SMALL SCALE WASTE -TO - ENERGY TECHNOLOGIES

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Executive Summary

The dominant technology for large Waste-to-Energy (WTE) facilities is combustion on a moving grate of “as-received” municipal solid wastes (MSW). However, there are circumstances where a low-capacity plant is required. This study examines the technical, economic, and environmental aspects of some small-scale WTE technologies currently in operation. The investigation included both existing grate combustion plants and novel processes, in particular, the Energos technology.

The Energos technology was developed in Norway, in order to provide relatively small communities with an economically efficient alternative to conventional grate combustion (also called ‘mass-burn’ incineration) with equally low emissions to the atmosphere and flexibility in feedstock. All Energos plants treat MSW plus additional streams of commercial or industrial wastes. Prior to thermal treatment, the materials are shredded in a high-torque, low-rpm shredder and ferrous metals are removed magnetically. The feedstock is partially oxidized on a moving grate in the gasification chamber where the fixed carbon is completely burnt off. The volatilized gases flow into a second chamber where they are fully combusted and the generated heat is transferred to a heat recovery system where steam is produced.

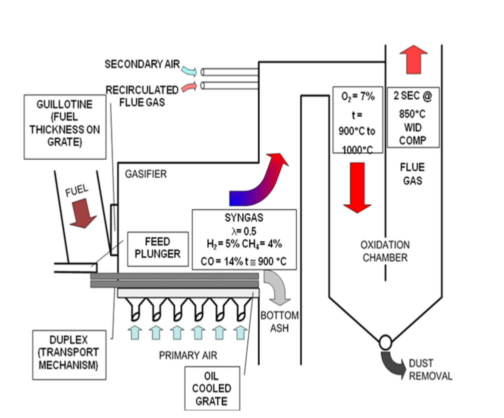
The Energos grate gasification and combustion technology is currently in operation at six plants in Norway, one in Germany, and one in the UK; they range in capacity from 30 tons/day per unit to a high of 118 tons/day per unit. As expected, the capital cost per ton of annual ton of capacity increases with decreasing plant capacity, while there is a linear relationship between energy recovery and capacity. These low capacity WTE facilities require a relatively small footprint of less than one hectare (<2.5 acres) and can be built at a capital cost per ton that is as low, or possibly lower, than that of large mass burn WTE facilities. Some other small-scale technologies examined in this study were the Novo Energy inclined fixed grate combustion technology, the emergence of various small scale thermal processes in Japan (e.g., Ebara), and the modular systems of Envikraft/Scan American Corp., KI Energy, and IST Energy GEM.

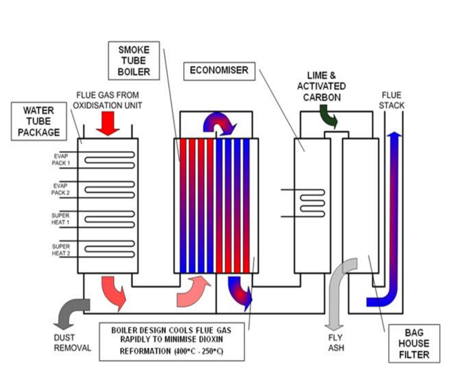
An analysis of a compilation of over 330 WTE plants in Europe by the International Solid Waste Association showed that there are about 170 small scale plants in Europe. It was determined that 84 plants (nearly 25% of the total number of plants included in the ISWA survey) have an annual capacity of less than 50,000 tons and another 85 plants range in capacity from 50,000 and 100,000 tons. The total capacity of these small scale plants is just over 8.5 million tons of feedstock combusted.

By analyzing the ISWA data further, in terms of plants which co-combust MSW with wastes other than commercial and industrial wastes (e.g., hospital waste and sludge cake from wastewater treatment plants), it was concluded that approximately 33% of European waste-to-energy plants in the ISWA survey are small scale plants that co-combust hospital waste. These plants ranged in annual capacity from 5,000 to 95,000 tons and, on the average, hospital waste amounted to about 3% of the combusted materials. Also, of the 24 plants in the ISWA survey that reported co-combusting sludge cake (from wastewater treatment plants) 25% are of low capacity, ranging from 50,000 to 79,000 tons per year. The co-combusted sludge cake ranged from 0.2% to 12% of the total feed.

