# PORS 2009

AECOM

## Anaerobic Digestion of Organic Solid Waste at WWTPs

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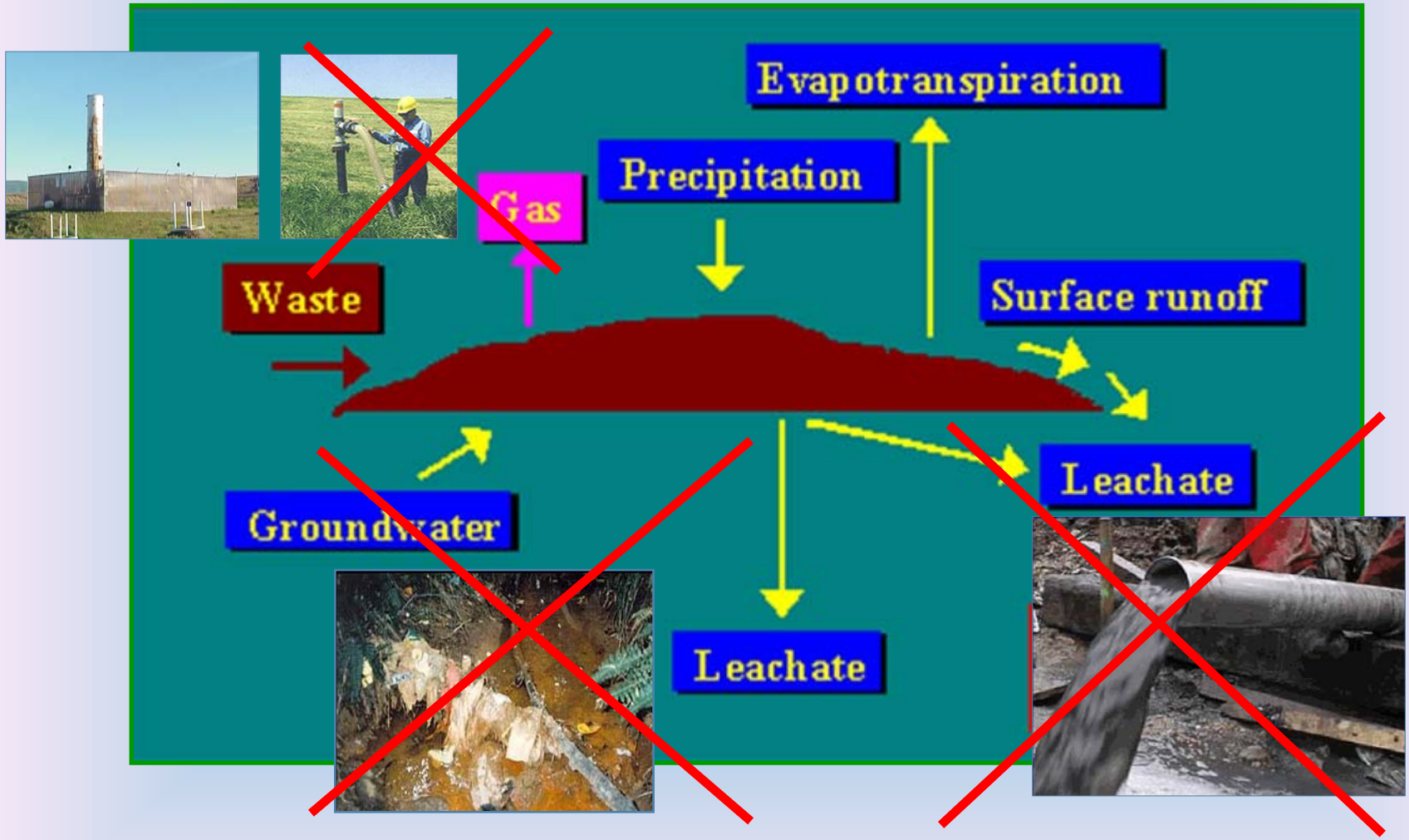
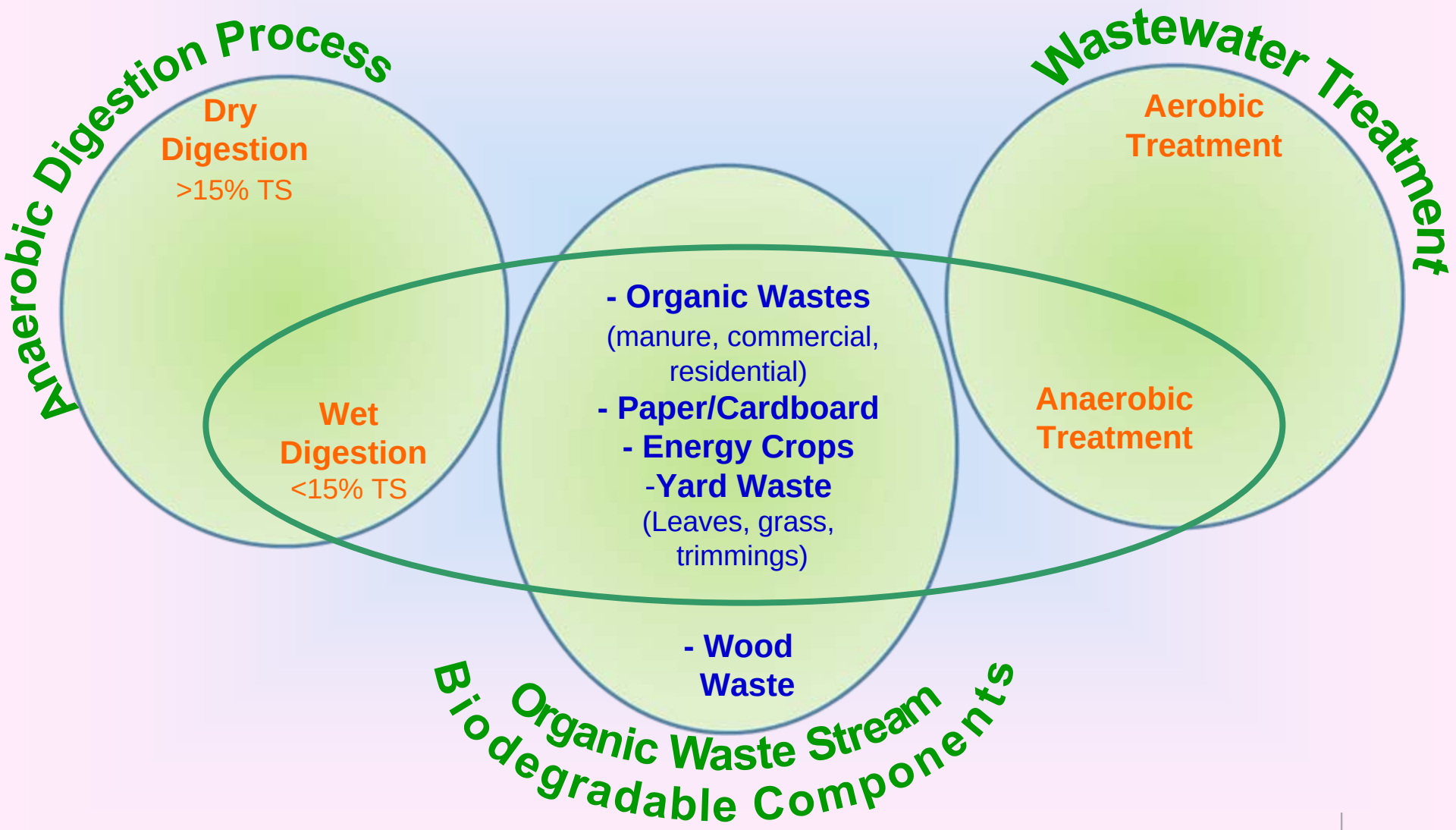
# Outline

