[7] Almost 46 per cent is organic, 36 per cent is potentially recyclable, and the remaining 18 per cent is composed of other types of materials (including ashes, diapers, ceramics and stone). Here, the "dry fraction" together with the "wet fraction" (mainly organics) constitute the main components of municipal solid waste. However, the relationship between fractions of waste with a high calorific value (such as paper, cardboard and textiles — as seen in Table 1 below) and those with a low calorific value (such as organics, metal and glass) is important. The organic fraction is more difficult to burn because of high moisture content, and even more so during rainy seasons when precipitation in tropical countries can be very high, especially when the waste management system is based on open waste containers and the collection is carried out in open vehicles. The lack of separation-at-source collection systems is often cited as one of the reasons for the failure of WtE facilities.

Figure 4: Composition of Global MSW



Source: Hoornweg and Bhada-Tata (2012)

Table 1: Approximate calorific value for common municipal solid waste fractions and relation with informal waste sector interests

Fraction	Approximate calorific value [MJ/kg]	Relation with informal waste sector
Paper / cardboard	16	Potential opposing interest
Organic material	4	No conflict
Plastics	35	Potential opposing interest
Glass	0	No conflict
Metals	0	No conflict
Textiles	19	Potential opposing interest
Other material	11	No conflict
Minimum recommended average lower calorific value for incineration	7	

Source: Adapted from International Solid Waste Association — ISWA (2012)

At the same time, the organic fraction in developing economies is often higher (as much as 60 per cent) and has a significantly higher water content than in industrialized economies where increased consumerism has led to a higher presence of packaging material from consumer goods (plastics, cardboard and paper). This means there is more organic waste to be treated in developing countries, which, at the time of collection, is often mixed with the other fractions.

Table 2 gives an example of the relative contribution plastics, paper and cardboard make to the heat content of MSW in Buenos Aires, Argentina. Using average MSW composition data from the period 2005-2008, it can be seen that these three materials account for 72 per cent of the heat content found in MSW in Buenos Aires. Without any of these materials, the calorific value of the MSW would be well below the threshold minimum of 7 MJ/kg. So even in this case, with the organic component being relatively low (40 per cent) in comparison to combined 32.5 per cent combined for plastics, paper and cardboard, the dependence on the latter three is still significant.

[7] Specific waste products deriving from construction and industrial and commercial waste are not included in this figure, but in some cases can represent most of a region's waste production.

Table 2: Heat content of municipal solid waste in Buenos Aires (2005-2008)

Components	Average % in weight 2005-2008 (A)	Approximate calorific value of component (MJ/kg) (B)	Heat content (MJ/kg) C = A*B	Relative contribution to heat content
Paper and cardboard	16.6	16	2.7	23%
Plastics	15.9	35	5.6	49%
Glass	5.6	0	0.0	0%
Ferrous metals	1.3	0	0.0	0%
Non-ferrous metals	0.4	0	0.0	0%
Textiles	3.5	19	0.7	6%
Wood	1.4	11	0.1	1%
Leather, rubber and cork	1.1	11	0.1	1%
Disposable diapers	4.2	11	0.5	4%
Construction and demolition waste	1.7	0	0.0	0%
Yard waste	4.1	4	0.2	1%
Hazardous waste	0.5	11	0.1	0%
Medical waste	0.4	11	0.0	0%
Food waste	39.5	4	1.6	14%
Miscellaneous fines (<12.7 mm)	3.6	0	0.0	0%
Total			**11.6**	**99%**
Total heat content without plastic			**6**	
Total heat content without plastic, paper and cardboard			**3.3**	

Source: Instituto de Ingeniería Sanitaria Facultad de Ingeniería Universidad de Buenos Aires – CEAMSE (2010)

Because of the low calorific value of organic matter, and the presence of ash, sand, dust and other inert matter in the mixed waste, these fractions alone would not serve as viable feedstock for any incinerator. The fractions with the higher calorific value (plastics, paper, cardboard and textiles) would be needed to compensate in order to even come close to the minimum threshold of 7 MJ/kg. Without these fractions, the viability of any potential MSW incineration facility would be at risk because the overall calorific value would be too low for combustion without the constant supply of auxiliary fuel. Textbox 3 provides an example of a WtE plant failure due to poor-quality calorific supply of feedstock.