By assessing these small scale technologies, it was concluded that, under certain circumstances, the construction of small scale WTE plants is beneficial because it avoids the economic and environmental impacts associated with the long distance transfer of waste.

The Energos Gasification and Combustion Technology





Parameter	EU Limits, mg/Nm^3	Energos
Dust	10	0.24
Hg	0.03	0.00327
Cd + Tl	0.05	0.00002
Metals	0.5	0.00256
CO	50	2
HF	1	0.02
HCl	10	3.6
TOC	10	0.2
NOx	200	42
NH3	10	0.3
SO2	50	19.8
Dioxins, ng/Nm^3	0.1	0.001

Plant Location (start up year)	Waste Input Streams	Total Annual Capacity, tons (no. of lines)	Approximate Site Area (m^2)[1]	Thermal Energy Produced (MWh/year)	MWh,th per ton	Investment per ton of annual capacity[2]	Investment per MWh, th produced
Ranheim, Norway (1997)	Paper mill rejects + various commercial wastes	10,000 (1)	N.A.	25,000	2.5	$1,350	$540
Averoy, Norway-Nordmore Region (2000)	Mixed MSW + various commercial wastes	30000 (1)	6,000	69,000	2.3	$1,033	$450
Hurum, Norway (2001)	Mixed MSW + commercial waste from airport + paper rejects	39000 (1)	6,000	105,000	2.7	$657	$238
Minden, Germany (2001)	50% Residual MSW + RDF (paper and plastic waste)	39000 (1)	6,000	105,000	2.7	$673	$243
Forus, Norway-Stavanger Region (2002)	Residual MSW + commercial wastes	39000 (1)	6,000	105,000	2.7	$825	$314
Sarpsborg 1, Norway (2002)	MSW + commercial wastes	78000 (2)	9,000	210,000	2.7	$525	$195
Sarpsborg 2, Norway (2010)	MSW + commercial wastes	78000 (2)	9,000	256,000	3.3	$525	$195

[1] Since site area is project specific, approximate site area has been estimated by use of the following data provided by Energos: Single Line site area is 6,000 sq meters and double line site area is 9,000 sq meters. The data shown in this Table will be further refined during continuing thesis research.
[2] Assuming Investment per ton for Sarpsborg 2 Plant is the same as Sarpsborg 1.

Small Scale Plants in Japan[1]

Japan has made a significant impact worldwide in the development and implementation of thermal treatment processes. Japan thermally treats over 60% of the approximately 65 million tons of MSW it generates, and recycles the remaining 40%27. Though the majority of Japan’s thermal treatment systems utilize the well-known Martin Grate combustion technology, there are several which do not and also operate in small scale, providing further proof that WTE can be economical in low capacity.

Technology	Number of plants	All plants, tons/day	Average tons/day per plant
JFE Volund grate (stoker)	54	10,100	187
Nippon Steel Direct melting	28	6,200	221
JFE Hyper Grate (stoker)	17	4,700	276
Rotary kiln	15	2,500	167
JFE Thermoselect (gasification)	7	1,980	283
All other fluid bed	15	1,800	120
Ebara fluid bed	8	1,700	213

Technology	Number of plants	All plants, tons/day	Average tons/day per plant
JFE Direct Melting (shaft furnace)	14	1,700	121
Hitachi Zosen fluid bed	8	1,380	173
JFE fluid bed (sludge & MSW)	9	1,300	144
All other Direct Melting	9	900	100
Fisia Babcock (2 forward, 1 roller grate)	3	710	237
Babcock & Wilcox air cooled grate	43	690	16

Modular and Microscale Systems

- KI Energy
- IST Energy/GEM
- Envikraft/Scan American Corp.

