Welcome to the MSW Webinar Series
Part II: Overview and Practical implementation of Organics Waste Treatment Options

THE WEBINAR WILL START AT 10:00 CET
PLEASE MUTE YOUR MICROPHONE AND KEEP YOUR WEBCAM SWITCHED OFF
MSW Webinar Series
Part II: Overview and Practical implementation of Organics Waste Treatment Options

Mitigating SLCPs from the Municipal Waste Sector
http://waste.ccac-knowledge.net/
Presenters

- Michele Giavini
- Gemma Nohales
- Marco Ricci
- ARS ambiente srl
- CIC – Italian Composting Association
- ISWA
- Urban Ecology Agency of Barcelona
CASE STUDIES: EUROPE
Current status of biowaste management in Europe

- Map focusing on food waste only

Established
In implementation
In beginning phase
No activities at present

Source: European Compost Network, updated by authors
Collection schemes

- The South-European ISSO (Intensive Source Separation of Organics) scheme is outperforming compared to the Central-European scheme in terms of food waste captures, also in metropolitan areas.
Italy: High captures with ISSO

• The Italian intensive source separation of organics (ISSO): maximisation of food waste capture rate through intensive dedicated kerbside collection

• Central Europe: lower capture rates, collection of co-mingled food and garden waste, home composting for small municipalities.

  • High Food Waste amount sent to composting and AD
  • Low amount left in the residual

  • Low Food Waste amount sent to composting and AD (mainly green waste)
  • High amount of Food Waste left in the residual
THE CATALAN CASE STUDY: BARCELONA
Barcelona

- Collection scheme in Barcelona is a bring scheme based mainly on road containers (but also pneumatic, subterranean containers, etc.). At the end of 2009 a new collection service contract started and the biowaste collection service was expanded to all the population.

- The biowaste container allows residents to deliver commingled food and green wastes, and residents are advised to use biodegradable and compostable bags to collect their kitchen waste. Because of the urban context, most of the dwellings served by this scheme are the flats from multi-family buildings.

- There is a door-to-door specific service for big/singular producers.
Citizens

Road container 34% inhabitants
33% impurities
4.164 bicompartimated+82 other types Capacity 2.718 m³
(since 2001-2004)

Road container 100% inhabitants
17% impurities
5.401 containers Capacity 9.722 m³.
Frequency daily

Big/singular producer

Door-to-door collection for big generators and commercial axis
(since 2001)

1st Nov 2009 to 28th Feb 2010

Door-to-door collection for big generators and commercial axis
+ new service for important producer like restaurants, fruit stores

2009 Selective collection 34% (73.793 t:41% HH/59% BP)
June 2010 Selective collection 43%
Impurities control and improvement

<table>
<thead>
<tr>
<th>Districte</th>
<th>Ciutat Vella</th>
<th>Eixample</th>
<th>Sants - Montjuïc</th>
<th>Les Corts</th>
<th>Sarrià - Sant Gervasi</th>
<th>Gràcia</th>
<th>Horta - Guinardó</th>
<th>Nou Barris</th>
<th>Sant Andreu</th>
<th>Sant Martí</th>
<th>TOTAL BARCELONA</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM compostable</td>
<td>70,23%</td>
<td>86,40%</td>
<td>73,86%</td>
<td>84,62%</td>
<td>78,03%</td>
<td>78,53%</td>
<td>84,89%</td>
<td>89,86%</td>
<td>82,73%</td>
<td>84,68%</td>
<td>82,41%</td>
</tr>
<tr>
<td>Improps totals</td>
<td>29,77%</td>
<td>13,60%</td>
<td>26,14%</td>
<td>15,38%</td>
<td>21,97%</td>
<td>21,47%</td>
<td>15,11%</td>
<td>10,14%</td>
<td>17,27%</td>
<td>15,32%</td>
<td>17,59%</td>
</tr>
</tbody>
</table>

Impurities average 17.6%; 5 districts < 15%; 4 districts >20-30%

• Plan for improvement testing to reduce impurities:
  • Container location in relation to the other 4.
  • Location of the group of containers.
  • Type of cover, reduce the cover using a sized hole for bags
  • Inspection for big/singular producers collection
  • Characterizations for all circuits each 3 month (provided by ARC)
  • Incidences with the quality of biowaste in: subterranean containers and pneumatic collection schemes (particular zones of Barcelona)
  • Destination of the Biowaste: Ecoparcs (AD/Composting with pre-treatment)
INFORMATION POINTS to provide citizens with the vented caddy, compostable bags, magnet, receipt book, instructions for the separation at homes and delivery.

Ubicacions: mercantil points and green points (to confirm with each district)

Data: Inici el 2 de Novembre, durant els 4 mesos

Campanya de mitjans

INFORMATION CAMPAIGN on the communication means: radio, newspaper, TV, etc.

Specific actions for schools

Dates: Inici 2 de novembre
1) Milan and the Italian scheme

2) A district management experience

BEST-PRACTISE CASES IN MIDDLE AND HIGH-DENSITY AREAS
Milan Metropolitan Area: intensive food waste collection
Il sacchetto, quale ci metto?

I sacchetti non sono tutti uguali. Per raccogliere l'umido si devono utilizzare solo sacchetti compostabili, certificati:

Possono essere utilizzati anche i sacchetti compostabili della spesa.

Utilizzando i sacchetti compostabili la qualità della raccolta è migliore e si evitano sanzioni.

Video: link
AVISO DI CONSEGNA DEI CONTENITORI DELLA FRAZIONE UMIDA

La consegna dei contenitori per la raccolta della frazione umida avrà luogo nei giorni seguenti:

- 22/10/2023
- 25/10/2023
- 28/10/2023

La consegna avrà luogo alle ore 8:00 e 18:00. Per qualsiasi informazione o richiesta, si invita a contattare il numero di telefono riportato sull'immagine.

