Powerful

First-Class Boiler and Combustion Systems & Complete Engineering Services

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Melbourne, 8th October 2009

Power generation from waste

ERK background

- Eckrohr boiler technology was developed in the mid 1940s (water tube boiler with natural circulation)
- First licensees started to build Eckrohr-boilers worldwide; ERK offers engineering only and licensees supply hardware
- Today 28 licensees worldwide (from small boiler manufacturers to turn-key suppliers like Alstom and Hitachi)
- >5.700 boiler and heater references worldwide (power plant to small industrial size)
- References for biomass (>450), waste (>580), cogeneration (>200), fuel mixtures (>350) as well as coal, oil and gas (>4,000)

Power generation from waste

Fuel selection

Industrial by-products / waste

Biological waste

Hazardous waste

Wood waste

Plastic

Metals / glass

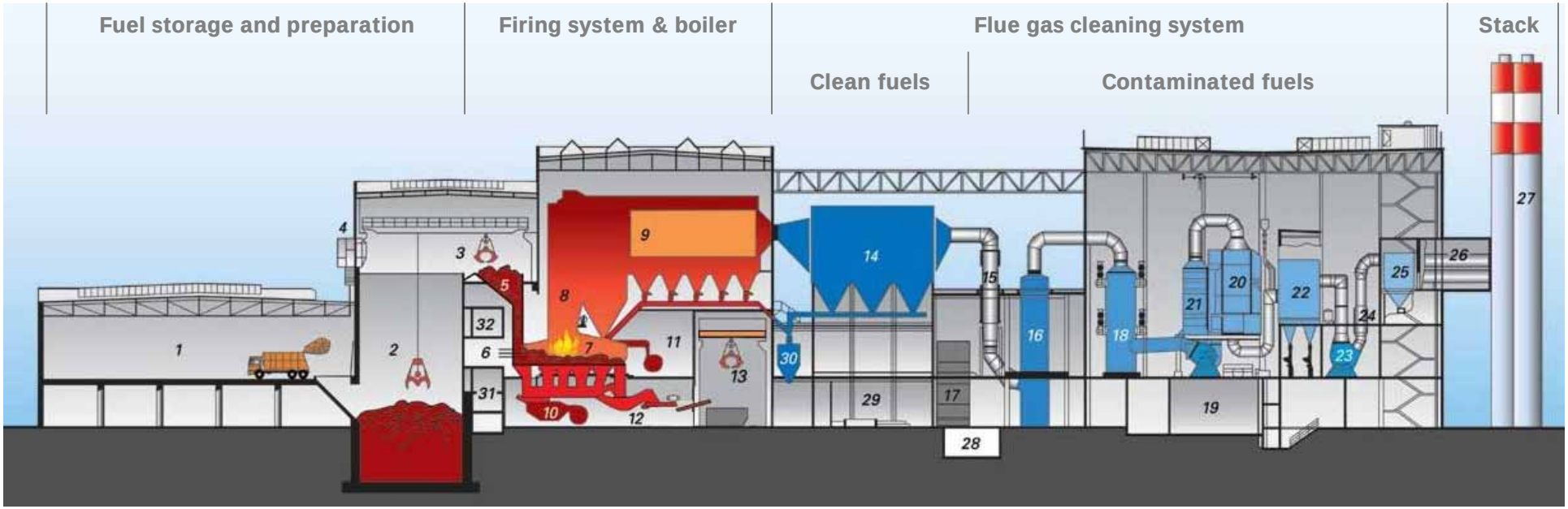
Composting

Fuel for power and process heat generation

Recycling

Power generation from waste

General plant arrangement



Power generation from waste

Conversion technologies

Fuels

Combustion (grate and fluidised bed)

Gasification

Choice of firing system depends on fuel quality, process and efficiency requirements as well as commercial constraints

Power generation from waste

Combustion

Principle:

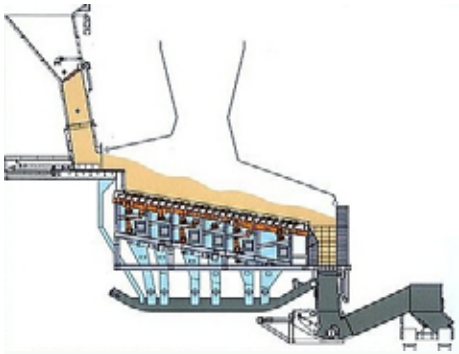
- Grate and fluidised bed systems burn fuel directly under stoichiometric conditions
- Grate systems burn fuel while transporting it horizontally through the furnace
- Fluidised bed systems burn fuel in suspension

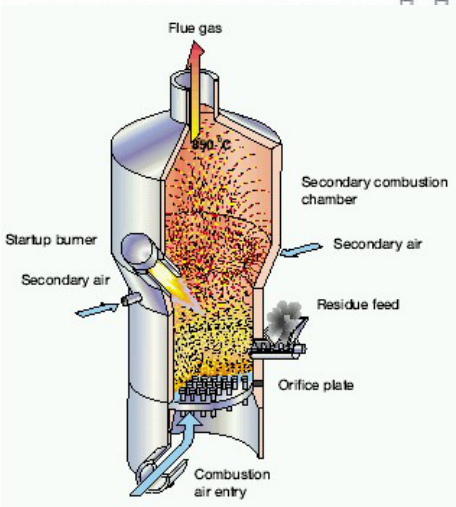
Advantages

- Grates accept a wide variety of fuels without intensive conditioning
- Fluidised beds have low NO_x emissions and achieve a good efficiency
- Many references in operation worldwide

Disadvantages

- Grate efficiency is relatively low
- Fluidised bed are capital intensive, fuel sensitive and require complex fuel conditioning





Power generation from waste

Gasification

Principle:

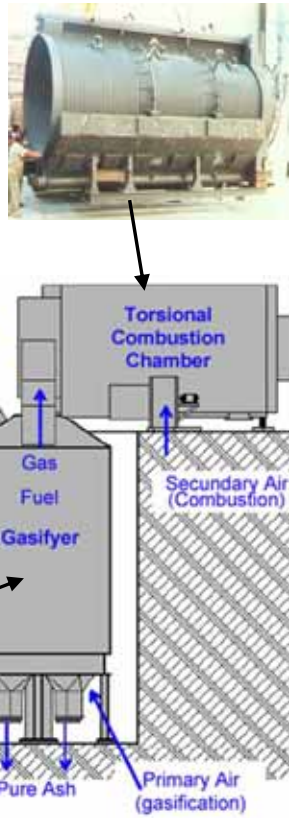
- Generation of predominantly carbon monoxide and hydrogen under sub-stoichiometric conditions (first phase)
- High temperature combustion in the second stage
- Low gasification temperatures keep complicated fuel substances, e.g. chlorine and potassium, in the ash, thus reducing fouling and corrosion

Advantages

- Higher steam parameters due to absence of complicated substances
- Higher plant efficiency
- Reduced maintenance
- Small plant components
- Low investment and complexity

Disadvantages

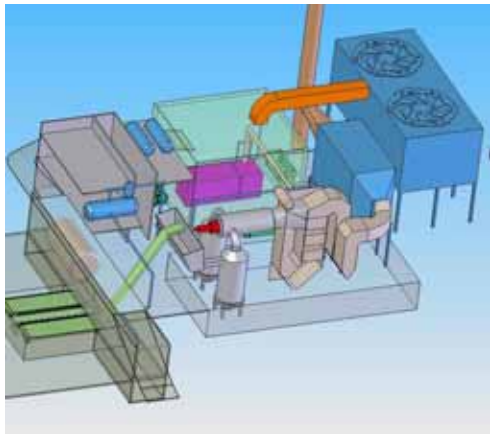
- Not proven for plastic and refuse derived fuels yet
- No existing references larger 70 MWth yet



Power generation from waste

Small wood waste example (gasification)

