Waste Management in Milan, E.U., Greece and China

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Methods of managing MSW

Waste Reduction

Reuse & Recycling

Anaerobic Digestion

Aerobic Composting

Energy Recovery (WTE)

Modern Landfill Recovering & Using CH₄

Modern Landfill Recovering & Flaring CH₄

Landfills without CH₄ Capture

Unsanitary Landfills & Open Burning

SourceSeparatedMaterials

“Recycling”

“Post-recycling”
“Recycling”: Source-separated wastes that can be used as materials or composted to soil conditioning “compost”

“Post-recycling”: Materials remaining after all possible/practical “recycling”
  – After nearly 100 years of research, only two ways of dealing with ”post-recycling” wastes:
    • sanitary landfilling (LF)
    • thermal processing with energy recovery (WTE)
Example of intensive recycling: Milan, Italy

- Milan is a good example of intensive recycling that the author has observed personally.
- Population of 1.35 million people (2015); 80% live in high rise buildings with several households.
- The city collects five separate streams:
  - three streams of recyclables (paper, glass, and metals with some types of plastics);
  - a fourth stream of compostable organics
  - and a fifth stream of post-recycling wastes combusted at a WTE plant located within the city.
Example of intensive recycling: Milan (cont.)

- Milan provides 5 collection bins to each multi-story building and each house.

- The city also provides to each household a small covered container for temporary storage of food/yard wastes. The compostable bags used in these containers are purchased at supermarkets and other stores, at €0.10/bag.
Recycling regulations in Milan are strongly reinforced by regular inspections by the city government of the materials discarded in the various recycling bins. Infractions are heavily fined, e.g., by a $200 fine on a building, which at the end of the year is divided among the households in the building.

The Milan recycling infrastructure and citizen participation have resulted in one of the best waste management systems in Europe.

The results of this intensive recycling are shown in the following table.
## Results of intensive recycling of Milan

<table>
<thead>
<tr>
<th>Materials collected</th>
<th>Tons/year</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>78,000</td>
<td>9.6%</td>
</tr>
<tr>
<td>Plastics &amp; metal</td>
<td>44,000</td>
<td>5.4%</td>
</tr>
<tr>
<td>Glass</td>
<td>65,000</td>
<td>8.0%</td>
</tr>
<tr>
<td><strong>Total recycled</strong></td>
<td><strong>187,000</strong></td>
<td><strong>23.1%</strong></td>
</tr>
<tr>
<td>Composted</td>
<td>141,000</td>
<td>17.4%</td>
</tr>
<tr>
<td><strong>Total recycled and composted</strong></td>
<td><strong>328,000</strong></td>
<td><strong>40.4%</strong></td>
</tr>
<tr>
<td>Post-recycling waste to Silla 2 WTE Power Plant</td>
<td>483,000*</td>
<td>59.6%</td>
</tr>
<tr>
<td>Total MSW, tons/year</td>
<td>811,000</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
How urban wastes are managed in various countries?

• We call the following graph: "The ladder of sustainable waste management"

• The nations higher up the "Ladder" are doing less or no landfiling
"Ladder" of sustainable waste management of nations (2016)

Recycling and composting

Landfilling

Switzerland
Japan
Sweden
Belgium
Denmark
Netherlands
Germany
Singapore
Austria
Norway
Estonia
Finland
Luxembourg
United Kingdom
France
EU (27 countries)
EU (28 countries)
Italy
Poland
Hong Kong
Czech Republic
Hungary
Lithuania
Spain
China
United States
Bulgaria
Latvia
Slovakia
Canada
Cyprus
Croatia
Romania
Greece
Turkey

U.S.A.
Similarity between denying “Climate Change” and opposing “Waste to Energy”

- The vast majority of scientists believe that carbon emissions cause climate change.
- The vast majority of scientists in sustainable waste management believe that WTE is much preferable to landfilling (LF).
Most deeply rooted misconceptions

1. Humans do not cause global warming (despite all scientific evidence and several national multi-billion dollar disasters)

2. You do not need either landfilling or waste-to-energy. All that is needed is 100% recycling (despite the fact that no city or country has even come halfway close to this goal)
If WTE is much preferable to LF why over 80% of global urban wastes go to landfilling?