CONSEGNA CONTENITORI PER LA RACCOLTA DELLA FRAZIONE UMIDA

900-2323206
Servizio Clienti
Municipality of Milan

- Collection done mainly with non-compacting vehicles
- Transport to AD/composting plant done with packer-trucks
- Collection of foodwaste done 2/week
- Most HH live in flats and high-rise building
- Restaurants, canteens, etc served 4-6times/week
Municipality of Milan
Weekly captures of foodwaste

- 1.7 kg/capita.week = 90 kg/capita.year
Results: effectiveness and food waste diversion from residual waste
Results: food waste quality

- Less than 5% contamination (non compostable materials)
- Quality is lasting over time
PD1 District: semi-detached houses and small urban centers
PD1 District

- Geo-data:
  - 237,315 inhab
  - 28 municipalities
  - Semidetached situation with some larger towns up to 20,000 inhab
  - 435 inhab/km²

- Key-Data about waste collection:
  - DtD collection of residual W (bags) 1/week (mixed MSW collected 3/week)
    FW (buckets and wheelyb.) 2/week
    GW at municipal collection centers and DtD on demand
  - Home-composting at 32% of hh
  - Since 1996 door-to-door collection of food waste and other recyclables
PD1- District

- Collection of foodwaste done with non-compacting vehicles
- Transport to AD/composting plant done with packer-trucks
- Collection of foodwaste 2/week
- Collection of gardenwaste 1/week in summer only
- Most HH live in HH with gardens
- Restaurants, canteens, etc served 2 to 3 times/week
PD1- District
Results

Collection in Vigonza municipality

- MSW disposed
- MSW sep. collection

Road cont. collection (start-up)

DtD collection (start-up)

Kg/inhab/day

Dates: 1995 to 2003
PD1 District: Separate collection (as % of total MSW)

Raccolta Differenziata* nel Bacino PD1*

* Avvio raccolta porta a porta del rifiuto umido e secco

* AL NETTO DEL COMPOSTAGGIO DOMESTICO
PD 1 District: switching from road containers to DtD collection
Non-compostables in Foodwaste
Public awareness campaign on sep. collection of foodwaste
CASE STUDY: SAN FRANCISCO, CALIFORNIA
General data

- Population: 825,000 & 1.3 million daytime
- Multilingual and multicultural: 40% don’t speak English at home
- Variable rates charged for garbage collection via City rate approval process
- 123 kg/capita of food waste
90% diversion

Glass and Plastic
Aluminum and Steel
5%

Recyclable
Paper
25%

Food Scraps
20%

Plant Trimmings
5%

Compostable Paper
& Fiber 10%

Construction and Demolition Waste
25%

Other 10%

All % numbers by weight or tons

SFEnvironment.org
The Fantastic Three
Outreach

www.SFEnvironment.org
Captures

- Total green bin 185 kg/capita.year
  - Food waste 123 kg/ca.y
  - Other is green waste and compostable packaging / fiber

- 80% diversion from landfill in 2010, including Construction and demolition waste

- Zero Waste target by 2020

Source: Jack Macy, personal communication to M. Giavini
QUESTION TIME
INSIGHT: CENTRALIZED VS. DECENTRALIZED COMPOSTING
Centralised vs. decentralised

- Centralised composting
  - Large scale: range 50 – 300 tonnes/day and more
  - Far from city dwellings, in low income countries usually close to the landfill

- Decentralised composting
  - Small scale: range 1-10 tonnes/day
  - Around 1,000 sq.m each
  - Inside urban areas
    - Examples: Surabaya, Dhaka
  - Borders of the urbans areas (Mexico)
  - In rural areas (e.g. the Austrian model, or SCOW Catalan model)

More information on decentralized:
urban in low income, Austrian, SCOW
Decentralized vs. Centralized

- The integrated solid waste management project at Guwahati, India, has been allotted 160,536 sq. m of land for processing 300 MT of waste.
- If the same quantity of waste were to be processed by setting up 150 decentralized facilities (1,000 sq.m each, with a 2 MT capacity), 150,000 sq. m of land would be required.

Source: PPP in MSWM. Link. Additional information: EAWAG, link and link.
Decentralised: feasibility

Research approach for determining indicators of feasibility of decentralised composting

Source: CWG – WASH workshop, link
Decentralized urban composting in lower income countries: key factors

- Land price
- Population density
- Compost value
- Informal sector involvement
- Competition with other uses: feeding animals, heating demand (especially green wastes).
- Legal requirements for facilities
Two key factors: compost value, land price

- See also Webinar part 1

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Dhaka: difference in total costs, decentralized vs. centralized

- $40
- $30
- $20
- $10
- $0
- $10
- $20
- $30

Land price ($/sqm)

Difference decentralized vs. centralized (collection+treatment, US$ per tonne)

-30 $/t (decentralized compost: free, centralized: 30$/t)
-0 $/t (both decentr. And centr. @30 $/t)
+30 $/t (decentr: 60, centr: 30)
+60 $/t (decentr: 90, centr: 30)

M. Giavini, personal calculations and elaborations on Waste Concern data. To be further improved soon.
Key factor: land price

- Real estate markets are highly cyclical. The demand for land, and the price of land parcels, fluctuates violently, even in urban areas experiencing strong, long-term growth.

- **Land price can increase before GDP per capita raises**, hampering decentralized solutions before more technological centralized options become affordable.