Textbox 3: Waste-to-energy plant failure in Delhi, India

Timarpur Incinerator; Delhi, India:

> "In 1987, the Ministry of Non-Conventional Energy Sources (MNES) commissioned the Timarpur Refuse Incineration-cum-Power Generation Station at a capital cost of Rs. 20 crores (US$ 4.4 million). Built by Volund Miljotecknik Ltd. of Denmark, the plant was designed to incinerate 300 metric tons of municipal solid waste (MSW) per day to generate 3.75 MW of electricity. The plant ran for 21 days of trial operations before shutting down due to the poor quality of incoming waste. It required waste with a net calorific value of at least 1462.5 kcal/kg, but the calorific value of the supplied waste was in the range of 600-700 kcal/kg. Plant operators tried to supplement the combustion with diesel fuel, but were unsuccessful.
>
> Following this failure, the Delhi High Court ordered an enquiry by the Comptroller Auditor General (CAG). In its findings, submitted in its annual report dated March 1990, the CAG observed that, 'The Refuse Incinerator-cum-Power Generation Plant installed by Ministry of Non-Conventional Energy Sources in March 1985 remained inoperative since its installation. The Ministry failed to utilise or dispose of the inoperative plant and incurred an expenditure of Rs 1.25 crore (US$ 278,000) on maintenance and insurance of the plant.' The project was officially scrapped in July 1990."

Source: Shah (2011)

To bring this back to how the WtE process intersects with the informal waste sector, it should be noted that, in the informal waste sector, the main recyclable materials handled and commercialized are plastics, metals, glass, paper and cardboard, and, to a certain degree, textiles. In concrete terms, this means that if fractions that otherwise would be recovered and commercialized by the informal waste sector are diverted directly to the incineration facility, the informal waste workers would not have access to these materials and would lose their access to income. Therefore, the argument is that it is crucial to make decisions based on an integrated municipal solid waste management plan which is supported by a material flow analysis and which respects the concept of the waste hierarchy.

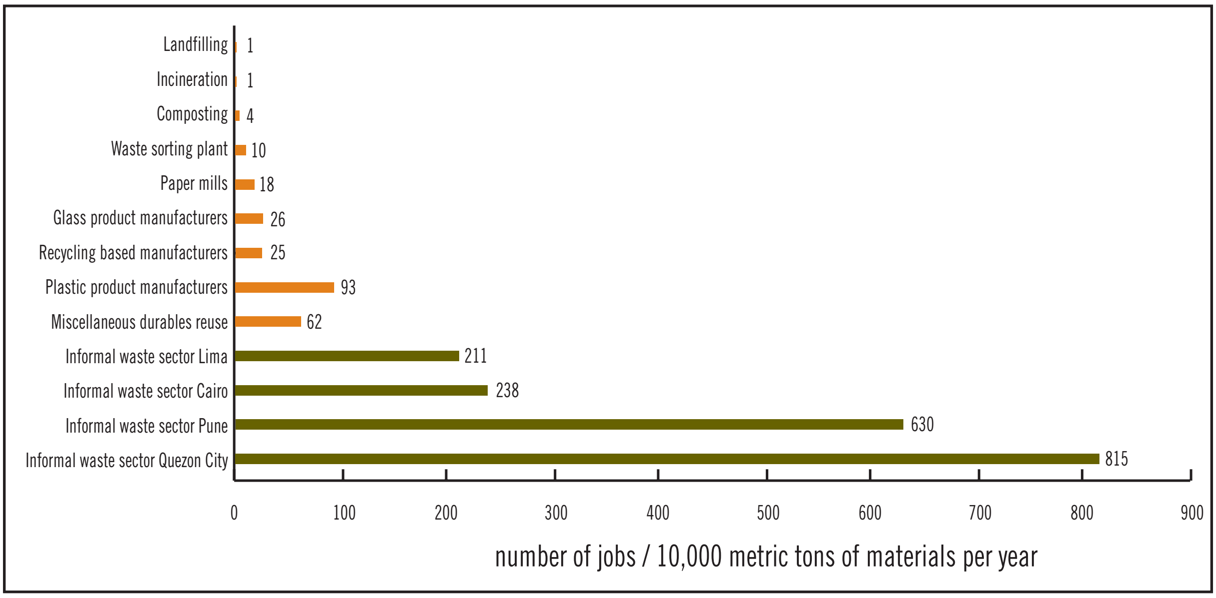
In the next section, this brief will dig deeper into how WtE has impacted livelihoods and the environment when established as part of municipal solid waste management (MSWM) plans in local communities.

