

Municipal Solid Waste – Disposal Problem or Energy Opportunity?



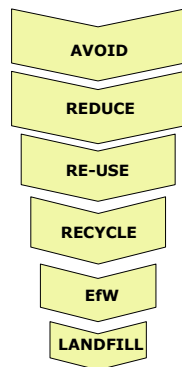
by
Lee Potts
AECOM



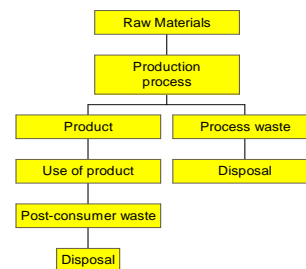
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 - The Waste Hierarchy and a Circular Production & Consumption
- The three parts of MSW
- The energy importance of recycling
- Energy from recycling
 - Option A: Anaerobic digestion of bio-wastes
 - Energy options from biogas
- Energy from residual waste
 - Option B1: Energy from Waste (thermal treatment)
 - Option B2: Mechanical Biological Treatment
- Final thoughts....

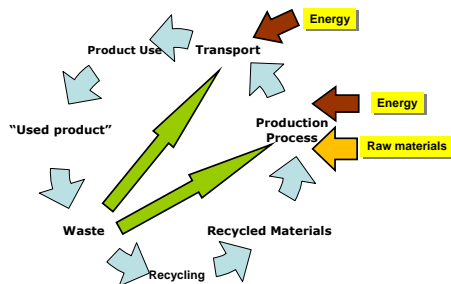
Waste Hierarchy



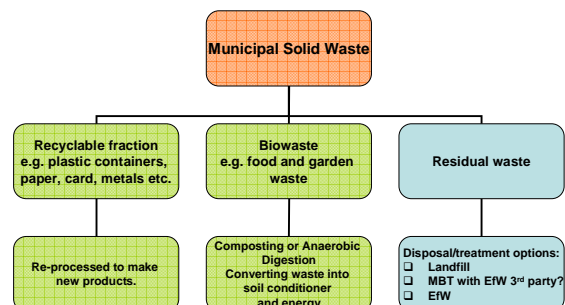
Linear Production & Consumption



Circular Production & Consumption



Three Parts of Municipal Solid Waste



The Recycling Energy Benefits

Material	Energy using virgin materials (MJ/t)	Energy using recycled materials (MJ/t)	% Reduction in Energy Requirements
Unbleached Cardboard	71,321	40,483	43%
Aluminium	241,688	9,668	96%
Glass	15,686	11,503	27%
Steel	22,774	19,637	14%

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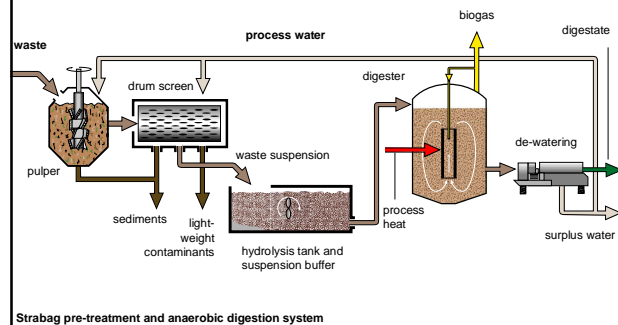
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A1: Food wastes – Commercial and Household Sources

- Kerbside collection of food wastes
 - Households
 - Commercial premises such as restaurants and shops
- Food wastes in mixed MSW are pre-cursors for:
 - Odour formation at landfills
 - Landfill gas production
 - Organics and ammonium in leachate



Anaerobic Digestion of Food Wastes



Biogas Cleaning

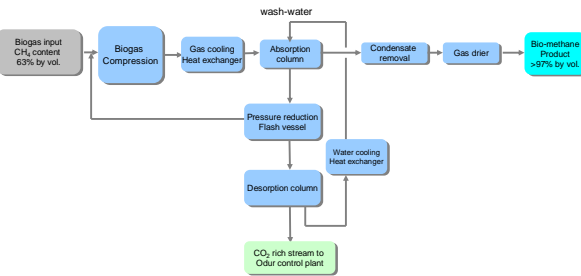
- The need to remove **hydrogen sulphide (H₂S)**
 - Corrosion
 - Odour
 - Strict limits in the upgraded product gas when used in vehicles or when injected into the natural gas grid
- When H₂S concentrations are high, it is normal to have a separate removal stage. Popular methods include:
 - Adsorption onto activated carbon
 - Biological filters
- **Water removal** – normally using condensate knock-out pots
- **Particulates** removal – mechanical filters

Biogas Upgrading

There are a number of biogas upgrading (CO₂ removal) techniques available:

- **Gas scrubbing (absorption)** – CO₂ is absorbed by means of a washing liquid e.g. water or amines.
- **Adsorption** – CO₂ is separated by becoming bound to internal surfaces of adsorbent materials.
- **Membrane processes** – CO₂ is separated due to different permeation rates at membrane barriers.
- **Liquefaction** – CO₂ is separated after being liquefied at very low temperatures leaving the gaseous methane.