1 USD = 6.25 CNY

- 2000: 100-150 USD/sqm
- 2008: 200-2500 USD/sqm
## Land price

<table>
<thead>
<tr>
<th>Questions</th>
<th>Country 1</th>
<th>Country 2</th>
<th>Country 3</th>
<th>Country 4</th>
<th>Country 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. What is the middle price range of residential land in formal/planned</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>settlements in the well established suburbs near the urban fringe?</td>
<td>US$ 147 per sq meter</td>
<td>Rp 15 million per sq meter</td>
<td>4,000-8,000 per sq meter</td>
<td>15,000 per sq meter</td>
<td>US$ 2.5 per sq foot</td>
</tr>
<tr>
<td>US$ per sq meter</td>
<td>$147.00</td>
<td>$1,614.47</td>
<td>$554.21</td>
<td>$453.97</td>
<td>$26.88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country 6</th>
<th>Country 7</th>
<th>Country 8</th>
<th>Country 9</th>
<th>Country 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buenos Aires</td>
<td>Bratislava</td>
<td>Kyiv</td>
<td>Bucharest</td>
<td>Bangalore</td>
</tr>
<tr>
<td>Argentina</td>
<td>Slovak Republic</td>
<td>Ukraine</td>
<td>Romania</td>
<td>India</td>
</tr>
<tr>
<td>US$ 250-300 per sq meter</td>
<td>US$ 150 per sq meter</td>
<td>US$ 100-300 per sq meter</td>
<td>400-2000 per sq meter</td>
<td>Rs 1,500 per square foot</td>
</tr>
<tr>
<td>$279.00</td>
<td>$150.00</td>
<td>$200.00</td>
<td>$475.20</td>
<td>$409.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
<td>Ho Chi Minh</td>
<td>Cape Town</td>
<td>Guezon City</td>
<td>San Ignacio</td>
<td>San Salvador</td>
<td>Penang</td>
<td>Warsaw</td>
</tr>
<tr>
<td>South Korea</td>
<td>Viet Nam</td>
<td>South Africa</td>
<td>Philippines</td>
<td>Belize</td>
<td>El Salvador</td>
<td>Malaysia</td>
<td>Poland</td>
</tr>
<tr>
<td>KRW 3,000,000 per sq meter</td>
<td>US$ 1,000-2000 per sq meter</td>
<td>Rs 5,000 per sq meter</td>
<td>P4,000 per sq meter</td>
<td>US$88.34 per sq foot</td>
<td>US$8.71 per sq foot</td>
<td>200 MYR per sq foot</td>
<td>200 Euro per sq meter</td>
</tr>
<tr>
<td>$3,178.30</td>
<td>$1,500.00</td>
<td>$617.28</td>
<td>$96.15</td>
<td>$1,057.42</td>
<td>$93.76</td>
<td>$659.70</td>
<td>$311.40</td>
</tr>
</tbody>
</table>

Source: [link](#) (year 2008)
Key factor: compost value

- Explore all possibility of increased compost market value
  - Small bags for retailers
  - Enrichment, pelletizing…
  - Carbon credits (CDM etc.)
  - Comply with standards for ecological agriculture or the requirements of the final users
  - Compost market need a particular attention. Calculating 150 kg biowaste /capita.year collected, this results in 35-50 kg/cap.year compost.
    - It must be used very close to the production source (i.e. the decentralized facility), otherwise transportation cost could make compost not appealing with respect to mineral fertilizers.
    - In some megacities, the production of this amount of compost could be too much to be used inside urban territory.

Additional information: EAWAG, marketing compost in low and middle income countries, [link](#)
ITALY: compost overtaking mineral fertilizers

Fertilizers marketed in Italy (Istat, 1998-2009)

Mineral NPK fertilizers consumption decreased due to their higher costs, the global economic downturn and increased public perception of compost quality.

Source: CIC, Italian Composting Association, link
Key factor: informal sector involvement

Table 2: Comparison of material recovery by formal and informal sector, baseline scenario (in tonnes and as a percentage of total waste generated)

<table>
<thead>
<tr>
<th>City</th>
<th>Formal sector</th>
<th>Informal sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cairo</td>
<td>13% 433,200 T</td>
<td>13% 8,900 T</td>
</tr>
<tr>
<td>Cluj</td>
<td>30% 979,400 T</td>
<td>8% 14,600 T</td>
</tr>
<tr>
<td>Lima</td>
<td>0.3% 9,400 T</td>
<td>19% 529,400 T</td>
</tr>
<tr>
<td>Lusaka</td>
<td>4% 12,000 T</td>
<td>2% 5,400 T</td>
</tr>
<tr>
<td>Pune</td>
<td>0% - Tonnes</td>
<td>22% 117,000 T</td>
</tr>
<tr>
<td>Quezon</td>
<td>2% 15,600 T</td>
<td>23% 141,800 T</td>
</tr>
</tbody>
</table>

Table 3: Differences in costs per tonne, net costs per tonne (with revenues for materials sales included), for formal and informal sectors

<table>
<thead>
<tr>
<th>City</th>
<th>Formal sector</th>
<th>Informal sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cairo</td>
<td>13 (benefit)</td>
<td>5 (benefit)</td>
</tr>
<tr>
<td>Cluj</td>
<td>25 (benefit)</td>
<td>7 (benefit)</td>
</tr>
<tr>
<td>Lima</td>
<td>42 (benefit)</td>
<td>41 (benefit)</td>
</tr>
<tr>
<td>Lusaka</td>
<td>35 (benefit)</td>
<td>15 (benefit)</td>
</tr>
<tr>
<td>Pune</td>
<td>23 (benefit)</td>
<td>21 (benefit)</td>
</tr>
<tr>
<td>Quezon</td>
<td>31 (benefit)</td>
<td>28 (benefit)</td>
</tr>
</tbody>
</table>

Source: The Economics of the Informal Sector in Solid Waste Management, GIZ-CWG, [link](#)
Informal sector: savings

- Most of the avoided costs in the study cities is avoided collection costs,
  - €14 million per year in Lima,
  - €12 million in Cairo,
  - €3.4 million in Quezon city.

- The average avoided costs per worker are €571, which in many cities is more than that same worker earns in a year.

- Source: The Economics of the Informal Sector in Solid Waste Management, GIZ-CWG, link

Additional information on informal sector in low income cities: CHINTAN 1, CHINTAN 2, WIEGO
A very peculiar case study

- Zabbaleen ("garbage people") in Cairo
  - Door to door collection
  - Waste sorted in 16 streams: recycling rate 80%
  - **Organic fraction used to feed pigs**
    - 2009: government order total pig cull after global swine flu
    - Devastating impact on Zabbaleen families and on the whole recycling system
  - Currently (2014) they are finally being re-integrated into the city's services, a decade after they were sidelined
  - the Zabaleen still deal with 9,000 of Cairo's 15,000 daily tons of household rubbish, recycling 85% of it.