4. Potential impact of incinerators on the livelihoods of informal waste workers

4.1. Job creation versus loss

Incinerators use capital intensive technologies that generate limited jobs, especially when compared to other waste management activities, both in industrialized and emerging economies. In emerging economies, where the active informal sector plays a vital role in the recovery of recyclable materials, incinerators not only generate few jobs, they also directly threaten the livelihoods of thousands working in the recovery and processing of recyclables. Figure 5 shows how, in selected cities, labour-intensive informal waste activities generated 10-40 times more jobs than similar recycling activities in an industrialized country.

Figure 5: Jobs per 10,000 metric tons of material per year (based on Institute for Local Self-Reliance 1997 and UN-Habitat 2010)



Source: Linzer and Lange (2013)

In the USA, in 2018, recycling activities generated 10 to 20 times more jobs than incinerators (Table 3), which has been one of the driving forces for promoting green jobs at the national level.

Table 3: Job production factors by material and management activity in the United States of America (Jobs per 1,000 metric tons)

Materials	Diverted Waste (Jobs per 1,000 metric tons)				Disposed Waste (Jobs per 1,000 metric tons)			
	Collection 2008	Collection 2030	Processing	Manufacturing	Reuse/ Remanufacture	Collection	Landfill	Incineration
Paper & Paperboard	1.67	1.23	2	4.16	Not Available (N/A)	0.56	0.1	0.1
Glass	1.67	1.23	2	7.85	7.35	0.56	0.1	0.1
Metals								
Ferrous	1.67	1.23	2	4.12	20	0.56	0.1	0.1
Aluminium	1.67	1.23	2	17.63	20	0.56	0.1	0.1
Other Nonferrous	1.67	1.23	2	17.63	20	0.56	0.1	0.1
Plastics	1.67	1.23	2	10.3	20	0.56	0.1	0.1
Rubber & Leather	1.67	1.23	2	9.24	7.35	0.56	0.1	0.1
Textiles	1.67	1.23	2	2.5	7.35	0.56	0.1	0.1
Wood	1.67	1.23	2	2.8	2.8	0.56	0.1	0.1
Other	1.67	1.23	2	2.5	N/A	0.56	0.1	0.1
Other Wastes								
Food Scraps	1.67	1.23	0.5	N/A	N/A	0.56	0.1	0.1
Yard Trimmings	1.67	1.23	0.5	N/A	N/A	0.56	0.1	0.1
Misc. Inorganic Wastes	1.67	1.23	0.5	N/A	N/A	0.56	0.1	0.1

Source: Goldstein and Electris (2011)

In Europe, the increased policy focus on recovery of materials and recycling since the year 2000 has seen the overall employment related to this activity increase from 177,000 in 2000 to 301,000 in 2007, not including separation-at-source collection activities (Fischer et al 2011).

Overall, the presence of incineration plants in emerging economies has resulted in several issues:

a) waste policy definition and planning activities did not consider the (large scale) presence of the informal waste sector in urban centres;
b) the diversion of recyclables to the incinerator led to a loss of income for the informal waste sector;
c) waste collection contracts are based on metric tons delivered to the WtE, which does not favour recycling;
d) long term high gate fees are required to make the operation financially sustainable, placing a burden on municipal finances and leading to sharp increases in user fees.

Textbox 4 highlights two such examples from India and Ethiopia.

Textbox 4: Impacts of waste-to-energy on the informal waste sector in India and Ethiopia

Okhla, Delhi, India: In January 2012, a WtE facility began operations in Sukhdev Vihar, near the Okhla Landfill in Delhi. Subsequently, 1,300 metric tons of waste that formerly was dumped at the landfill every day now went to the feedstock supply fuelling the incinerator. Chintan Environmental Research and Action Group conducted a survey on the landfill to assess the impact the incinerator had on the livelihoods of those (formerly) working on the landfill. At the time of the survey, 300 of the 450 individuals active at the landfill were no longer working there. The key findings presented in the report were a) significant drop in the populations of communities dependent on the income generated on the landfill; b) a drastic decrease in income for the waste pickers; and c) reduced consumption of meat and fish.

References: Chintan Environmental Research and Action Group (2012); Demaria et al. (2012)

Reppie waste-to-energy plant, Addis Ababa, Ethiopia: in 2017, a 50MW WtE plant started processing the MSW generated in the capital Addis Ababa, Ethiopia. The project is being implemented by a consortium comprised of Cambridge Industries Ltd. and its partners: China National Electric Engineering Co. and Ramboll of Denmark. The 118-million-dollar project will convert 350,000 metric tons of solid waste into electricity annually, supplying 30 per cent of household energy needs. Proclaimed as the first WtE facility in Africa, the project received international coverage because of the 100 deaths suffered as a result of a landslide on the adjacent landfill site. One internationally published article (see reference below) of 2018 — one of many similar articles written about the event — focuses extensively on technical, financial, environmental and institutional challenges faced by the City Cleansing Management Office of Addis Ababa in operating the facility. However, no mention is made of the informal sector: not if and how they were involved in the planning stage and also in how they were affected by the operation of the WtE facility.