- Anaerobic Digestion of Organic Waste
  - » Business as Usual (BAU) - Uncontrolled Digestion
  - » Controlled Digestion
    - Suitable Feestocks & Processes
    - Waste Characteristics and Challenges
    - Pre-treatment Technologies
    - Case Study: Toronto
- Digestion of Organic Solid Waste at WWTPs
  - » The BTA Process
  - » Case Studies
  - » Cost Comparison
  - » GHG Emissions

# BAU - Organic Waste Disposal
# Why Diversion?



# Anaerobic Digestion (AD) at WWTPs
# Suitable Feedstocks and Processes



# Organic Feedstocks & Properties for AD

| |
|---|
| Manure, Sewage Sludge; Food Processing Waste |
| Industrial Sludge (e.g. Thin Stillage from EtOH Production); FOG |
| Commercial Food Wastes (Restaurants; Cafeterias) |
| Slaughter House Wastes |
| Commercial Food Wastes (Groceries; Packaged Waste) |
| Residential Source Separated Organic Waste; Organic Fraction of MSW |

**Increase in total solids (TS) content**

**Decrease in homogeneity**

**Increase in contamination (non-digestible)**

# AD of Organic Solid Waste

## Challenge

Organic solid waste (source separated organics or the organic fraction of MSW) is inhomogeneous and contains impurities

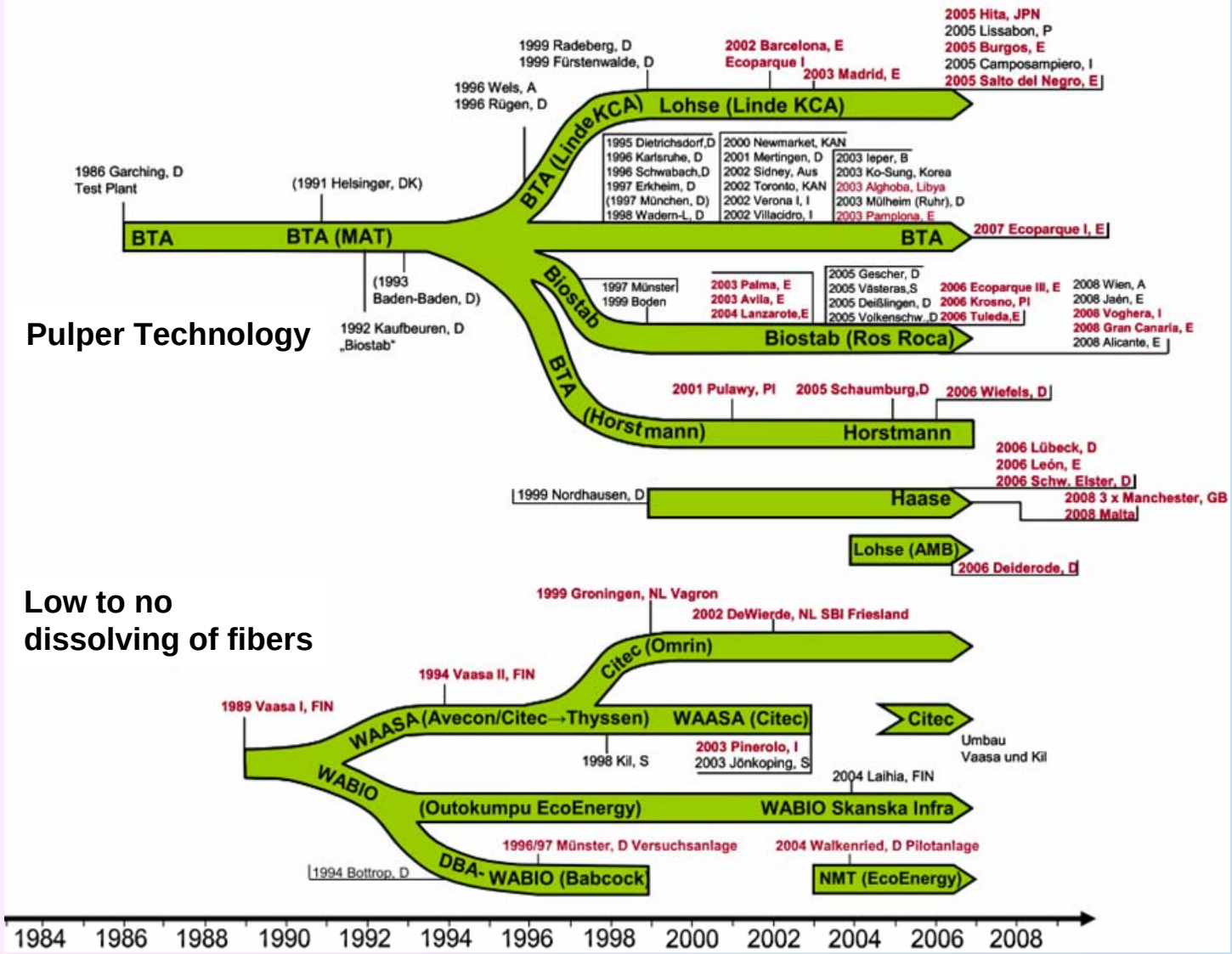
(e.g. plastic bags, textiles, cardboard, stones, sand, bones, shells, glass, metals, batteries)