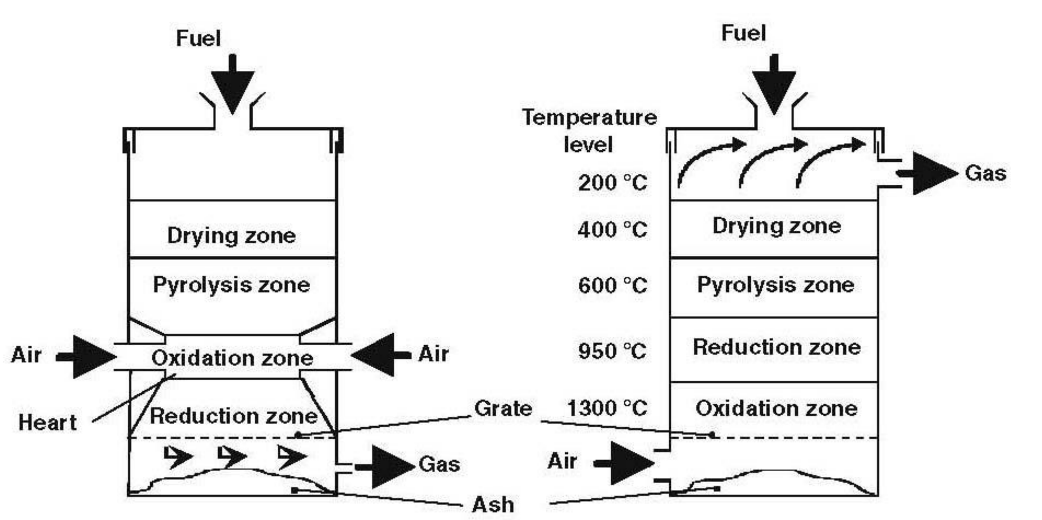
KI Energy

-Fixed Bed Gasifier
-Fluidized Bed Gasifier
-Fluidized Bed Combustor

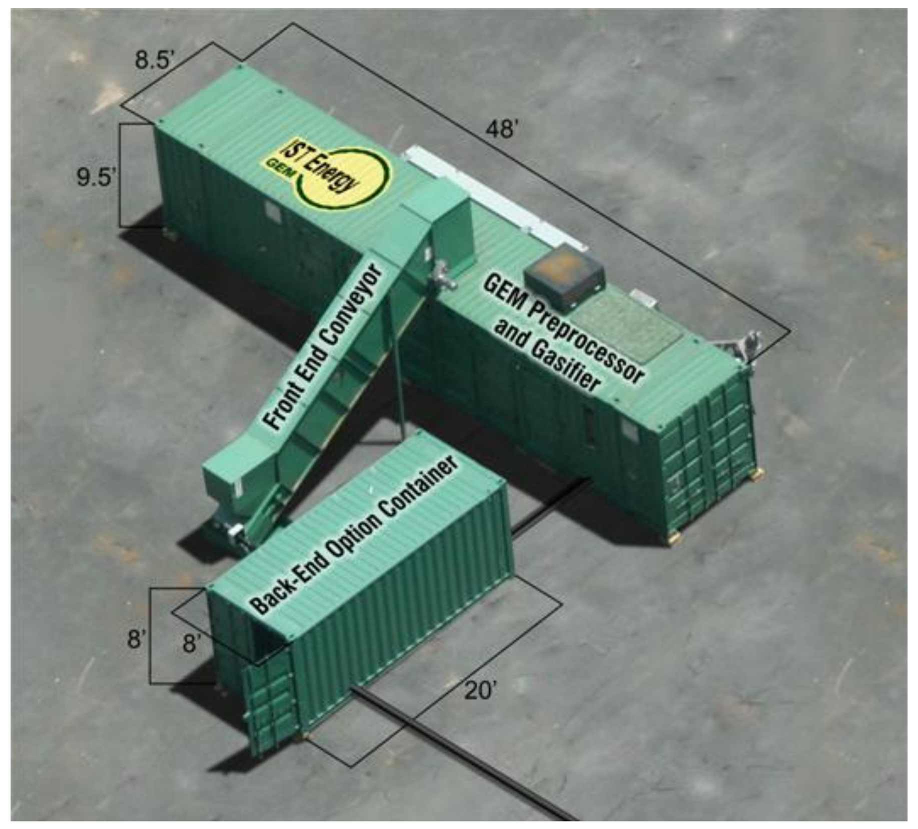
Micro Scale Fixed Bed Gasifier Design Details[2]