Typical Water Based Absorption Biogas Upgrading Process



Bio-methane Usage Options

Source: IEA Bioenergy	Gas Fuelled	Diesel Fuelled (Euro V engine)
Hydrocarbon (g/kWh)	0.03	1.1
NO _x (g/kWh)	0.4	2.0
Particles	0.004	0.03

Gas Grid Pipe

Case study: Hendriksdaal, Sweden

- Waste feed to the AD plant:
 - 27,000 tonnes DS of sewage sludge
 - 25,000 tonnes of fats from the City's grease separators.
 - 2,000 tonnes of food waste from restaurants
- 7 No. anaerobic digesters with a total volume of 39,000 m³.
- Digester HRT is 19 days and they operate at 37°C.

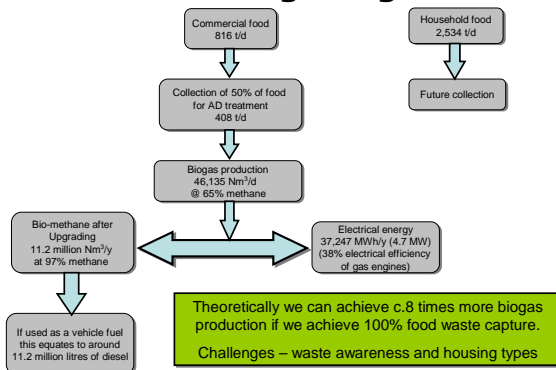


Case study: Hendriksdaal, Sweden

- Pressurised Water Scrubbing upgrading plant.
- Biogas input 1,400 Nm³/h.
- Bio-methane output 900 Nm³/h at 97% CH₄ (by vol.)
- Bio-methane is transported around 2 km by pipeline to the bus company to fuel 120 buses.
- Some bio-methane is transported by pipeline to supply gas to 1,000 apartments.
- Some bio-methane is supplied to filling stations.



Energy Potential of Food Waste AD in Hong Kong



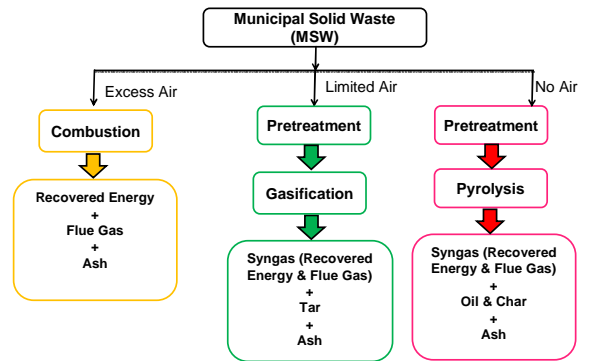
A1: Food Waste AD – the issues

- Reduces environmental impact due to the diversion of food waste from landfill:
 - Landfill gas, leachate quality, odour and vector attraction
- Energy flexibility:
 - Biogas to electricity and heat
 - Bio-methane to the gas grid
 - Bio-methane to vehicles
- The potential of the waste collection vehicles being fuelled on bio-methane – reduction in air pollutants from transport activities and a massive carbon reduction.
- The production of good quality soil conditioner from the digestate residue.

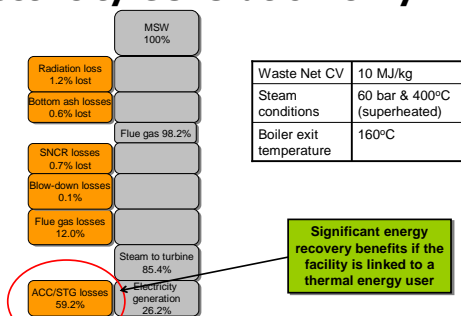
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Thermal Treatment Options