requiring pre-treatment prior to digestion.

## Solution

Application of a ”Wet Pre-Treatment Process” for effective removal of contaminants and homogenization.

# Historic Development of Wet AD Technologies in Europe




Source: Schu, K. (2008); adapted

# Toronto's Dufferin Anaerobic Digestion Demonstration Plant w/BTA Process

- Commissioned 2002
- 25,000 tpy SSO(Design); 2008: >40,000 tpy*
- Area < 1 Ha
- Building < 2,200m²
- BTA technology
- City owned
- Contractor operated

**Plastics: >10 Percent**

*** Metric tons per year**

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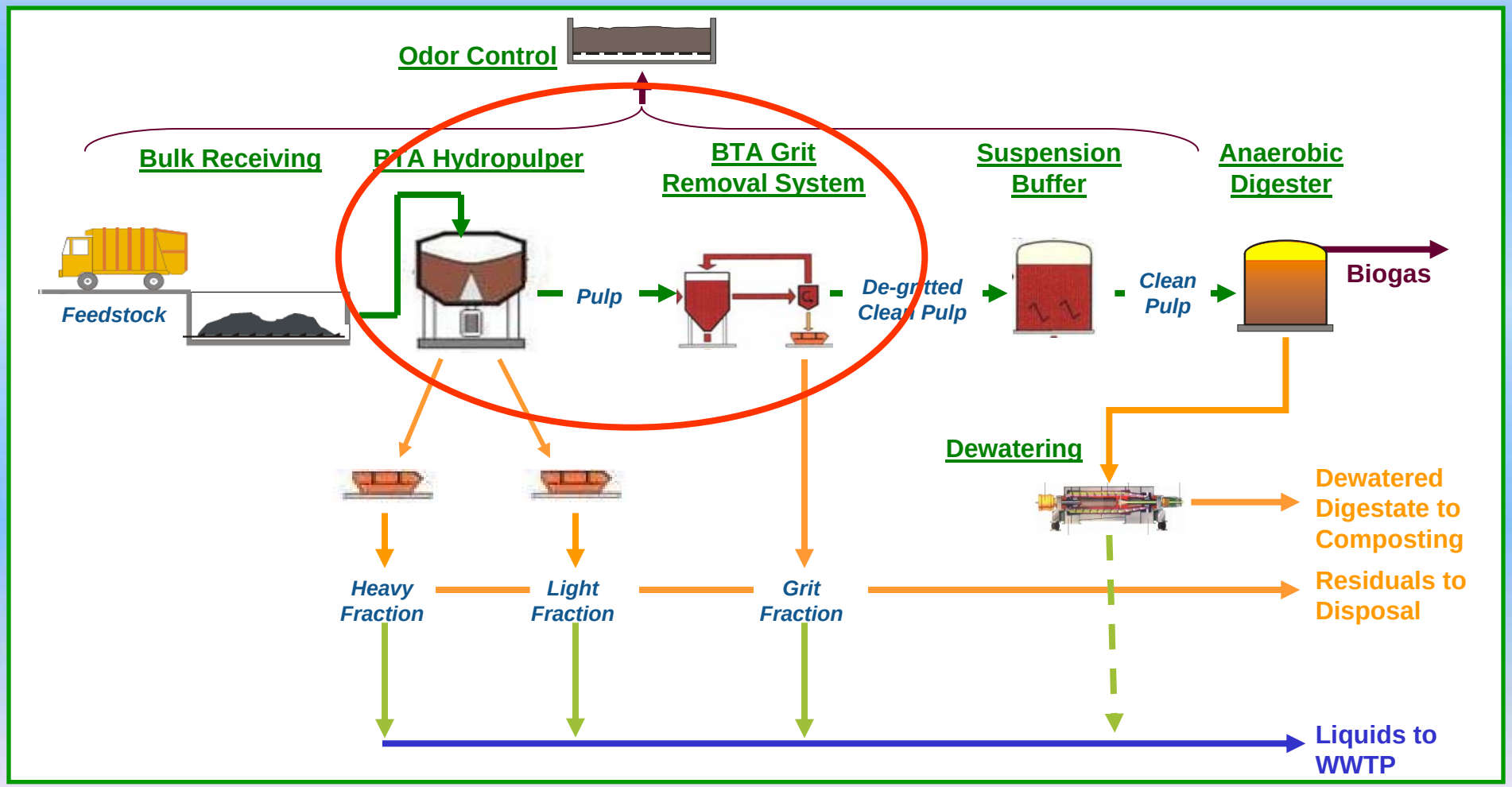
# Technology Application at WWTP