Reference: Abebe 2018

4.2. Investment and operation costs

Incinerators are capital intensive, both in investment and operation. The World Energy Council reports that, for 2016, investment costs ranged from 300 to 900 USD$ per metric ton of capacity (Table 4), depending on the size of the plant and the technology applied. Gasification technologies are usually more expensive than the usual grate combustion technologies. A gasification plant in the USA with a capacity of 750 metric tons per year would need an estimated investment cost of USD $550 per annual capacity metric ton (WEC 2016). Investment costs for the same technology and similar plant size can also vary significantly due to location, site implementations, and land availability.

However, caution should be taken to generalize investment costs for each technology because there are regional differences in government incentives and market dynamics, and the amount of revenue gained depends on very localized conditions such as electricity prices, access to the district heating network and recovery markets for recyclables (i.e. metals, paper, glass and plastic). In addition, investment costs of individual projects will vary depending on a range of factors including financing type, the project developer, conditions in financial markets, maturity of technology, and risk and political factors.

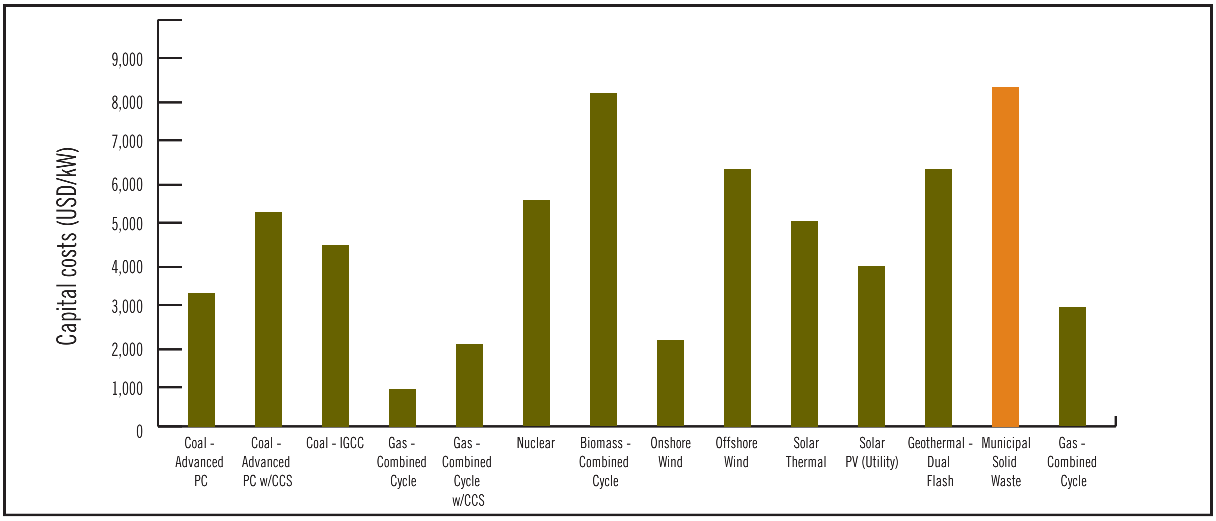
Table 4: Investment costs for incineration

Income	Investment costs (USD$/yearly tonnage capacity)	Characteristics
Low-income countries	300-500	• Low labour costs • Low calorific value of waste • Low need for structural protection of equipment
Middle-income countries	400-600	• Some requirements for structural protection of plant • Slightly higher calorific value of waste • Higher labour cost
High-income countries (EU and North America)	600-900	• Stringent demands on equipment and safety • High architectural standard of buildings

Source: World Energy Council (2016)

In the same World Energy Resource (2016) report, the World Energy Council indicates that energy generation from waste is a costly option in comparison with other established power generation sources. Average capital costs for power generation from MSW are much higher than for other sources in the USA (Figure 6); MSW power generation capital costs are more than eight times that of combined cycle gas plants for instance.