-Feedstock: Biomass Woodwaste, Hazel nutshells and Lignites
-Fuel Feeding Rate: 1100 ton/yr
-Thermal Capacity: 300 kWth
-(Electricity) Production: 50 kWe
-Commissioning Date: 2008
-Investment Cost: 750,000 Euros

Fixed Bed Updraft and Downdraft Gasification[3]



IST Energy Mobile GEM (Downdraft Gasifier)

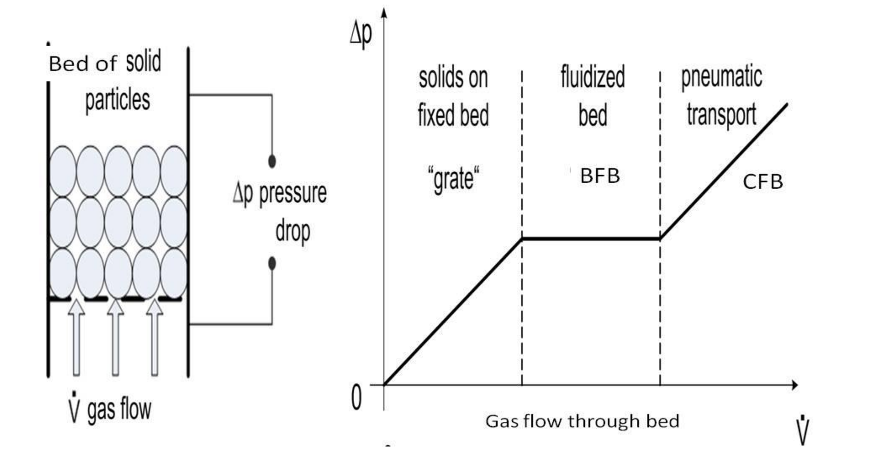


Capacity	3 tons/day
Waste Conversion Rate	200 lb/hr dry
Allowable Moisture Content of Waste	5% to 40%
Nominal Pellet Size	Approx. 1/2"diameter
Combined Heat and Power (CHP) Efficiency	up to 60%
Net Electrical Output - CHP	72 kWe[1]
Net Thermal Output - CHP	614,000 Btu/hr[1]
Net Thermal Output - Boiler	1,200,000 Btu/hr[1]
Max Gasification Temperature	1650° F

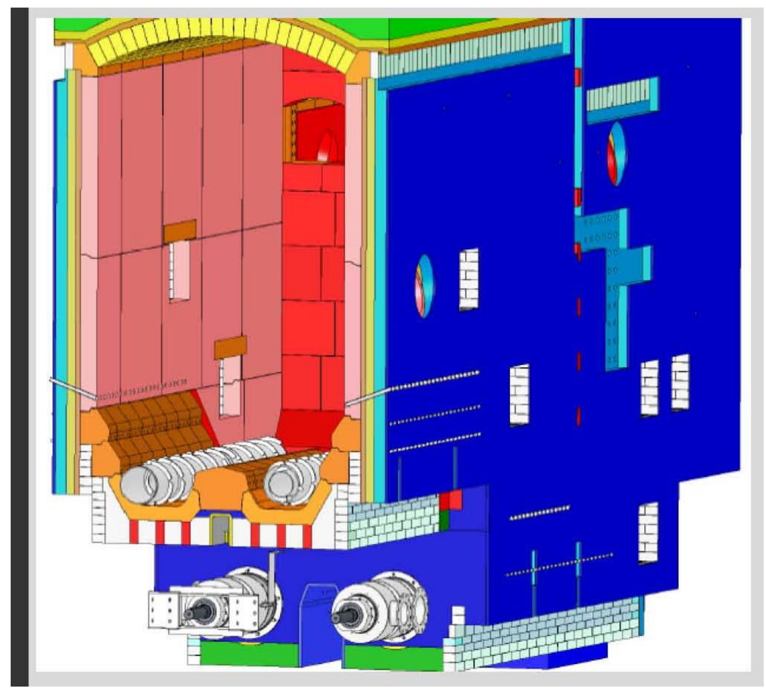
Capacity	3 tons/day
Motive Force for Gas Movement	Blower or Engine Vacuum
Gas Cooling Method	Gas-to-Air Heat Exchanger
Gas Cleaning Method	Dry Filter
Solid Waste Constituents	Ash + Small Amount of Char (5% by weight)
Tar Content After Gas Cleaning Operations	< 250 ppm
Nominal Gas Energy	180 Btu/Std ft^3
Combustible Gas as % of Total Gas Output	20% CO; 14% H_2; 7% CH_4