- For example: California has 137 WWTPs with anaerobic digesters and an estimated excess digestion capacity of 15 to 30%*.
- WWTPs are significant energy users with growing future energy demands due to additional treatment requirements (e.g. nutrient removal, UV).
- Co-locating an organic solid waste pre-treatment facility for digestion or co-digestion at a WWTP provides multiple infrastructure and economic synergies.



* Source: Hansen, O. (2006)

# Process Flow Schematic Description of the BTA Process



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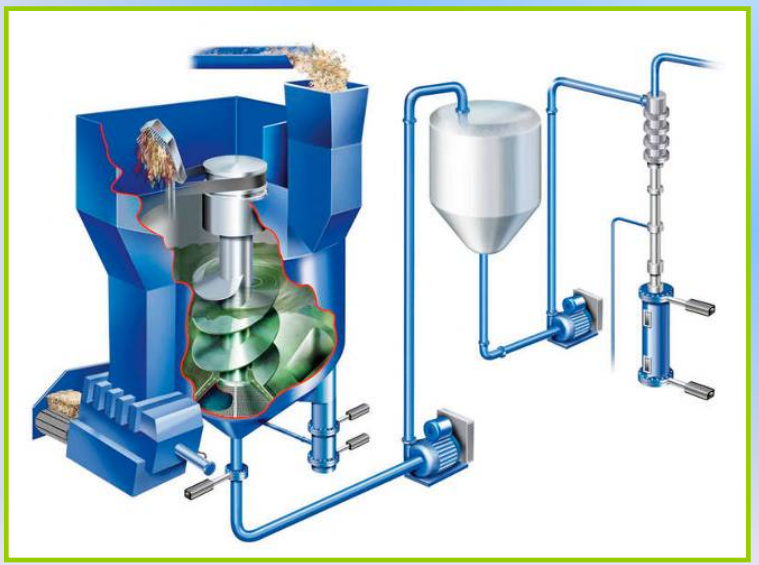
**Inside the pulper**



**Organic waste slurry to be fed into the digester**



Source: BTA International

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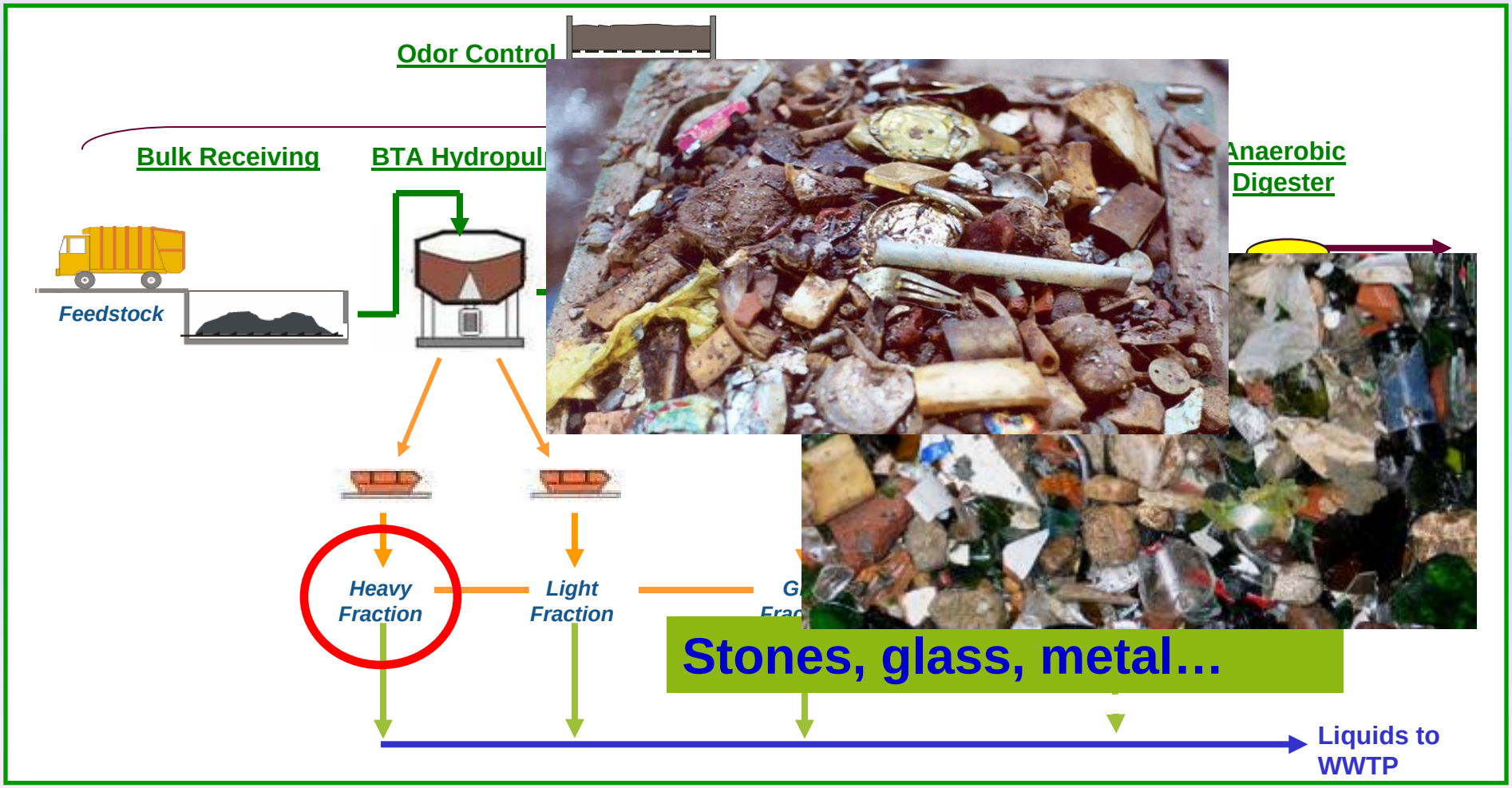