Figure 6: Capital cost estimates for utility scale power generation plants in the United States of America



Source: World Energy Council (2016)

Table 5 presents an overview of the comparative costs of incineration in different EU member states (2001) reported to the European Commission (ECOTEC 2001). Although all the costs are more than 15 years old, several points of interest emerge:

a) The economy of scale factor has a strong influence as costs decrease significantly while the capacity of the facility (ktpa)[8] increases. This holds for all countries reporting different sized facilities, but especially for Austria (AU) and Germany (GE). Low operational costs can only be achieved if larger feedstock can be guaranteed in addition to larger initial investment costs.
b) Most countries consider having separate costs for the treatment of ash and flue gas, ranging from EUR 16-75 per metric ton for bottom ash treatment, to EUR 129-363 per metric ton for flue gas residue control. Considering that the bottom ash represents 20-30 per cent of the incoming weight, significant funds need to be reserved for this treatment.

[8] Ktpa – kilo ton per annum (year)

The same report indicated that unit costs for composting vary from EUR 22-94 per metric ton, depending on the type of technology and the capacity of the plant. For sanitary landfilling, the costs (including landfill tax) vary between EUR 6-30 per metric ton in Mediterranean countries and EUR 40-110 per metric ton in other European countries.

Table 5: Comparative costs of incineration in European Union member states (2001)

	Pretax Costs Net of Revenues	Tax (for plant with energy recovery)	Revenues from Energy Supply (per kWh)	Costs of Ash Treatment
Austria	€326 @ 60 ktpa €159 @ 150 ktpa €97 @ 300 ktpa		Electricity €0.036 Heat €0.018	Bottom ash €63/tonne Flue gas residues €363/tonne
Belgium	€71-75 @ 150 ktpa €83/tonne	€12.7/tonne (Flanders)	Electricity €0.025	Not available
Denmark	€30-45/tonne	€44/tonne	Electricity €0.05	Bottom ash €34/tonne Flue gas residues €134/tonne
Finland	None		For gasification, Electricity €0.034 Heat €0.017	
France	€118-129 @ 18.7 ktpa €91-101 @ 37.5 ktpa €86-101 @ 37.5 ktpa €80-90 @ 75 ktpa €67-80 @ 150 ktpa		Electricity €0.023	€13-18/tonne input
Germany	€250 (50 ktpa and below) €105 (200 ktpa) €65 @ 600 ktpa		Electricity €0.046	Bottom ash €28.1/tonne Fly ash / air pollution control residues €255.6/tonne
Greece	None		Not known	Not known
Ireland	€46 (200 ktpa, est)		Not known	Not known
Italy	€41.3-93 (350 ktpa, depends on revenues for energy and packaging recovery)		Electricity €0.14 (old) €0.04 (market) €0.05 (green cert.)	Bottom ash €75/tonne Fly ash and air pollution control residues €129/tonne
Luxembourg	€97 (120ktpa)		Electricity €0.025 (est)	Bottom ash €16/tonne input waste Flue gas residues €8/tonne input waste
Netherlands	€71-110* (VVAV) €70-134* (OVAM)		Electricity €0.05/tonne (est)	
Poland	€46-76 (est)			No data
Spain	€34-56		Electricity €0.036	
Switzerland	€21-53		Electricity €0.03 Heat €0.02	
United Kingdom	€69 @ 100ktpa €47 @ 200ktpa		Electricity €0.032	Bottom ash recycled (net cost to operator) Fly ash circa €90/tonne

Source: ECOTEC (2001)

Table 6 provides a comparison between processing recyclable materials (such as plastics, paper and cardboard) using WtE technologies and diverting the same materials through the recycling chain involving the informal waste sector. While both options lead to volume reduction in the amount of waste diverted to landfills, they are completely different approaches in terms of technology and operation requirements, financial consequences, employment generation opportunities, and national autonomy.

Table 6: Comparing processing recyclable materials via incineration versus the recycling chain

Factor	Incinerator initiatives	Recycling chain (involving the informal waste sector)
Investment costs	Very high	Low-medium
Operation costs	High	Low
Employment generation	Very low	Very high
Dependence on permanent minimum feedstock	High	Low
Volume reduction	High	High-medium
Skill level required for operation	Very high	Low-medium
Dependence on foreign technology	Very high-high	Low-medium

Source: Author's observations during research

What can be learned from the above Tables and Figures is that incineration is a costly enterprise with few returns, and, especially in those municipalities where there is already an active informal waste sector, a decision to implement a WtE initiative will most likely lead to:

- Extensive loss of employment and loss of livelihood for those working in the informal waste sector;
- Extensive loss of employment generation opportunities that would require limited investment;
- Limited generation of high-skilled employment;
- Strong dependence on foreign technology for implementation, training, maintenance and operation;
- Strong need for long-term, high-cost financial commitment to solid waste management and contractual obligations.