- Problem: dirty and tough work, health risks, technically "illegal" (don’t actually own land for processing waste)
Key factors for successful projects

- Key factors for sustainability of community-based projects are:
  - Community should have a felt need or demand for the project
  - Willingness to share the project cost (and benefit).

- Be careful when thinking about giving bins and services for free through donors.

- Very little environmental protection attitude in low-income areas.

Source: CWG-WASH workshop, [link]
COMPOSTING INSIDE A MEGACITY: THE CASE STUDY OF DHAKA, BANGLADESH
Dhaka: key figures

- Population: 14 million (estimate), 27,700 people/sqkm, 11th largest city in the world
- Waste generation rate: 0.56 kg/cap.day
- % organics in MSW: 67.65%
- Waste collection coverage: 60%
- Per capita GDP: US$ 1,350
- Urban land price: US$ 300-500 (World Bank, 2000; now higher)
- 3.4 millions living in slums

The Waste Concern model

In slums:

Barrel Type Composting

In other areas:

Aerator Type Composting

Box Type Compost

Source: Waste Concern
Also: centralized large composting facility, supported by Clean Development Mechanism (CDM) credits

Project based on carbon trading (CER/VER) between industrialized and developing countries

Dutch Company WWR and Banks, FMO and Triodos

CDM investment $$

Industrialized country

Emission reduction credits (CER)

Project Reducing GHG emissions in Dhaka

Source: Waste Concern. Full presentation on CDM project in Dhaka: link
The basic decentralized composting model

- Up to 3 / up to 10 tons/day (1,000-3,000t/year)
- Box type composting system

Waste Concern Full presentation: [link]
• Recently Waste Concern’s model has been replicated with more than 40 decentralized facilities in cities in Bangladesh, ten towns in Asia and Pacific countries and in ten cities in Africa

• High importance of the informal sector, not only for composting but also for recyclables sorting and sale

Schematic overview of the waste management system for households in Dhaka (source: EAWAG, link)
THM

- Other decentralized model: Surabaya (Indonesia), Takakura Home Method (THM)
  - Ventilated small plastic bucket for households, with cardboard inside
  - “Seed compost” produced at a small (de)centralised facility and distributed in bags to the households
  - key features:
    - Composting actually happens at home
    - Good way to keep in touch with citizens

Additional information (Japanese, English, Spanish: IGES)
ON THE EDGE OF MEGACITIES: LOW COST COMPOSTING CASES
**Cuautlán Izcalli EM (NW México DF)**

- 7 t/day 5% municipal-big producers+other sources
- Open windrows. 6400 m²
- Production cost $400 (MX) per ton

**Bordo Poniente (Gobierno DF). Al lado relleno sanitario**

- 10 t/day biowaste big producers+municipal green waste
- Open turned windrows. 6000 m²

Más info [Link 1](#) [Link 2](#)
OTHER LOW COST-LOW TECH SOLUTIONS
Key elements:

– Own made individual or community composters, wood composting modules (possibility of recycle materials)

– Own made machinery and equipments, second hand or agricultural equipment (adapted)

– Considering the optimum process conditions since the beginning (porosity, moisture, C/N rate,…) to allow:
  - Simple aeration systems for static piles
  - Reduction of the surface needed
  - Increasing the efficiency of turnings (less turnings and with better effect)
  - Simple covers for avoiding odours (location near landfills or other sources of odours)
Key elements:

– Maximum reduction of using concrete, or use other surfaces like some types of asphalt, compact ground,…

– Reductions of the facility covers, walls,.. according to the climatology of the area.

– Minimization of leachates. Watering the composting piles using simple systems adapted for leachates, clean water or other liquids. Natural water treatment (wetlands)

– Simple monitoring and control systems to guarantee the process conditions.
Local Compost Plant funded by the Government of Japan
Jericho. Palestine

- 3t/day of compost from manure+green wastes
- Open windrows. 5,000m2
- **Investment:** 220,000 AEHS

Djerba. Tunis

- 2 t/day biowaste (DtD collection) +4m3 bulking
- Composting in trenches. Forced aerated system.
Larrabetzu Vizcaya (ES)  
- Farmer collaboration  
- 10t/a biowaste (DtD collection). Force aerated system. 14 m²  
- **Investment**: about 800 €. The council pays the farmer 3,000€/year for the service. (collection+treatment).

Aritzaleku Navarra (ES)  
- Facility inside a camping  
- 30t/a biowaste+green wastes (camping and village). 130 m²  
- **Investment**: less than 5,000 € (including land preparation).

Berriz Vizcaya (ES)  
- Facility inside the municipality/park area  
- 100t/a biowaste (60 families, DtD) +park green wastes. 40 m²  
- **Investment**: 60,000€. Including electric truck

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ENPI CBCMED ȘCOW Project - Ramon Plana, Database [Link](#)
INSIGHTS ON LARGE SCALE BIOWASTE TREATMENT OPTIONS: COMPOSTING, AD, MBT
COMPOSTING/AD BIOWASTE
(SEPARATED AT SOURCE)
**High income countries: gate fees**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Material / Type of Facility / Grade</th>
<th>Median (£/tonne)</th>
<th>Range</th>
<th>Median ($/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organics treatment</td>
<td>Open-air windrow</td>
<td>24</td>
<td>£6 to £45</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>In-vessel composting</td>
<td>46</td>
<td>£28 to £60</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Anaerobic Digestion</td>
<td>41</td>
<td>£25 to £66</td>
<td>69</td>
</tr>
<tr>
<td>MBT</td>
<td></td>
<td>76</td>
<td>£66 to £82</td>
<td>128</td>
</tr>
<tr>
<td>Incineration with energy recovery</td>
<td>Pre-2000 facilities</td>
<td>58</td>
<td>£32 to £76</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Post-2000 facilities</td>
<td>90</td>
<td>£62 to £126</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>Defra gate fee data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;200kt</td>
<td>111</td>
<td>£80 to £135</td>
<td>187</td>
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<tr>
<td></td>
<td>200kt to 300kt</td>
<td>78</td>
<td>£57 to £105</td>
<td>132</td>
</tr>
<tr>
<td></td>
<td>350kt to 450kt</td>
<td>68</td>
<td>£59 to £80</td>
<td>115</td>
</tr>
<tr>
<td>Landfill</td>
<td>Non hazardous gate fee only</td>
<td>21</td>
<td>£8 to £49</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Non hazardous gate fee plus landfill tax</td>
<td>93</td>
<td>£80 to £121</td>
<td>157</td>
</tr>
</tbody>
</table>