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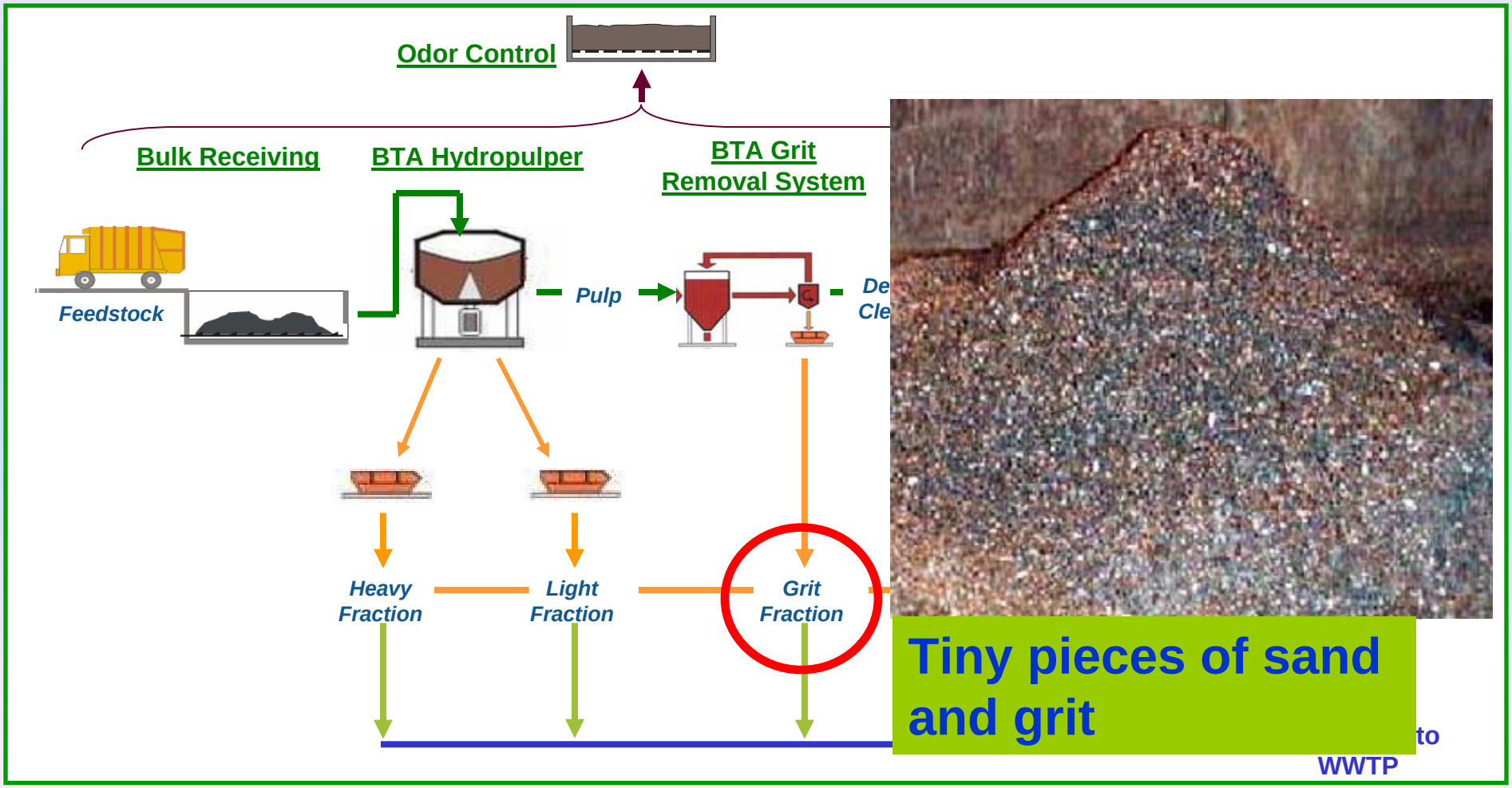