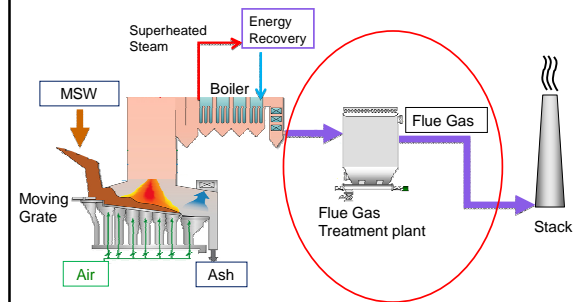


EfW Plant – Energy Balance for Electricity Generation Only



ACC = Air Cooled Condenser
STG = Steam Turbine Generator

EfW Process



Typical Flue Gas Leaving the Boiler and WID Requirements

Flue Gas Inlet		Typical	WID (daily average)
Main components in % v/v			
	CO ₂	11.20	
	H ₂ O	17.3	
	O ₂	8.0	
	N ₂	63.5	
HCl (mg/Nm ³)		800	10
HF (mg/Nm ³)		10	1
SO ₂ (mg/Nm ³)		300	50
Particulate (mg/Nm ³)		3,000	10
NO _x (mg/Nm ³)		300	200
Solid heavy metals (mg/Nm ³)		60	0.5
Hg (mg/Nm ³)		0.7	0.05
Cd + Tl (mg/Nm ³)		3	0.05
Dioxins and furans (ng/Nm ³)		5	0.1

All concentrations expressed at reference conditions 273 K, 101.3 kPa and 11% O₂ dry gas.

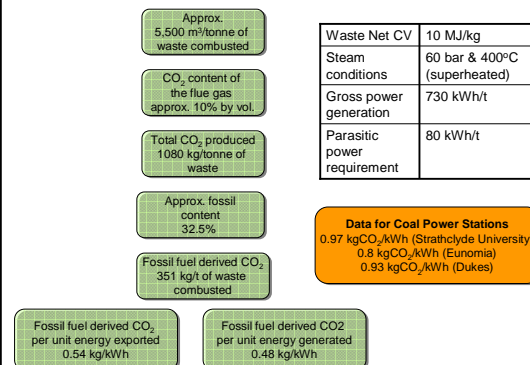
Flue Gas Treatment

- CO & TOC – combustion control.
- Acid gases – three scrubbing options.
- Particulate removal – most common approach is a fabric filter system.
- Heavy metals – activated carbon addition
- Dioxin/furans – combustion control, boiler design, activated carbon and/or catalytic destruction.
- NO_x (NO/NO₂)
 - air control
 - selective non-catalytic reduction using urea and ammonia
 - selective catalytic reduction (SCR) using urea

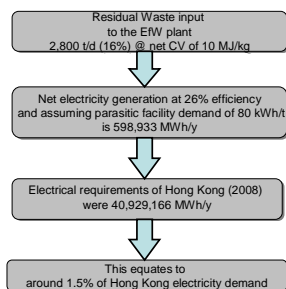
Emissions to Air from Incineration Plants and Waste Incineration Directive Limits

Component	Emissions to air (mg/Nm ³ - except dioxins in ng/Nm ³) (Reference conditions 11% O ₂ and dry gas)				Mean Emissions to Air (E)	% Reduction (Based upon 1991 values) (E - A)
	(A) Measured (UK Best Practice)	(B) Austrian	(C) Dutch	(D) WID		
Particulates	0.9	0.5	2.2	1.0	500	99.8
HCl	2.0	0.6	1.6	1.0	68.9	97.1
HF	<0.1	0.05	0.3	-	N/A	-
SO ₂	3.6	3.5	2.2	5.0	33.9	8.9
NO _x as (NO ₂)	27.4	3.1	2.9	20.0	N/A	-
CO	5	3.0	-	5.0	22.0	9.8
VOC	<5	0.3	-	1.0	N/A	-
Hg	<0.02	0.006	<0.001	0.05	0.25	9.9
Cd	<0.001	0.001	<0.001	0.05 (C & D)	0.6	99.8
Heavy Metals (sum)	<0.1	0.02	0.16	0.5	>11	9.9
Dioxin (toxic equivalence)	0.006	0.032	<0.01	0.1	>225	99.9
NH ₃	-	0.8	<0.1	-	-	-