UK: gate fees in a typical situation of advanced stage of waste management policies

Source: UK, WRAP gate fee report 2013, simplified. [Link](#)
Need for landfill taxes
Gate Fee comparative in Catalonia: need for landfill tax introduction and progressive increase

<table>
<thead>
<tr>
<th>Year</th>
<th>Cánon vertido</th>
<th>Cánon incineración</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>10 €/Tm</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>10 €/Tm</td>
<td>5 €/Tm</td>
</tr>
<tr>
<td>2011 (Oct.)</td>
<td>12 €/Tm</td>
<td>5,5 €/Tm</td>
</tr>
<tr>
<td>2012 (Marzo)</td>
<td>12,4 €/Tm</td>
<td>5,7 €/Tm</td>
</tr>
<tr>
<td>2013</td>
<td>12,7€/Tm</td>
<td>5,8€/Tm</td>
</tr>
<tr>
<td>2014</td>
<td>15,8 €/Tm</td>
<td>7,4€/Tm</td>
</tr>
<tr>
<td>FUTURO</td>
<td>Incremento de 3€/año en 2 años Llegar a 50€/t 2020</td>
<td></td>
</tr>
</tbody>
</table>

Composting and AD: Key numbers

- As seen before, in emerging and transitional megacities in low income countries composting is feasible both at decentralized small scale level and at large scale (low tech solutions, e.g. Dhaka)

- Large scale anaerobic digestion is more complicated to establish because of its higher investment costs

- Key numbers:

<table>
<thead>
<tr>
<th></th>
<th>Composting</th>
<th>Anaerobic digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific surface needed</td>
<td>0.8 – 1.3 m²/ tpy</td>
<td>0.4 – 1 m²/ tpy</td>
</tr>
<tr>
<td>Specific investment (BAT)</td>
<td>200 - 400 Euro/ tpy</td>
<td>450 - 1,000 Euro/ tpy</td>
</tr>
</tbody>
</table>

Source: Scuola Agaria del Parco di Monza, [link](#)
Add. info on SWM in megacities: Mavropoulos, [link](#)
Large scale composting – key issues

- Odor emissions
  - Need for enclosed buildings with air treatment

- Input biowaste quality -> need for pre- and post-treatments in order to get a quality compost
  - Use of compostable bags
  - Sensitization campaigns
  - Heavy metals as impurities, affectation to the final compost quality, problems to comply with End of Waste regulation or state laws.

- Compost marketing
Composting technologies – large scale

- Open air / In vessel
- Heap / windrows
- Static / dynamic
- With / without forced aeration
AD technologies – large scale

- Different AD technologies, each with pros and cons
  - Dry, semi dry, wet
  - Mesophilic, thermophilic,
  - Batch, Continuous flow
  - Single stage, multi stage

Additional info: link

Pros and cons of AD technologies: link
Large scale AD – key issues

- High investment

- More a “biochemical” facility than a simple composting plant, more expertise needed

- Economic sustainability strictly related to national subsidies
  - Feed in tariffs for electricity from RES (Renewable Energy Sources)
  - Incentives on biomethane production (biogas upgrading)

- Digestate may not be used as a product as it is (End of Waste criteria) -> a post composting stage is needed
Costs of AD: key numbers

Figure 31. Capital cost curves for European MSW digesters
PPP and inflation-adjusted to 2007 dollars [120, 121].

## AD: technologies

Table 13: Summary of commercial large scale AD technologies (Rapport et al., 2008; based on data from Nichols, 2004 and company websites as of February 2008)

<table>
<thead>
<tr>
<th>No. of plants</th>
<th>Capacity [t/y]</th>
<th>Continuity of feeding</th>
<th>Temp. [°C]</th>
<th>TS-content</th>
<th>No. of stages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1’000-60’000</td>
<td>65’000-270’000</td>
<td>CSTR</td>
<td>PFR</td>
<td>Batch</td>
</tr>
<tr>
<td>AAT</td>
<td>&lt; 10</td>
<td>3’000-55’000</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Arrow Bio</td>
<td>&gt; 10</td>
<td>90’000-180’000</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Biocel'</td>
<td>23</td>
<td>1’000</td>
<td>-</td>
<td>150’000</td>
<td>x</td>
</tr>
<tr>
<td>Biopercolat</td>
<td>1</td>
<td>35’000</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Biostab</td>
<td>13</td>
<td>10’000</td>
<td>-</td>
<td>90’000</td>
<td>x</td>
</tr>
<tr>
<td>DBA-Wabio</td>
<td>4</td>
<td>6’000-60’000</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>DRANCO'</td>
<td>17</td>
<td>3’000</td>
<td>-</td>
<td>120’000</td>
<td>x</td>
</tr>
<tr>
<td>Entec</td>
<td>2</td>
<td>40’000</td>
<td>-</td>
<td>150’000</td>
<td>x</td>
</tr>
<tr>
<td>Haase</td>
<td>4</td>
<td>50’000</td>
<td>-</td>
<td>200’000</td>
<td>x</td>
</tr>
<tr>
<td>KOMPOGAS*</td>
<td>38</td>
<td>1’000</td>
<td>-</td>
<td>110’000</td>
<td>x</td>
</tr>
<tr>
<td>Linde-KCA/BRV</td>
<td>8</td>
<td>15’000</td>
<td>-</td>
<td>150’000</td>
<td>x</td>
</tr>
<tr>
<td>Schwarting-Uhde</td>
<td>3</td>
<td>25’000</td>
<td>-</td>
<td>87’500</td>
<td>x</td>
</tr>
<tr>
<td>Valorga'</td>
<td>22</td>
<td>10’000</td>
<td>-</td>
<td>270’000</td>
<td>x</td>
</tr>
<tr>
<td>Waasa</td>
<td>10</td>
<td>3’000</td>
<td>-</td>
<td>230’000</td>
<td>x</td>
</tr>
</tbody>
</table>