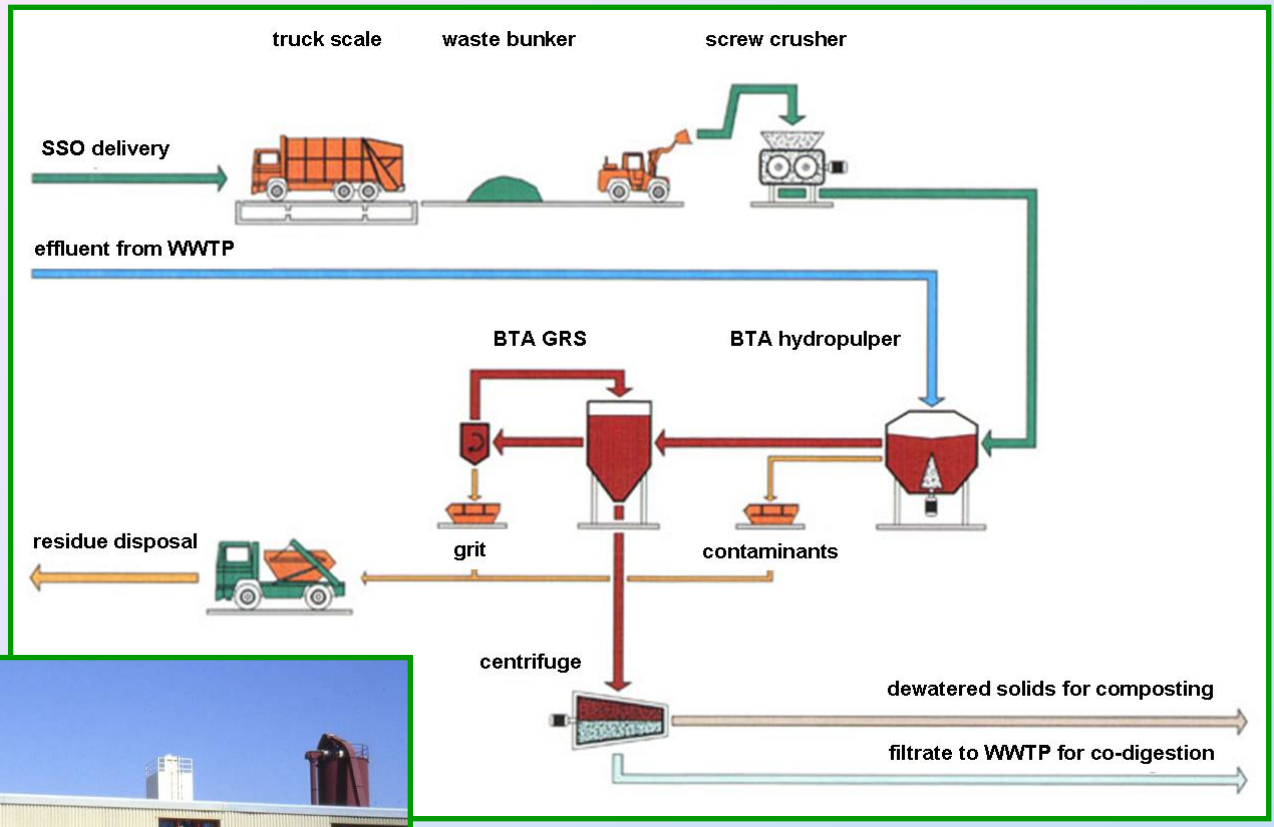
# Case Study: Pre-treatment of SSO for Co-digestion at WWTP, Leoben, A

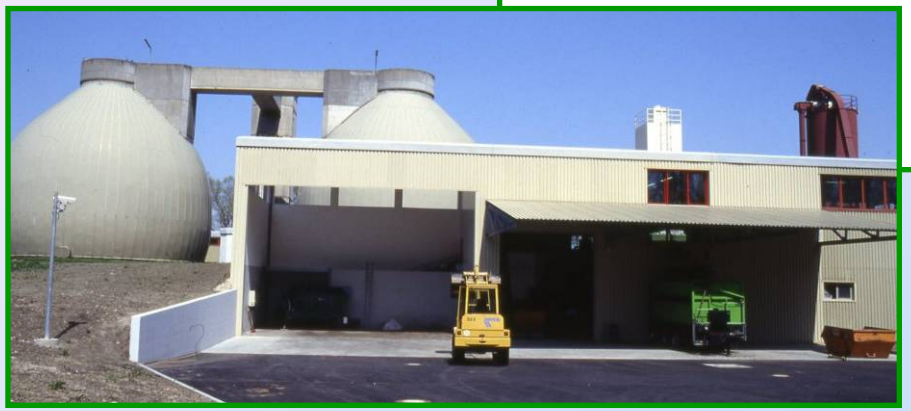
**Start-up:** Spring 2009
**Capacity:** 18,000 MT/yr
**Waste input:**
- Biowaste (residential SSO w/some yard waste);
- Commercial SSO (restaurants; grocery stores, dairy sludge);
- Grass clippings

Source: BTA International

# Case Study: Pre-treatment of SSO for Co-digestion at WWTP, Baden-Baden, D

**Start-up:** 1993
**Capacity:** 5,000 MT/yr
**Waste input:**
- Biowaste (residential SSO mixed w/some yard waste);
- Commercial SSO (primarily from restaurants and cafeterias)