In the EU, policy is focused on recovering those materials (such as paper, cardboard, plastics and textiles) that can be (easily) recycled. As stated in the *Resource Efficiency Roadmap* of the EU (European Commission 2011), the main objectives are to achieve zero landfilling, to maximize recycling and reuse, and to limit energy recovery to non-recyclable waste.

Furthermore, as stated by Environment Commissioner (Potočnik 2011):

> "Waste is too valuable to just throw away, and if you manage it right you can put that value back into the economy. Six Member States now combine virtually zero landfilling and high recycling rates. Not only do they exploit the value of the waste, they have created thriving industries and many jobs in the process. They have achieved this by making prevention, reuse and recycling more economically attractive through a selection of economic instruments. We now have a common responsibility with the Member States and local authorities to ensure that these instruments are effectively used and spread across the EU. This is one of the central goals of the Resource Efficiency Roadmap."

As such, it would be important to place efforts that strengthen recycling in developing economies and divert the potential recyclable materials away from the landfill towards the process industry.

5. How to prepare as a municipality/community when waste-to-energy initiatives are proposed?

Incineration technology is complex, capital intensive, repair and maintenance sensitive and requires highly skilled staff for operation and management. If a municipality is presented with a proposal to embark and invest upon such a technology, then it is only correct to ask whether the municipality is ready for such a step.

Even more importantly, it is essential to understand within what context these technologies have been developed and implemented in industrialized (and high-income) countries, as well as the state of the MSW management system when the decision was made to build and operate incineration plants. What were the national (and local) solid waste policies and planning frameworks that supported the inclusion of WtE options as part of the mix of technologies used to treat municipal solid waste? Were WtE technologies the only option considered, or was there also a focus on recycling?

The main driving forces behind the development of municipal solid waste management systems in these countries have been related to concerns over 1) public health, 2) environment (pollution), 3) the resource value of waste, and finally 4) the impacts municipal solid waste management (MSWM) has on climate change.

The highly industrialized countries where incineration plants have been operating for decades (often) have the following in common:

- There is a long history of solid waste planning and policy development;
- The waste collection system is well structured with distributed responsibilities and control of all waste types;
- The disposal of waste is fully controlled (i.e. there are no open (uncontrolled) dumps used for the disposal of MSW);
- All waste is disposed of in environmentally controlled landfills (ie. in sanitary landfills);
- The waste generators (users of the system) pay for the full cost of waste collection and disposal.

All the above-mentioned factors were acquired as a result of waste management systems developing and maturing gradually. It took time to implement the necessary infrastructure and policy and planning tools and instruments, as well as to develop the required human management skills and capacities.

Before even considering WtE as an alternative for a municipality or within a country, it is essential to assess the current state of the solid waste management system functioning in the municipality or country. Is the system mature enough to be able to integrate and manage a complex and expensive technology? To support this understanding, it can be helpful to consult the different decision matrices and checklists presented in the guides published by CWG, GiZ, WorldBank and ISWA.

Textbox 5: Crucial questions to ask

Crucial questions to ask include:

- Are there waste collection systems in place that have guaranteed full collection coverage to all households for several decades? Do these systems also process bulky waste? Construction and demolition waste?
- Is all generated waste collected and transported in a controlled and registered manner, including fully functioning weighbridges at solid waste facilities?
- Does all collected waste go to authorized treatment and disposal facilities?
- Is waste disposed of in controlled sanitary landfills?
- Do all waste generators pay for the full cost of waste collection and disposal and have they been doing so for several decades? Is payment for solid waste management fully embedded in society through effective legislation that supports compliance with this payment through fully functioning fee collection systems?
- What would be the impact on the livelihoods of existing informal collectors of recyclables?

If any of these questions cannot be answered positively, then a municipality should really question whether it can (or should) embark on even talking about WtE. Instead, it would be in the municipality's best interest to focus its efforts on making sure all waste is collected and treated in an environmentally correct manner and that society is willing to pay for the associated costs.

Because if a municipality cannot guarantee the continuous functioning of, for instance, a sanitary landfill or a composting facility because of lack of funds to pay for operational costs, or because of a lack of supervision capabilities, then it will have even more difficulties in guaranteeing the functioning of an incinerator with much higher operational costs and higher levels of complexity related to technology.