Input		
▪ Fuel	wood and sawmill residues	
▪ Fuel demand	ca 50,000 Mg/a (40 % moisture)	
Conversion		
▪ Live steam parameter	21 t/h, 480 degC and 65 bar	
Output		
▪ Electrical output	5 MW	
▪ Process heat	6 MW	
▪ Availability	8,000 h/a	
Fossil fuel substitution		
▪ Coal & CO_2 reduction	24,400 t/a	76,600 t/a
▪ Oil & CO_2 reduction	14,400,000 l/a	38,000 t/a
▪ Gas & CO_2 reduction	14,000,000 m^3/a	20,300 t/a
Renewable bonus		
▪ REC income	AU $2,400,000	(AU $60/MWh)



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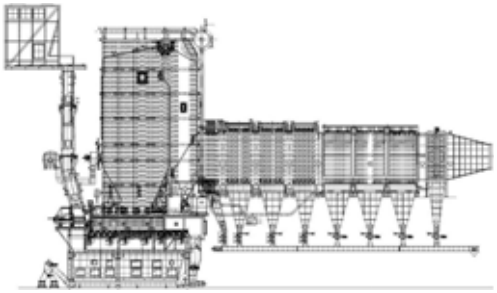
Power generation from waste

Medium wood waste example (combustion)

Input		
▪ Fuel	construction & demolition timber	
▪ Fuel demand	ca 260,000 Mg/a (30 % moisture)	
Conversion		
▪ Live steam parameter	2x 66 t/h, 450 degC and 66 bar	
Output		
▪ Electrical output	20 MW	
▪ Process heat	80 MW	
▪ Availability	8,000 h/a	
Fossil fuel substitution		
▪ Coal & CO_2 reduction	138,200 t/a	435,200 t/a
▪ Oil & CO_2 reduction	81,300,000 l/a	215,600 t/a
▪ Gas & CO_2 reduction	79,000,000 m^3/a	115,300 t/a
Renewable bonus		
▪ REC income	AU $9,600,000	(AU $60/MWh)



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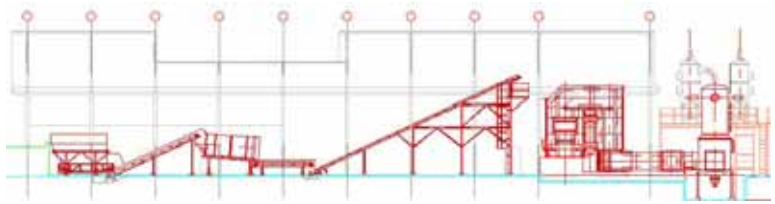
Power generation from waste

Micro energy from waste example (combustion)



Input

- Fuel — refuse derived fuel
- Fuel demand processed — ca 9,000 t/a
- Fuel demand unprocessd — ca 18,000 t/a

Conversion

- Live steam parameter — 4 t/h, 370 degC and 31 bar

Output

- Electrical output — possible but small turbines not competitive
- Process heat — 3 MW
- Availability — 8,000 h/a