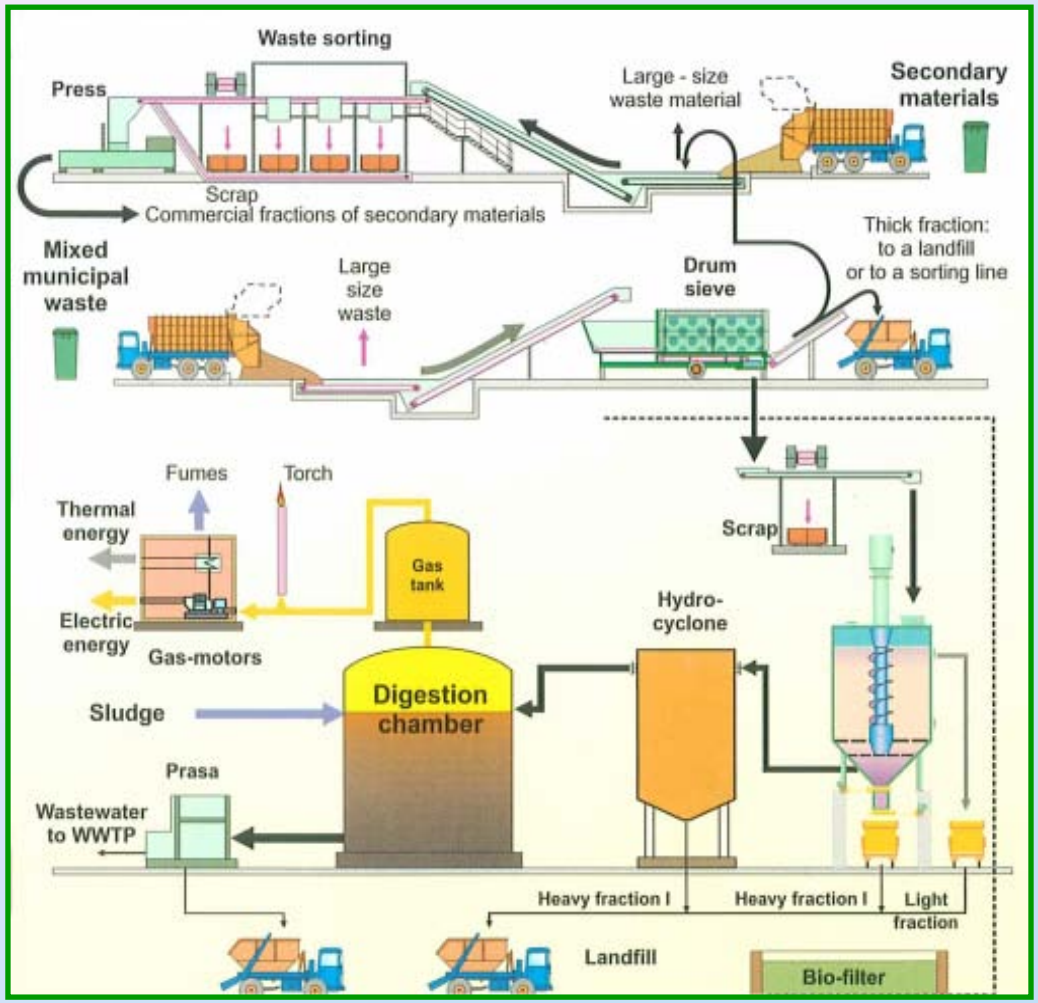





Source: BTA International

# Case Study: Pre-treatment of OFMSW for Co-digestion at WWTP, Puławy, PL

**Start-up:** 2001
**Capacity:** 22,000 MT/yr
**Waste input:** Organic fraction of MSW






Source: Ecoservice

# Cost Comparison – Co-digestion vs. Conventional Biowaste Treatment

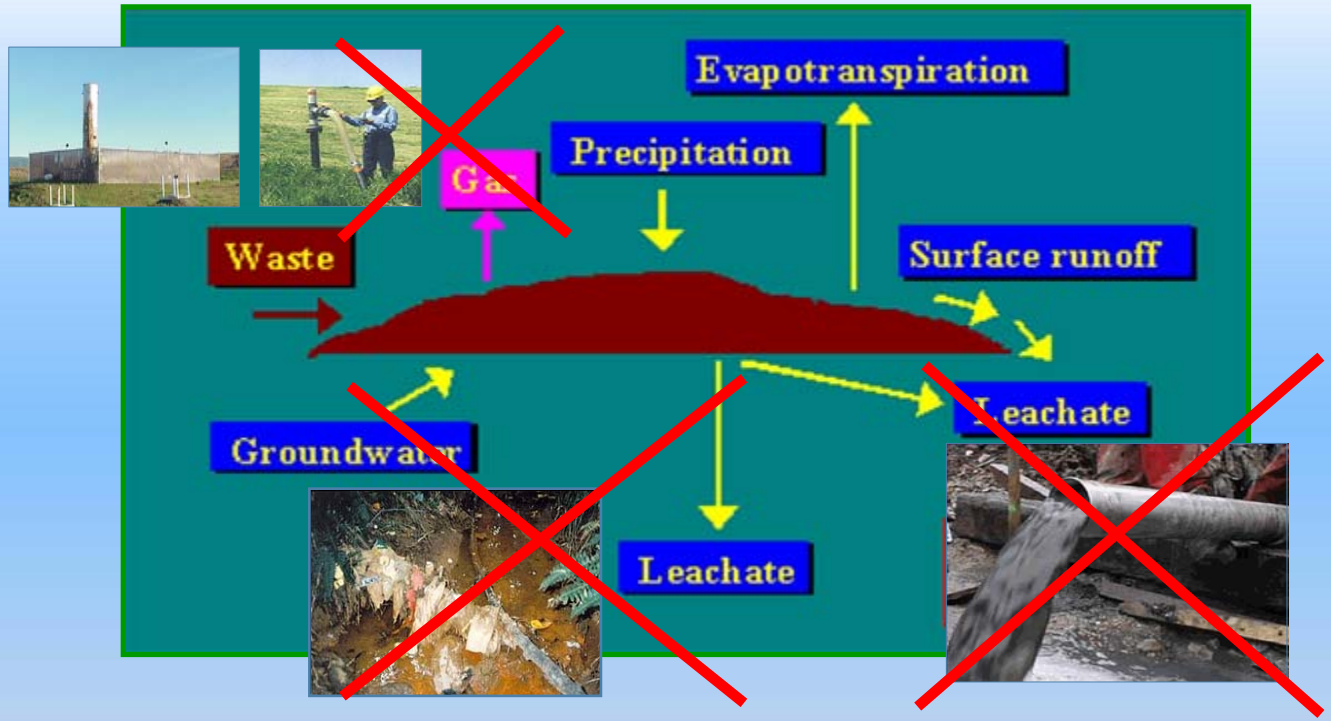
| Type of Installation | Throughput [MT (wet)/yr] | Costs [Euro/MT (wet)] |
|---|---|---|
| Co-digestion Baden-Baden WWTP [a] | 5,000 | ~ 56 |
| Co-digestion Radeberg WWTP [a] | 15,000 | ~ 50 |
| Composting [b] | 15,000<br>30,000 | 85 - 130<br>80 - 110 |
| SSO AD [b] | 10,000<br>20,000<br>30,000 | 125 - 185<br>100 - 135<br>85 - 110 |