Therefore, it is important to remember that the inclusion of incineration in the solid waste management system is not, per definition, an end goal. Not all industrialized countries have decided to include incineration in their solid waste management systems. As discussed previously, the EU member states decided to curb the maximum amount of waste that can be incinerated to 35 per cent by 2030, which has led to an overcapacity of incinerators in some member states.

In addition, decisions should only be taken based on an integrated MSWM plan (and supported by/ embedded in national policy), which is based on material flow analysis and which respects the concept of the waste (and waste management) hierarchy.

Finally, several tools and guides have been developed to support decision makers in evaluating WtE initiatives (Table 7). While these tools often are directed at decision makers and municipal staff, they can also be very useful for community leaders and non-government organizations' representatives from the informal waste sector as they provide an insight into specific critical questions to ask of those proposing (and selling) WtE initiatives.

Table 7: Overview of decision maker guide and assessment tools for waste-to-energy initiatives

Organization	Source	Check list	Comments
CWG	Waste to Energy Rapid Assessment Tool. (2016)	Eight different checklists covering a variety of aspects.	32 pages
GiZ	Waste-to-Energy Options in Municipal Solid Waste Management; A Guide for Decision Makers in Developing and Emerging Countries Waste. (2017)	Chapter 4 (p.42-47) DECISION MAKING SUPPORT MATRIX with 12 essential parameters and Annex with description of the parameters.	58 pages. Separate section with recommendations (p.48-49) for a) decision makers at national and local levels; b) national and international companies.
ISWA	ISWA Guidelines: Waste to Energy in Low and Middle-Income Countries. (2013)	Strong focus on what needs to be done to make a WtE project successful, emphasize on feasibility study phase.	28 pages
World Bank	Municipal Solid Waste Incineration. A Decision Maker`s Guide. World Bank Technical Guidance Report. (1999)	10 page Municipal Solid Waste Incineration Checklist included in the annex.	110 pages

Table 8 gives an overview of publications that give a critical view of WtE initiatives that have been implemented in developing economies.

Table 8: Overview of waste-to-energy publications

Publication	Comments
SMOKE SCREEN; Why the United Kingdon must turn its back on incineration and embrace the circular economy as a solution to the global waste crisis; Tearfund 2017	Contains useful references and case studies.
Chintan: Waste to energy or waste of energy; India, 2011	Social and Economic Impact Assessment of Waste-to Energy Projects on Wastepickers near Ghazipur and Okhia landfills in New Delhi.
Global Alliance for Incinerator Alternatives: FACTS ABOUT "WASTE-TO-ENERGY"INCINERATORS	This paper looks at the hard facts about "waste-to-energy" incineration, and how it fails both as a waste and resource management option, and as an energy generating facility.
Timarpur-Okhla, Waste to Energy Venture	Documented example prepared by Global Alliance for Incinerator Alternatives (GAIA).
https://ejatlas.org/	Examples of proposed WtE initiatives and resulting conflicts.

6. Final Considerations

This technical brief focused on incineration WtE technology and the impact it can have on livelihoods (especially those of informal waste workers) in municipalities in emerging economies where new projects promoting incineration technology are proposed.

As was discussed, incineration technology is complex, capital intensive, repair and maintenance sensitive, and requires highly skilled staff for operation and management. Even though incinerators have formed an integral part of the MSWM systems functioning in highly industrialized countries, their role remains minor and is also shrinking as a result of new environment policies being put into place. This has led to those companies selling WtE technology to shift their attention to developing economies, to sell facilities under the guise of development.

As such, it is paramount for municipalities and stakeholders in developing economies to understand the impacts that WtE technology can have on the environment, economy, and livelihoods of the urban (and rural) areas receiving them. It is also important to understand that there are alternatives to WtE that can be explored to address the continuing growth of solid waste in urban settings.

Advocates of incineration technology will argue that incinerators will lead to a 75 per cent reduction in volume and mass of MSW — and at the same time generate energy that can be used for heat application and electricity generation.

In order to achieve this reduction, the ovens burning the mixed MSW require a permanent and large supply (feedstock) of MSW that cannot be devoid of high calorific fractions such as plastic, paper and cardboard — primarily because organic matter is humid and, mixed with ashes and inert materials, does not provide sufficient fuel to burn continuously. It is precisely here where the main conflict of interest emerges with the informal waste sector as informal waste collectors recover and trade these high calorific fractions. If plastics, paper, cardboard and textiles are diverted to the incinerator they are not available to generate income for the informal waste sector.