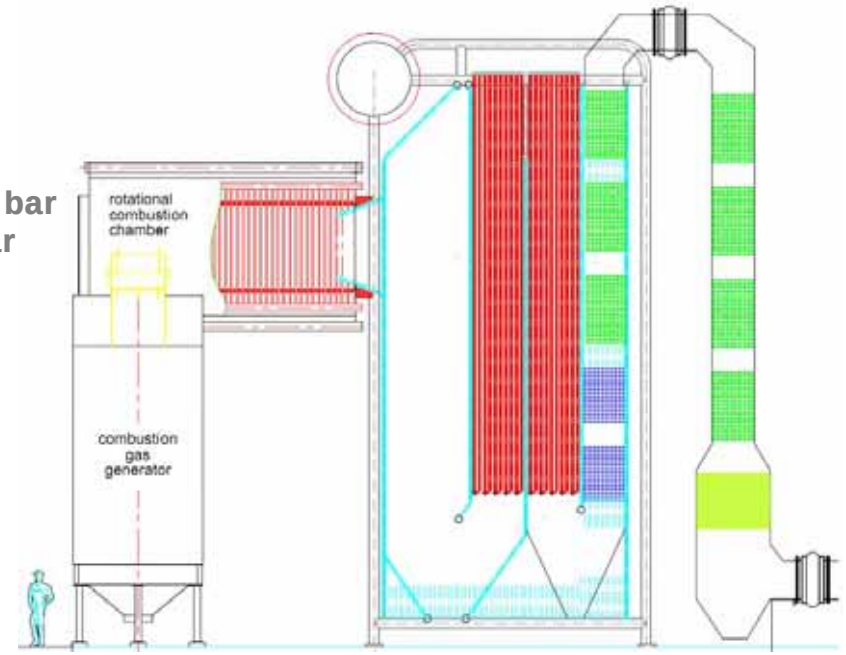
Fossil fuel substitution

- Coal — 4,750 t/a
- Oil — 2,800,000 l/a
- Gas — 2,700,000 m^3/a

Power generation from waste

Small energy from waste example (gasification)

Input	
▪ Fuel	refuse derived fuel
▪ Fuel demand processed	ca 20,000 t/a
▪ Fuel demand unprocessed	ca 40,000 t/a
Conversion	
▪ Live steam parameter (a)	9.8 t/h, 550 degC and 60 bar
▪ Live steam parameter (b)	11.2, 420 degC and 40 bar
Output	
▪ Electrical output	2.3 MW (a) & 2.0 MW (b)
▪ Process heat	7 MW
▪ Availability	8,000 h/a
Fossil fuel substitution	
▪ Coal	11,000 t/a
▪ Oil	6,500,000 l/a
▪ Gas	6,300,000 m³/a



Power generation from waste

Medium energy from waste example (combustion)

Input

▪ Fuel	municipal / industrial waste
▪ Fuel demand processed	ca 48,000 t / a

Conversion

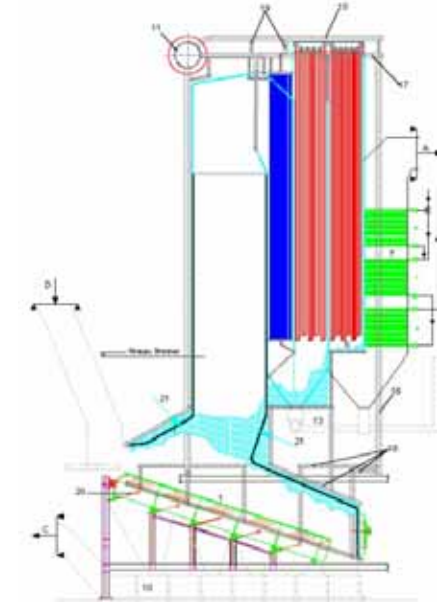
▪ Live steam parameter	20 t / h, 400 degC and 40 bar

Output

▪ Electrical output	4.7 MW
▪ Process heat	15 MW possible
▪ Availability	8,000 h / a

Fossil fuel substitution

▪ Coal	23,700 t / a
▪ Oil	14,000,000 l / a
▪ Gas	13,500,000 m^3 / a



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Power generation from waste

Emission comparison

- Generation of 200,000 MWh electricity and 280,000 MWh process heat
- EfW plant ranks better than coal and oil fired plants

Pollutants	EfW plant Bielefeld	Black coal power plant	Brown coal power plant	Oil fired power plant	Natural gas power plant	Wood fired power plant
Dust (kg/a)	230	23,476	24,760	3,503	56	58,440
Carbon monoxide (kg/a)	18,200	39,126	41,267	29,192	22,199	292,203
Nitrogen oxides (kg/a)	70,000	156,503	165,067	87,576	55,497	350,643
Mercury (kg/a)	6.0	23.5	24.7	0.1	0.1	7.0
Hydrocarbons in exhaust (kg/a)	467.0	2,017.0	2,028.0	2,034.0	555.0	5,844.0
Dioxines & furanes (mg/a)	1.6	9.4	9.9	5.8	3.3	47.0
Carbon dioxide from fossil fuels (t/a)	183,000	233.892	289.592	151.033	108.984	-
Fuel throughput (t/a)	330,000.0	80,672.0	144,796.0	47,856.0	48,682.0	131,327.0
Lower calorific value (MWh/t)	3,47	7,0	3,9	11,8	11,6	4,3