[a] Including disposal cost for additionally generated biosolids

[b] Typically without disposal cost for residuals

Source: Schmitt et al. (2007)

# Anaerobic Digestion – Greenhouse Gas Emissions




- Greenhouse Gas Emission Mitigation Strategy
- Avoided Methane Emissions through AD of SSO or OFMSW most likely Eligible for Registration with Climate Action Reserve

# Additional Slides

# Characterizing Features of AD Processes

- **Number of Stages**
  - » Single-Stage
  - » Two-Stage
- **Feed Total Solids (TS) Content**
  - » Wet Process (<20% TS)
  - » Dry Process (>20% TS)
- **Operating Temperature**
  - » Mesophilic Process (approx. 93 - 98 °F or 34 - 37 °C, respectively)
  - » Thermophilic Process (approx. 131 - 140 °F or 55 to 60 °C, respectively)
- **Mixing**
  - » Gas Injection
  - » Internal Mechanical Components (Agitator)
  - » Re-Pumping / Re-Circulation
- **Reactor / Digester Type**
  - » Vertical Positioning
  - » Horizontal Positioning
- **Process Flow**
  - » Continuous Process Flow (fully mixed or plug flow)
  - » Discontinuous/Batch Process Flow

# Organic Waste Recovery

- Commercial & Residential Source Separated Organics
- Objectives & Measures:
- Increase Waste Diversion towards the Zero Waste Goal
- Close the Carbon and Nutrient Loop
- Provide cheap feedstock for renewable energy production
- Develop and implement ordinance & organics collection program
- Educate food establishments, food processors, retailers and residents about organics collection

# Case Study Toronto: Green Bin Program

- Part of City's "Zero Waste to Landfill by 2012 Initiative"
- Green Bin Collection (weekly)
- **Objective:** Maximize Recovery of Source Separated Organics (SSO) through:
  - » User convenience; nothing else to buy
  - » Inclusive material list
  - » Allow for plastic containers (difficult for composting)
  - » Bi-weekly residual waste collection to encourage diversion

**Accepted Material:**

§ fruits
§ meat, shellfish, fish products
§ pasta, bread, cereal
§ dairy products, egg shells
§ coffee grounds, filters, tea bags
§ soiled paper towels, tissues
§ soiled paper food packaging: fast food paper packaging, ice cream boxes, muffin paper, flour and sugar bags
§ paper coffee cups, paper plates
§ household plants, including soil
§ diapers, sanitary products
§ animal waste, bedding (e.g. from bird/hamster cages), kitty litter
§ pet food

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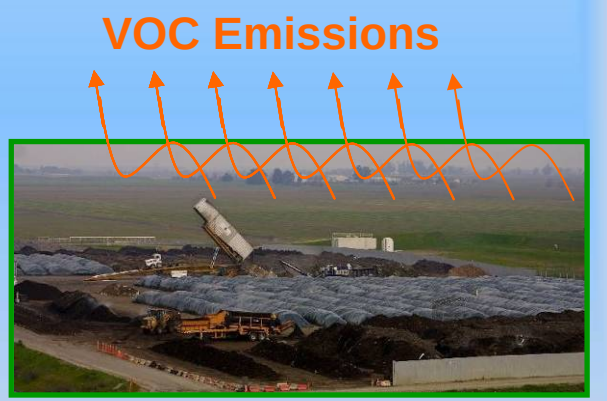
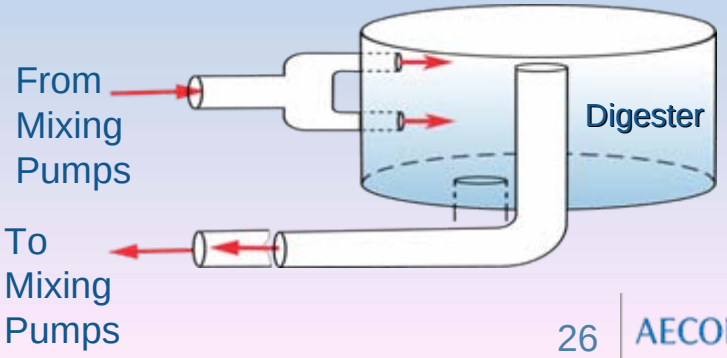
# Toronto's Multi-Unit Residential Organics Collection Pilot Projects

Green Bins

Deep Collection

# Anaerobic Digestion – Aspects to Consider

- Utilization of Additional Biogas On-Site (boiler, CHP)
  - » Challenging due to permitted emission limits
- Effective Odor Control System Required to Comply with AQ Regulations
  => Public Nuisance
- AQ Regulations Limit the Amount of Volatile Organic Compounds (VOCs) Emitted from Composting Operations
  - » AD reduces the volatile solids content of organic waste prior to composting
    => Improvement in air quality and air quality compliance
- Effective Digester Mixing Required:
  - » Prevent formation of dead zones, sedimentation, blankets and foam
    => Evaluation and Enhancement