Neighbourhoods would not only be affected by the potential loss of income for those working in the circular economy activity of recovery and trading of recyclables, but also by a significant increase in waste management fees as the high operation costs of the incinerator would need to be financed through stiff gate fees. Furthermore, the potential environmental and health risks remain a concern as 25 per cent of MSW received by the incinerator remains as bottom ash and hazardous fly ash. Technologies for treating this ash in accordance with required international environmental and health standards are often not available in developing economies.

Even the World Energy Council recognizes that there are more efficient and cheaper alternatives to generate energy. This is one aspect for decision makers to consider when vendors of WtE arrive at the municipal doorstep. If the municipality has difficulty guaranteeing the continuous functioning of the (sanitary) landfill according to environmental standards, either because of a lack of funds to pay for operational costs or because of a lack of supervision capabilities, then surely it will have even more difficulties in guaranteeing the functioning of an incinerator with much higher (operational) costs and levels of complexity related to technology.

Instead it would be better to assess alternatives that would need to be embedded in an integrated MSWM plan and be supported by national policy, based on material flow analysis and a sensible waste (and waste management) hierarchy. Through the integration of concepts such as the circular economy and the creation of green jobs, there can be a focus on strengthening those initiatives that generate far more jobs than one incinerator can do.

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8. Glossary

Anaerobic digestion — the decomposition of organic matter through microorganisms in the absence of free oxygen. Anaerobic digestion occurs naturally under oxygen-deprived conditions, such as when submersed in some lake sediments, and can be used under controlled conditions to produce biogas. Biogas is a mixture of different gases that can be converted into thermal and/or electrical energy. For that purpose, a gas-tight reactor, a so-called anaerobic digester, is used to provide favourable conditions for microorganisms to turn organic matter, the input feedstock, into biogas and a solid-liquid residue called digestate.

Circulating Fluidized Bed (CFB) — is a developing technology for coal combustion to achieve lower emission of pollutants.

Combustion — the process of burning material.

Co-processing — the use of waste-derived materials to replace natural mineral resources (material recycling) and/or traditional fossil fuels such as coal, fuel oil and natural gas (energy recovery) in industrial processes. Co-processing is applied worldwide mainly in the cement industry and in thermal power plants; in a few cases it is also applied in the steel and lime industry. In thermal plants where only energy recovery takes place this is called co-incineration.

Feedstock — raw material to supply or fuel a machine or industrial process.

Fly ash — fine particulates in exhaust gases that are created during incineration.

Landfill Gas — generated by the natural degrading and decomposition of municipal solid waste by anaerobic microorganisms in sanitary landfills. The main gases produced are carbon dioxide and methane. The methane percentage can vary from 40 to 60 per cent, depending on several factors including waste composition (e.g. carbohydrate and cellulose content). The methane in landfill gas may be vented, flared, combusted to generate electricity or useful thermal energy on-site, or injected into a pipeline for combustion off-site.

Lower Calorific Value (LCV) — LCV of a fuel portion is defined as the amount of heat that was created when a unit weight (or volume in the case of gaseous fuels) of the fuel is completely burnt and water vapour leaves with the combustion products without being condensed.

Material Flow Analysis (MFA): also referred to as substance flow analysis (SFA), is an analytical method to quantify flows and stocks of materials or substances in a well-defined system. MFA is an important tool to study the circular economy and to devise material flow management.

Pyrolysis and gasification — technologies sometimes known as Advanced Thermal Technologies or Alternative Conversion Technologies. They typically rely on carbon-based waste such as paper, petroleum-based wastes like plastics, and organic materials such as food scraps. The waste is broken down to create gas, solid and liquid residues. The gases can then be combusted in a secondary process. The pyrolysis process thermally degrades waste in the absence of air (and oxygen). Gasification is a process in which materials are exposed to some oxygen, but not enough to allow combustion to occur. Temperatures are usually above 750°C. In some systems, the pyrolysis phase is followed by a second gasification stage in order that more of the energy carrying gases are liberated from the waste energy content.

Slag (bottom ash) — fine particulates that fall to the bottom of the incinerator during combustion.

Waste hierarchy — a tool used in the evaluation of processes (related to waste management) that protect the environment alongside resource and energy consumption from most favourable to least favourable actions. It establishes an order of priorities of different options.

Weighbridge — A scale used to weigh cargo (including MSW) transported by trucks.

About WIEGO: Women in Informal Employment: Globalizing and Organizing is a global network focused on securing livelihoods for the working poor, especially women, in the informal economy. We believe all workers should have equal economic opportunities and rights. WIEGO creates change by building capacity among informal worker organizations, expanding the knowledge base about the informal economy and influencing local, national and international policies. Visit: www.wiego.org.

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