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Power generation from waste

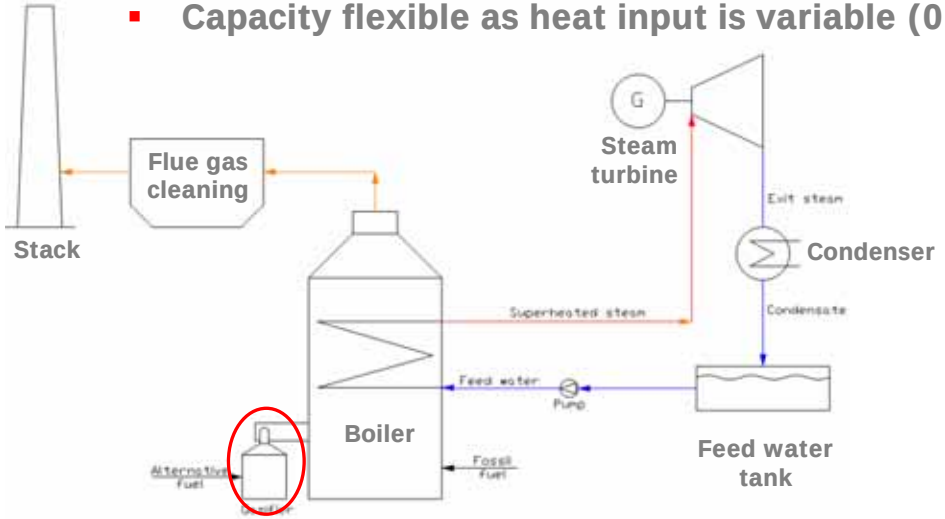
Alternative fuel considerations

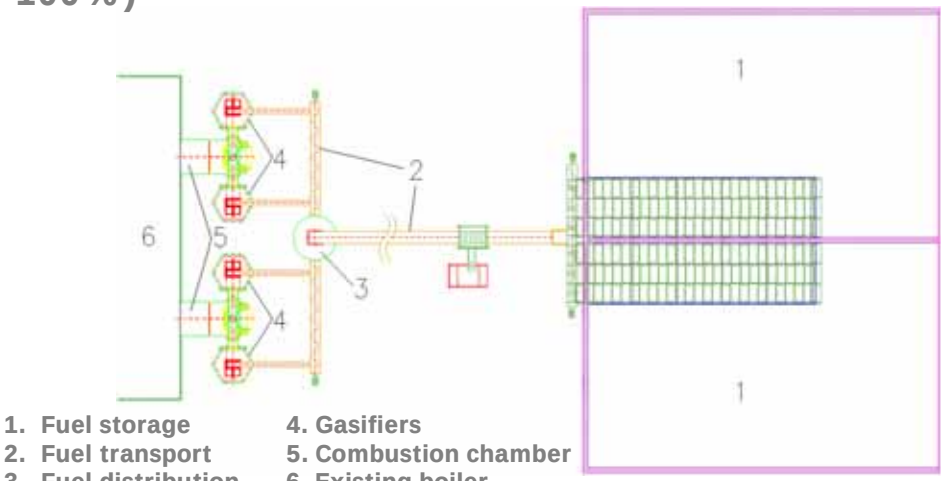
- Electricity / process heat demand ≠ alternative fuel available
  - Multi fuel boiler / heater to match energy demand
  - Existing boiler as back-up system
  - Electricity from the grid
- Higher specific investment than conventional fuel fired boilers / heater
  - Possible generation of REC's to increase profitability
  - Lower fuel costs through conventional fuel substitution
  - Reduced carbon emission costs when using biomass
  - Adaptation of existing boilers often possible
- Few references in Australia
  - Several hundred biomass and waste references overseas
  - Training qualified staff to operate the plant