Fluidized Bed Technology

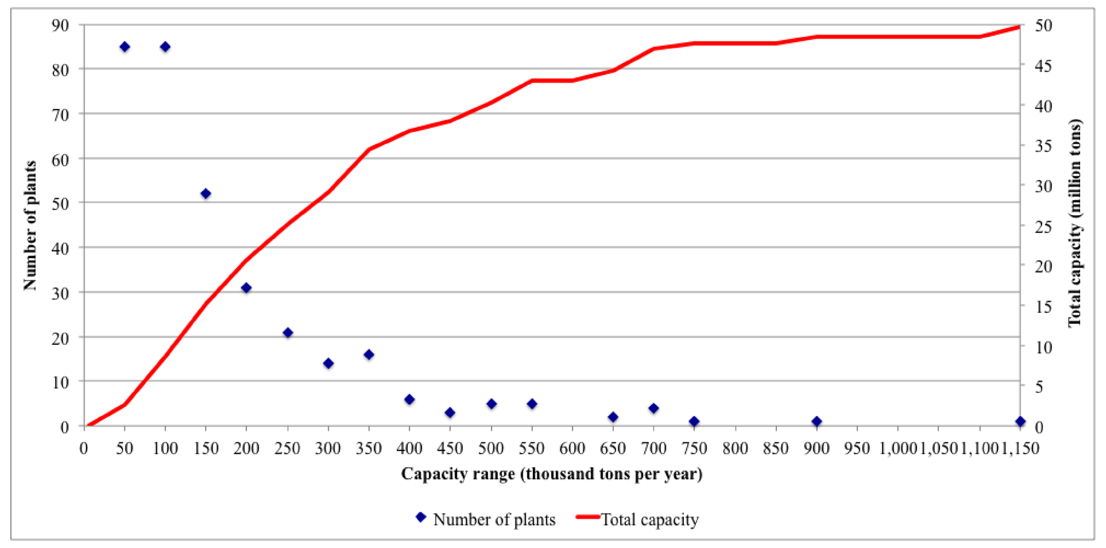
Increasing Pressure Drop with Increasing Gas Flow for Grate, BFB, and CFB Systems[4]

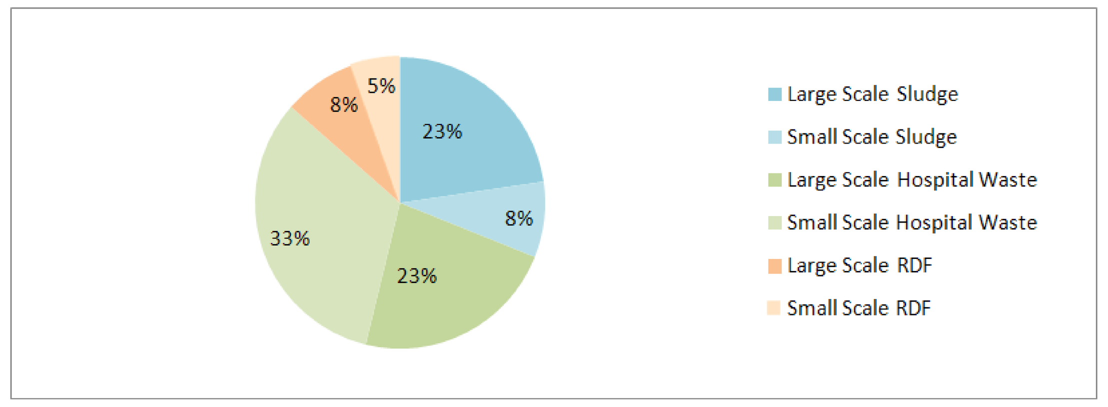


Envikraft Auger System



Small Scale Plants Statistical Analysis from ISWA Data Set





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