



ENERGY

**INFORMATION
AND DATA**

UNIQUE ADVANTAGES

OF THE PYROMEX ULTRA-HIGH TEMPERATURE GASIFICATION SYSTEM

- § Optimum recovery of energy contained in the waste or biomass
- § Transportable and storable clean energy
- § Total conversion of the organic waste content to syngas
- § No harmful emissions
- § No condensate
- § Highly profitable recycling of all types of waste
- § Small investment and simple operation
- § Interesting possibilities of cultivating biomass as a profitable income for farmers
- § Possibility of replacing the syngas with natural gas, if required for emergency situations

Pyromex offers a complete line and upgrading system to treat waste without waste residues

- ∅ Rational
- ∅ Economical
- ∅ Environmentally compatible
- ∅ Highly profitable

POTENTIAL ELECTRICITY PRODUCTION

A plant using organic waste has the following approximate production potential per ton of waste:

(Formula to convert kcal into kWh/kg: $\frac{\text{kcal} \times 1.16}{1000} = \text{kWh/kg}$)

Calorific Content of Waste (see list)	kWh / kg	kWh / ton
3000 kcal / kg	3.5	3500
4000 kcal / kg	4.6	4600
5000 kcal / kg	5.8	5800
6000 kcal / kg	6.7	6700
7000 kcal / kg	8.1	8100
8000 kcal / kg	9.3	9300
9000 kcal / kg	10.4	10400

Example:

Calorific value of waste : 4000 kcal / kg
Production capacity : 24 t / day



4640 kWh / h x 24 h = 111'360 kW / day

Available chemical energy: approx. 90% = approx. 4'000 kWh

Excluding utilization of off-heat 35% efficiency (gas engine) = approx. 1'400 kWh
Own consumption = approx. 330 kWh
Remaining for sale = approx. 1'070 kWh
Per day (24 hours) per ton = approx. 25'680 kWh

Including utilization of off-heat 60% efficiency = approx. 2'400 kWh
Own consumption = approx. 330 kWh
Remaining for sale = approx. 2'070 kWh
Per day (24 hours) per ton = approx. 49'680 kWh

CALORIFIC VALUES

OF VARIOUS WASTE TYPES

SECONDARY ENERGY MATERIAL	APPROXIMATE kcal / kg	APPROXIMATE MJ / kg	APPROXIMATE kW / kg
Bamboo	3'800	15.9	4.4
Braun coal	4'500	18.9	5.2
Cacao shrub	3'300	13.8	3.8
Cardboard	3'800	16.9	4.4
Cardboard corrugated	3'910	16.4	4.5
Citrus peels	4'500	18,9	5.2
China grass	4'030	16.9	4.6
Car tires	8'300	34.8	9.6
Coconut shell	3'800	15.9	4.4
Coffee bean shells	6'000	25.1	6.8
Compost	4'200	17.6	4.8
Cork	6'300	26.4	7.3
Corn	4'400	18.4	5.1
Cotton seeds	3'300	13.8	3.8
Hay	3'200	13.4	3.7
Household waste pre-sorted	4'500	18.9	5.2
Hospital waste	6'780	28.5	7.8
Leather	4'020	16.8	4.6
Manure (dried)	3'760	15.9	4.4
Neoprene	7'100	29.7	8.2
Nylon	7'570	31.7	8.8
Oil sludge	8'800	36.8	10.2
Paper	4'400	18.4	5.1
Paper sludge	3'910	16.4	4.5
Paper coated	6'390	26.8	7.4
Paper adhesive coated	4'200	17.6	4.8
Newspaper	3'910	16.4	4.5
Tar paper	6'390	26.8	7.4
Paraffin	10'340	43.3	12.1
Polyethan foam	9'770	40.9	11.3
Polyethylene	10'990	46.1	12.7
Polypropylene	11'030	46.2	12.8
Polystyrol EPS	9'800	41.1	11.3
Polystyrol carbon reinforced	10'840	45.4	12.6
Rice pods	2'900	12.1	3.3
Rubber	5'600	23.4	6.5
Sewage sludge (dried)	3'300	13.8	3.8
Sunflower residue	4'200	17.6	4.8
Straw	4'000	17.2	4.6
Tobacco powder	3'000	12.6	3.4
Tar and refinery residues	9'200	38.5	10.7
Tar acid	5'600	23.4	6.5
Textiles	4'000	16.7	4.6
Treated wood	4'500	18.9	5.2
Untreated wood	4'200	17.6	4.8
Plywood	4'500	18.9	5.2