Source: SANDEC, [link](#)
Comparison of options for biological treatment and optimal capacity ranges

<table>
<thead>
<tr>
<th>Food waste options</th>
<th>Annual amount [t] (optimal range)</th>
<th>End-product</th>
<th>Typical energy win</th>
</tr>
</thead>
<tbody>
<tr>
<td>General concept</td>
<td>Minimum</td>
<td>Maximum</td>
<td>Type</td>
</tr>
<tr>
<td>Open windrow composting</td>
<td>n.a.</td>
<td>15.000</td>
<td>compost</td>
</tr>
<tr>
<td>In vessel composting</td>
<td>20.000</td>
<td>&gt;200.000</td>
<td>compost</td>
</tr>
<tr>
<td>Wet AD systems</td>
<td>30.000</td>
<td>&gt;200.000</td>
<td>digestate liquid</td>
</tr>
<tr>
<td>Dry AD systems</td>
<td>20.000</td>
<td>&gt;200.000</td>
<td>digestate</td>
</tr>
<tr>
<td>Integrated AD-A</td>
<td>20.000</td>
<td>&gt;200.000</td>
<td>compost</td>
</tr>
</tbody>
</table>

Source: ISWA  Food Waste As A Global Issue, [link](#)
MECHANICAL – BIOLOGICAL TREATMENT
Basic flow-sheets of MBT

Residual waste → Screening → Small size materials (high moisture; high fermentability) → Biological stabilisation

“MT” → Coarse materials (low moisture, low fermentability) → Density refiner → RDF

“BMT” → MBT → Biostabilised fraction

Biodried fraction

Rejects → Recyclables → MRBT
MBT: key role

- Europe: more than 330 plants, 33 million Mg treated
  - Italy has the higher treatment capacity all over the world
  - The specific treatment costs including residual waste disposal in most plants with MBT technology are approximately 80 to 120 €EUR/Mg

- Case studies outside Europe: Thailand, Buenos Aires (1,000 t/day)

- Key role:
  - Transition phase before implementing source separation of organics
  - Quick solution for avoiding methane emissions (aerobic biostabilization): compliance with national regulations (e.g. European Landfill Directive)
  - Possibility of recovering dry recyclables with new technologies

Source: MBT Outlook, [link]
MBT as a transition

- MBT for source-separated organics
- Anaerobic digestion
- Composting
- MRBT for the residual
- Subsidies for renewable energy
- Towards Zero Waste

Landfill bans / taxes

Landfilling
MBT with biostabilisation: general issues

**Biostabilisation**

- Impurities entering in the biostabilisation process -> Transmission of contaminants to biowaste -> Low quality of the biostabilized organic obtained. Can be used for one-off applications or for land reclamation, but if quality is poor, destination is landfill again

- High loss of organics in pre-treatment or post-treatment

- Important quantities of refuse (45-55%)

- In order to get to a good final product (to be used not in landfill) there is need for some expensive technologies for pre- and post- treatment… try to look at the overall economic balance
Compost from FW+GW has a wide acceptance in almost all the applications (except for substrate preparation). That differs from the most restricted applications of compost made of Organic Matter contained in Residual Fraction.

Fuente: Gea, 2005, modified.
AD applied to mechanically selected organic fraction of MSW: general problems

- Insufficient elimination of contaminants
- Constantly clogged pipes
- Floating layers and massive sediments in the digester
- Inefficient mixing of the material in the digester
- High loss of organics in the separation resulting in low biogas yield
- Quality and final use of the organic amendments obtained
- Important quantities of refuse (45-55%)
An MRBT: Ecoparc 4, Barcelona

Municipal Solid Waste

VIDEO Ecoparc 4 in operation: [LINK]

Ecoparc 4, Barcelona. Info: [link]
MRBT: key issues

- quantity (5-20%) - quality of the separated recyclables is strictly dependent on:
  - Separation technology (optical, densimetric, balistic…)
  - Level of source separation performed by citizens
- Worldwide, MRF are more spread and common (selection of commingled dry recyclables)
- MRBT used for mixed MSW are a recent innovation (Ecoparc 4 and others)
MBT: CASE STUDY
ECOPARCS, CATALUNYA
Case study AMB: 4 Ecoparcs to treat biowaste/MOR

**AMB** 33 municipalities, 3,161,812 inhabitants, 5,031 inh/km²

**Ecoparc 1:** 245,000 t/y (160,000 RF; 85,000 OF) AD OF/Bioestabil. ORF

**Ecoparc 2:** 260,000 t/y (160,000 RF; 100,000 OF) AD OF/Bioestabil. ORF

**Ecoparc 3:** 198,000 t/a RF AD ORF/incineration

**Ecoparc 4:** 360,000 t/y (285,000 RF; 75,000 OF) Comp OF/Bioestabil. ORF

2010 Re-engineering only AD of sep. biowaste and other improvements

OF: Organic Fraction RF: Residual Fraction ORF: Organic contained in RF
Ecoparque 4- Mass Balance

- Operation starting: Nov. 2011
- Investment: 58,679,302.30€
- Gate-fee: 70€/t

46% Refuse sent to landfill

14% Quantity-Quality materials

7% Application/destinations?

http://www.consorciecop4rc.cat/
Improvements planned for Ecoparcs-AMB

Applied improvements
• AD only for organics separated at source, previous shredding
• Reduction of the final refuse:
  • Increase of the dry materials recovery
  • Reduction of organic flows losses

Potentialities
• Application of digestate directly to agricultural use
• Co-digestion of agro-food waste to increase biogas production
• Uses and quality of organics in RF including the energetic (biogenic fuel) and of biostabilized
• Use of refuses for Refuse-derived fuel (RDF), refineries 2nd generation
CASE STUDY: MBT OF BUENOS AIRES
MECHANICAL BIOLOGICAL TREATMENT FACILITY
• MBT facility inside Complejo Ambiental Norte III, project data:
  – 1000 t/d of MSW, 310 days/ year.
  – 3 lines with 333.33 t/d capacity each.
  – 115 operators in 3 shifts / day

• targets:
  – Treat MSW to recover recyclable materials, reduce weight and volume of rejects to be disposed of into landfill, extending its operational capacity for the following years.
  – Stabilize the organic putrescible fraction with a biologic process, reducing its potential generation of leachate and biogas.
PLANT CAPACITY

Planned to treat 310,000 tonnes/year, so:

- 1000 t/d
- 333.33 t/d for each line
- 20.83 t/h for each line
- 62.5 t/h total
- 115 operators in 3 shifts
Separation of MSW with three lines, each of them includes a screen to separate the organic fractions (undersieves < 80 mm) and dry overscreen (> 80 mm)

The dry fraction then passes through a manual sorting line for recovering recyclable materials.