Power generation from waste

Alternative concepts – plant retrofitting using gasification

- Retrofitting gasifiers is a low investment approach to substitute fossil fuels as capital intensive equipment is already on site, e.g. boiler, steam turbine, condenser
- Simple to retrofit as almost no changes on the existing boiler
- 100 % redundancy in case of biomass supply issues as old burners can take over
- Capacity flexible as heat input is variable (0-100 %)



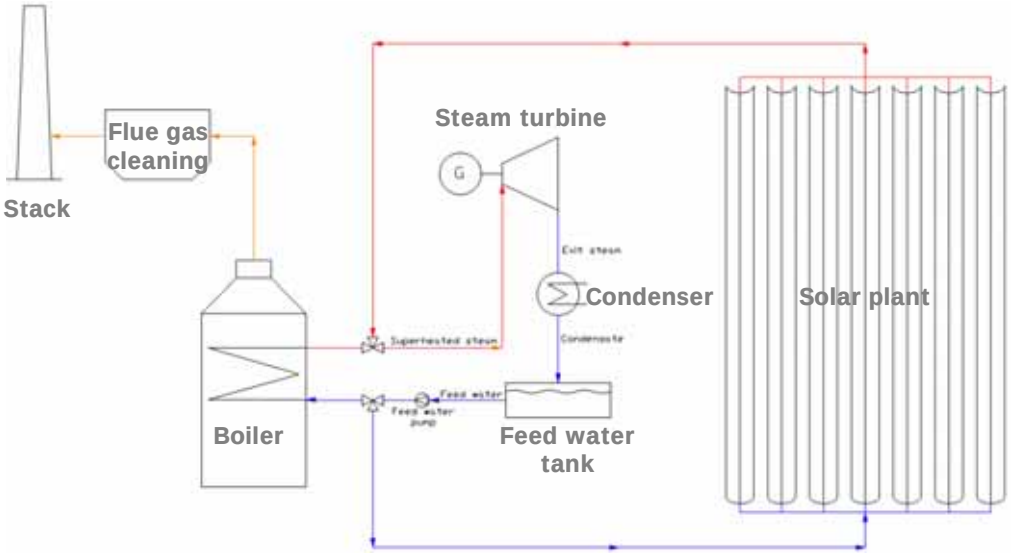


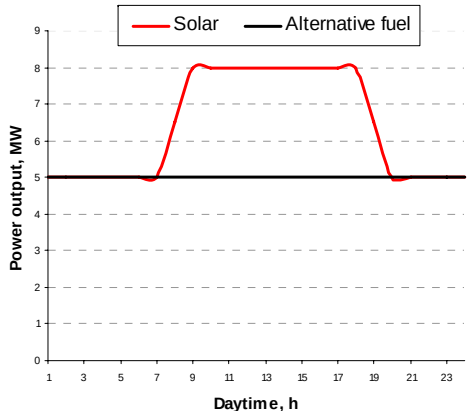
1. Fuel storage
2. Fuel transport
3. Fuel distribution
4. Gasifiers
5. Combustion chamber
6. Existing boiler

Power generation from waste

Alternative concepts – waste with solar enhancement

- Base load capability plus increased energy output during daytime
- Reduced specific investment due to combined turbine and condenser
- Supplementary firing to cope with unsuitable weather conditions





Picture courtesy of Solar Power Group

Power generation from waste

Summary

- Despite a higher complexity than a gas, oil or coal fired plants is waste very interesting fuel as it is free energy currently discarded and usually involves disposal costs
  - ↳ Fuel and disposal cost savings plus possible generation of REC's
- Waste accumulates close to power consumers
  - ↳ Transmission infrastructure accessible and low transmission losses
- The fuel potential for wood waste (combined aggregate of domestic, construction & demolition, and commercial & industrial wastes) was 1.8 million tonnes in 2007
  - ↳ Sufficient to generate ca 250 MWel
- The municipal waste land filled in 2007 was ca 17 million tonnes
  - ↳ Ca 11.5 million tonnes have fuel potential to generate ca 1,400 MWel
- Clean biofuels from plantation, agriculture, saw & sugar mills etc comes on top of that
  - ↳ Unclear data situation but estimates indicate up to 3,000 MWel)