EfW CO₂ Production



Energy Potential from EfW Plant in Hong Kong



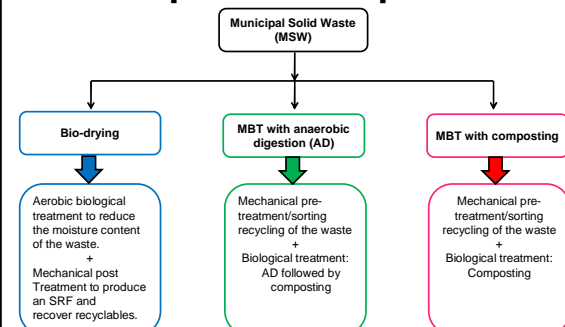
B1: EfW of Residual Waste - the Issues

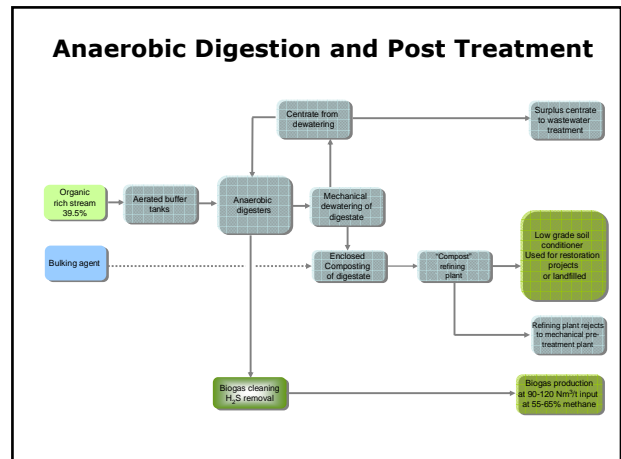
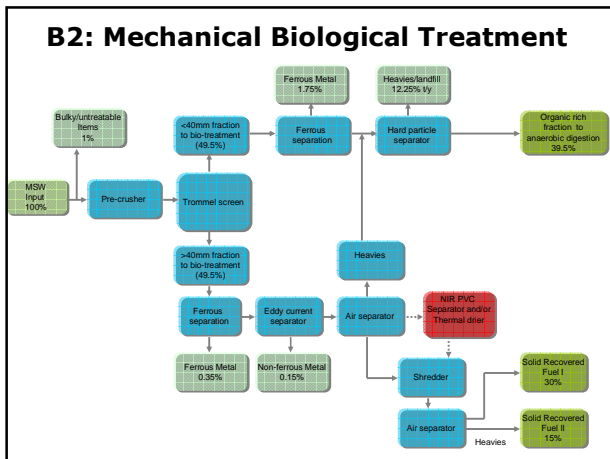
- Public perception
 - Especially concern surrounding emissions to air and health effects
- Sometimes can be considered to be stifling to recycling activities
 - If suitably sized it can work along side recycling activities and developments.
- Minimal residues to landfill
 - Especially with bottom ash recycling
- The benefits of power generation and also the potential for heat use, making the facility highly efficient.
- Climate change benefits compared with a coal fired power station.
- Moving grate technology is extremely robust and reliable (long track record worldwide).

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Popular MBT Options





- ### Two Possible SRF Options
- **Cement Manufacture**
 - Cement kilns generally require a strict standard for substitute fuel requirements.
 - In Europe, 18% of the thermal energy input for cement kilns came from alternative fuels (including SRF type materials). Equivalent to 5 million tonnes of coal.
 - Ash from alternative fuel forms part of the cement clinker
 - Alkaline environment in process helps manage the acid gas release from combusting the waste.
 - **Co-combustion at coal fired power stations**
 - Power station may have to operate to a higher air emission standard.
 - Potential reduction in the operating cost and carbon footprint of the power station.

- ### B2: MBT of Residual Waste - the issues
- Generally less public concern with MBT facilities
 - Potential to capture further recyclables from residual waste
 - e.g. metals and plastic containers (quality issues?)
 - The potential of the "hard" carbon being "locked" into digestate/compost
 - Outputs issues
 - What do we do the SRF/combustible rich stream and low quality conditioner?
 - The need to be reliant on a 3rd party facility.
 - Low quality soil conditioner – is only outlet is landfill cover or restoration?
 - Landfilling of the residues
 - Potentially a large proportion of the waste still requires landfilling.
 - Significant land requirements
 - Odour management
 - e.g. thermal oxidiser or wet scrubber/bio-filtration combination.
 - Potentially higher overall cost compared with EFW
 - The need for two plants (MBT plus thermal treatment solution).

- ### Final Thoughts.....
- **The energy based optimum solution is likely to be:**
 - Materials recycling.
 - Anaerobic Digestion of food waste with biogas upgrading and use of bio-methane as waste collection vehicle fuel.
 - Combustion of the residual waste on a moving grate using state of art flue gas treatment.
 - **Why?**
 - Maximisation of resource (materials & energy) recovery.
 - Minimisation of waste to landfill.
 - No need for third party management of residues.
 - Minimisation of emissions from collection, treatment and disposal activities.
 - Using affordable and reliable technologies.
 - Producing energy from waste in an energy limited world

Acknowledgements

Thank you to Strabag for giving me permission to use their anaerobic digestion related pictures and diagrams in this presentation.

Please note some photographs have been removed to enable to presentation to be clearly seen.

**Municipal Solid Waste –
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Thank you for listening.
Any questions?

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