The organic fraction is biostabilised by means of a Goretex cover system, with continuous monitoring of moisture, oxygen and temperature.

The biostabilised fraction is used as a cover layer of the landfill.

The unrecoverable rejects are sent to landfill.

Surf. Separation: 1.04 Ha
Surf. Biostabilization: 0.94 Ha

The process is performed in enclosed windrows with air treatment by biofilter.
PROJECT DESCRIPTION

- General layout
PROJECT DESCRIPTION

1. Truck unloading area

2. Separation of bulky waste and feeding of MSW to the plant with a crane
PROJECT DESCRIPTION

3 Bag opening with a dedicated machine
PROJECT DESCRIPTION

4. Mechanical separation of organic fraction / dry inorganic fraction

Screen size 80 mm
Manual separation of materials for reuse / recycling:
- Paper
- Cardboard
- Plastics
- Glass

Mechanic separation of recyclables:
- Ferrous metals
- Non ferrous metals
PROJECT DESCRIPTION

7 Pressing of selected materials
PROJECT DESCRIPTION

8 Bioestabilization of Organic Fraction
Biostabilization of Organic Fraction

Process:
- 12 cells of 1.398 m³
- Retention time: 20 - 25 days

Parameters monitored:
- Temperature
- Moisture
- pH
- O₂
- C/N ratio
PROJECT DESCRIPTION

- Products

Receivables sold on the market

Rejects to landfill

Biostabilized for landfill cover
Air treatment – BIOFILTER
Muchas Gracias
Ing. Marcelo E. Rosso
Gerente de Nuevas Tecnologías
Y Control Ambiental
CEAMSE
Email: mrosso@ceamse.gov.ar
COLLECTION COSTS AND OPTIMIZATION TOOLS (MARCO)
### Overview of collection cost with different schemes for biowaste

<table>
<thead>
<tr>
<th></th>
<th>Bring- scheme</th>
<th>Door to Door (Mediterranean)</th>
<th>Door to Door (Central Europe)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Separate collection inside kitchen</strong></td>
<td>Kitchen caddy optional</td>
<td>Kitchen caddy necessary</td>
<td>Kitchen caddy optional</td>
</tr>
<tr>
<td><strong>Containers for sep. collection</strong></td>
<td>Wheely-bins or road container for all</td>
<td>Buckets Wheely-bins for high-rise only</td>
<td>Wheely-bins for all houses</td>
</tr>
<tr>
<td><strong>Collection vehicle</strong></td>
<td>Compacting (commingled food- and gardenwaste)</td>
<td>Non-compacting</td>
<td>Compacting</td>
</tr>
<tr>
<td><strong>Separate collection</strong></td>
<td>Low-medium</td>
<td>High</td>
<td>High (but includes also garden waste)</td>
</tr>
<tr>
<td><strong>Quality of biowaste (non-compostable materials)</strong></td>
<td>Medium – high</td>
<td>Low</td>
<td>Low-Medim</td>
</tr>
</tbody>
</table>
Cost analysis: lesson to be learned

- Collection costs
- Investments
- Gate - fees (compost, disposal, etc)

separate single items!
Disadvantages of commingled collection of food- and garden waste

- Seasonal fluctuations
- Same gate fee

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Waste</th>
<th>Collection (kg/inhab)</th>
<th>Composting (€/t)</th>
<th>Cost (per inhab)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediterranean (DtD)</td>
<td>Foodwaste</td>
<td>75</td>
<td>90</td>
<td>€ 6,75</td>
</tr>
<tr>
<td></td>
<td>Garden waste</td>
<td>35</td>
<td>45</td>
<td>€ 1,58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110</td>
<td></td>
<td>€ 8,33</td>
</tr>
<tr>
<td>Central Europe (DtD)</td>
<td>Biowaste (Food and Garden waste)</td>
<td>110</td>
<td>90</td>
<td>€ 9,90</td>
</tr>
</tbody>
</table>

Difference in cost per inhab/yr 19%
Economics of biodegradable bag use

FAMILY BIOBAGS

ADDITIONAL COST RELATED TO THE USE OF BIODEGRADABLE BAGS:

some 10-12 €/ton collected

ADDITIONAL OPERATIONAL COSTS AND FEES PLAYED BY COMPOSTING PLANTS FOR POLYETHYLENE BAGS DELIVERY:

some 15-20 €/ton delivered
Lessons to be learned

- Cost-assessment per unit weight NOT the best indicator – cost per inhabitant (or household) much more significant
  - At a given cost per inhabitant, waste minimisation might misleadingly show a higher “cost per tonne”
  - Higher cost per kilo of biowaste exerts a positive effect on lower costs for residual waste
MSW management in Veneto Region - 2000

Source: ARPAV - SAPM analisi Comuni in tariffa 2002; sett. 2002 Venezia
Cost comparison for road container and door to door collection (from Italy)
Assessment of performances for source-separation of foodwaste-only schemes

- Innovative schemes for source separation focusing on intensive collection of foodwaste
  - High captures,
  - Good quality (low non-compostables)
  - Low costs for collection

- High density of food waste alone implies lower costs for its collection
  - Pick-up time is much lower with hand-loading
  - Open lorries are adopted instead of packer-trucks
Solution