No. 1 reason:

- Waste dumping costs practically nothing
- Sanitary landfilling can be done for an overall cost of $30 to $40 per ton (depending on biogas capture)
- Because of the high initial capital investment, WTE requires a gate fee of $60 per ton, at $60/MWh of electricity; and $40/ton, for $100/MWh

Notes:

a) the above costs do not include the “external” environmental costs of landfilling

b) In Greece, on a 20-year horizon, WTE would be more economic than sanitary landfilling.
If WTE is much preferable to LF why over 80% of global urban wastes go to landfilling? (cont.)

No. 2 reason:

- Continuing misinformation within the general public and even policymakers as to the “external” environmental costs of landfilling:
  - Loss of land (estimated at about 400,000 square meters annually for Greece)
  - Greenhouse gas emissions of landfill gas (estimated at 4 million tons CO$_{2\text{equ}}$ for Greece)
  - Severe dioxin and mercury emissions during unintentional landfill fires (about three thousand fires annually, in the U.S.)
No. 2 reason (cont.):

- Misinformation against WTE is spread by well-intentioned “environmental” organizations who believe that WTE conflicts with recycling. They effectively perpetuate landfilling.

- Sanitary landfilling is a very profitable industry. It can afford strong lobbying and public relations to ensure its future well being.
The E.U. has put in place directives which should phase out landfilling in the first half of this century.

Some EU members have already phased out landfilling, as shown in earlier graph.

Some others have not moved, even though they have to pay large fines for non-compliance.

- Landfilling: 25.3%
- Recycling: 29.5%
- WTE: 28.4%
- Composting: 16.8%

Greece, 2015: 80% landfilling

2015 EU MSW generation: 243 million tons  
2015 EU population: 510 million  
y-axis: kg per capita
Sustainable waste management in Asia

- Japan was the first country in the world to abolish landfilling by a combination of recycling and WTE.
- South Korea has policies that promote recycling and WTE but still does some landfilling.

Emerging WTE leader in Asia: China:
- National 5-year energy plan includes energy from MSW.
- Credit of $30/MWh for WTE electricity.
- Place for WTE in Belt and Road Initiative (BRI) funding.
Remaining obstacle to expansion of WTE, both in developing countries and, also, in the U.S.

• **Initial capital investment:** Repayment of the capital investment, per ton of MSW processed, is the major cost item of a WTE plant, affecting the gate fee of WTE vs landfilling

• This is true even for the U.S., where the WTE gate fee (e.g. $60/per capita) is a minute fraction (1/1000) of the GDP per capita, because federal and state governments do not participate in waste management infrastructure.
China has gone a long way since the Wang Juliang film “Beijing besieged by landfills”

The past: 500 landfills of Beijing
21st century growth of WTE industry in China
By 2019: 330 WTE plants plus 200 under construction
In the course of the last fifteen years, China has become a major player in the global WTE industry.

China has demonstrated that it is possible to reduce the capital cost of WTE plants by means of:

- Dedicated Industrial and academic R&D
- Rapid growth of industry, instead of custom building one plant at the time
- Assembly line production of WTE equipment
- Favorable national policies (e.g., $30/MWh credit to WTE electricity)
Lower CAPEX offered by Chinese companies makes the WTE technology more cost-competitive with sanitary landfills (for sure in Greece)

• As the use of WTE grows in Asia, it will force developed countries (e.g., U.S., Canada and Australia) to re-consider WTE vs sanitary landfilling, especially with regard to GHG emissions

• Cities in the developing world can skip the sanitary landfill stage and move directly from waste dumps to WTE power plants (e.g. Azerbaijan, Ethiopia, Belarus, Vietnam).
A new energy challenge: What to do with Non-Recycled Plastics (NRP)

• The Chinese ban on “recycled” plastics has certified the known fact that <10% of the global plastic wastes are actually recycled

• Two possible routes for Non-Recycled Plastics (NRP):
  1. Plastics to Energy power plants (PTE)
  2. Pyrolysis of NRP to synthetic oil
Worldwide WTE examples: Copenhagen, Denmark (400,000 tons, ARC)
West Palm Beach, Florida, USA
(1 million tons per year; Babcock Wilcox)
Ningbo WTE plant, China (SUS Environment)
Guidelines for Sustainable Management of Municipal Solid Waste

- A 530-page compendium of accumulated experience in E.U., U.S., Japan, and China. Several case studies

A collaboration of:
- WtERT-Asia and China Everbright
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- Columbia University
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