- Small-size receptacles (at detached houses)
  - No delivery of garden waste – to be tackled through separate, cheaper schemes
  - High density of food waste

- Fast hand-picking

- Low cost for collection – small lorries needed

- Higher frequency for collection possible
  - Higher captures
  - Simplified schemes for the collection of residuals
Resuming: tools for intensive SS of foodwaste:

- **Buildings up to 6 families (HH)**
  - Compostable bags
  - Vented kitchen-caddy 20-30 liter buckets

- **Buildings with Flats/appartments**
  - Compostable bags
  - Vented kitchen-caddy 120/240 liter HDPE wheelbins
## Optimising collection of foodwaste

<table>
<thead>
<tr>
<th>Tool</th>
<th>Details</th>
<th>Applies where…..</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of the frequency of collection</td>
<td>Effective systems to collect biowaste – letting people feel comfortable - make its percentage in residual waste fall down to 10-15 % and less.</td>
<td>…captures of FOOD waste are increased</td>
</tr>
<tr>
<td>for residual waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of bulk lorries instead of compactors</td>
<td>Bulk density of food waste on its own is much higher (0.7-0.8 kg/dm³) than when biowaste is composed of both food and garden waste</td>
<td>…tools for collection of food waste prevent large deliveries of garden waste – use of small buckets at houses with gardens</td>
</tr>
<tr>
<td>Reducing unit pick-up time</td>
<td>The use of buckets implies hand pick-up, much less time-consuming than mechanical loading of bins</td>
<td>…food waste collected separately from garden waste, in small receptacles</td>
</tr>
</tbody>
</table>
Integration of food waste and residual waste collection

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional MSW collection</td>
<td>3 times/week</td>
</tr>
<tr>
<td>Residual &amp; Foodwaste collection</td>
<td>1 times/week (residual waste)</td>
</tr>
<tr>
<td></td>
<td>2 times/week (food waste)</td>
</tr>
</tbody>
</table>
Cost of different collection vehicles
Gastos para vehículos de recogida

<table>
<thead>
<tr>
<th>Collection of residual waste</th>
<th>Compactor</th>
<th>Details</th>
<th>Collection of foodwaste - only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 – 20 m³, 2 axes, back-loader</td>
<td>main data</td>
<td>Non-compacting vans</td>
</tr>
<tr>
<td></td>
<td>5 – 8</td>
<td>Load (t)</td>
<td>4 – 6 m³, 2 axes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Compaction</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Lifting device (for wheel-bins)</td>
<td>Yes</td>
</tr>
<tr>
<td>Investment cost (€)</td>
<td>95.000 – 110.000</td>
<td>32.000 – 40.000</td>
<td></td>
</tr>
<tr>
<td>Running cost * (€/h)</td>
<td>25,14</td>
<td>8,68</td>
<td></td>
</tr>
</tbody>
</table>
PD1 – District: average cost for residual and foodwaste management

Traditional MSW collection 3 times/week

Residual & Foodwaste collection
1 times/week (residual waste)
2 times/week (food waste)
cost-assessment – Lombardia Region

- Italy’s largest Region of about 2000 municipalities and 9.8 million inhabitants
- With increasing separate collection rates, the total cost of collection (green bars) remains unchanged in most of the municipalities.
- The costs for processing / treatment / disposal (blue bars) steadily decrease.
Good results both in rural areas (low population density) and in highly urbanized cities

- Lombardy: collection and population density

720 municipalities

- 148 with 1-200 inh/km²
- 162 with > 1200 inh/km²
Biobins – assessment of performances

- The use of biobins usually implies high deliveries of garden waste
- Bins require mechanical loading
- Low density implies adoption of expensive packer trucks – or high costs for transport
- Reduced frequency of collection is therefore considered to save money
- This impairs captures of food waste – fairly high percentages in residual waste
Biobins – assessment of performances

- Collection of VGF or Bioabfall
- Revision of existing frequencies
- Collection schemes
- Break-even only for high disposal costs
Impact of biobin collection on costs (D)

- calculations for typical disposal situations
- Settlement: 1 very urban; 2 very rural
- logistic and treatment costs of the separate collection biowaste and residual waste compared to mixed MSW collection
Impact of biobin collection on costs

- alternate weekly collection of residual and biowaste is cost-competitive provided the average treatment costs for residual of 125 €/t and for biowaste 60 €/t

- in case of insufficient capture rates of biowaste and higher composting cost → an increase of costs can be expected.

- the “design” of collection and transport alone would not permit to maintain costs constant
Collection costs and optimization tools: conclusions

- For double-bin collection (i.e. residual waste & biowaste)
  - the “design” of collection and transport alone would not permit to maintain costs constant
  - System becomes cost-competitive when waste disposal is much higher than composing (or AD)

- For D-t-D Mediterranean collection (with buckets, labourintensive and open-skips)
  - the “design” of collection and transport alone may permit to maintain costs constant
  - Advantages from revision of residual waste collection
  - System becomes cost-competitive when waste disposal is similar to composing (or AD)
Conclusion

- Separate collection of biowaste a PROVEN strategy
- Similar schemes deliver similar results everywhere –
  - Food waste remarkably different from garden waste (fermentability, volume)
    – adopt “fit for purpose” systems
- Separation of food and garden waste shows to be fundamental for optimization
- Intensive collection of food waste may deliver high diversion (fulfillment of the EU landfill targets) and savings on collection
QUESTION TIME
Our organizations links

- Urban Ecology Agency of Barcelona: www.bcnecologia.net
- Waste Agency of Catalonia: ARC www.arc-cat.net
- European Compost Network: ECN www.compostnetwork.info
- SCOW Project www.scow-biowaste.eu
- CIC- Italian Composting and Biogas Consortium www.compost.it
- ISWA : www.iswa.org
- ARS ambiente www.arsambiente.it
Thank you

- For any further information from the presenters:
  
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  - Gemma Nohales: nohales@bcnecologia.net
  
  - Michele Giavini: giavini@arsambiente.it
Please kindly provide your feedback on the webinar by filling in the very brief questionnaire

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