CALORIFIC VALUES

OF BIOMASS

SECONDARY ENERGY MATERIAL	APPROXIMATE kcal / kg	APPROXIMATE MJ / kg	APPROXIMATE kW / kg
Acacia wood	6'600	27.65	7.4
Bamboo	3'800	15.9	4.4
Cacao shrub	3'300	13.8	3.8
Coconut shells	3'800	15.9	4.4
Coffee bean pods	6'000	25.1	6.8
China grass	4'030	16.9	4.6
Compost	4'200	17.6	4.8
Cork	6'300	26.4	7.3
Corn	4'400	18.4	5.1
Cotton seeds	3'300	13.8	3.8
Eucalyptus wood	7'200	30.1	8.2
Hay	3'200	13.4	3.7
Manure (dried)	3'760	15.9	4.4
Olive oil press residues	7'400	31.0	8.4
Pine cones	7'900	33.1	9
Reeds	4'030	16.9	4.6
Rice pods	2'900	12.1	3.3
Sewage sludge (dried)	3'300	13.8	3.8
Straw	4'000	17.2	4.6
Sunflower residue	4'200	17.6	4.8
Tobacco powder	3'000	12.6	3.4
Untreated wood	4'200	17.6	4.8

CALORIFIC VALUE OF PYROMEX SYNGAS

RELATIVE TO 3'100 kcal FEED MATERIAL

Description		Vol. (Nm ³)	kWh/Nm ³	H gas (kW)
Hydrogen	H ₂	738.5744	2.998	2214.246
Carbon monoxide	CO	429.3988	3.509	1506.76
Carbon dioxide	CO ₂	100.576	0	0
Methane	CH ₄	0.1344	9.949	1.337146
Thermal value total				3722.344
Enthalpy in the converter	H \dot{d} =			111.2327 kW
Calorific value	H u =		13 MJ/kg = 3.611111 kWh/kg	
Material throughput	m \dot{d} =			1000 kg/h
	H \dot{d} R=			3611.111 kW

APPROX. GAS COMPOSITION

AT GASIFICATION TEMPERATURES
OF OVER 1200°C

Carbon monoxide	(CO)	21% to 32%
Hydrogen	(H ₂)	19% to 24%
Methane	(CH ₄)	1% to 2%
Carbon dioxide	(CO ₂)	12% to 14%
Nitrogen	(N ₂)	5% to 10%

CONVERSION FACTOR

MULTIPLY		BY	RESULT	
British thermal unit	Btu	2530	Kilogram calories	kcal
British thermal unit	Btu	1054	Joules	kJ
Joules	kJ	9.486×10^{-4}	British thermal unit	Btu
Joules	kJ	2.39×10^{-4}	Kilogram calories	kcal
Kilogram calories	kcal	4183	Joules	kJ
Kilogram calories	kcal	3.968	British thermal unit	Btu

DESCRIPTION		EQUALS	RESULT	
1000 Watt	W	=	1 Kilowatt	kW
1 Kilowatt	KW	=	1.36 Pferde Staerken	PS
1 Pferde Staerke	PS	=	0.736 Kilowatt	kW
1 Joule	J	=	1 Watt second	Ws
1 Watt second	Ws	=	0.239 calories	cal
1 Watt hours	Wh	=	3,600 Joules	J
1 Kilowatt hour	kWh	=	1000 Watt hour	Wh
1000 Watt hours	Wh	=	3,600,000 Joules	J
1,000,000 Kilowatt hours	KWh	=	3.6 Tera Joules	TJ

EFFICIENCY COMPARISON

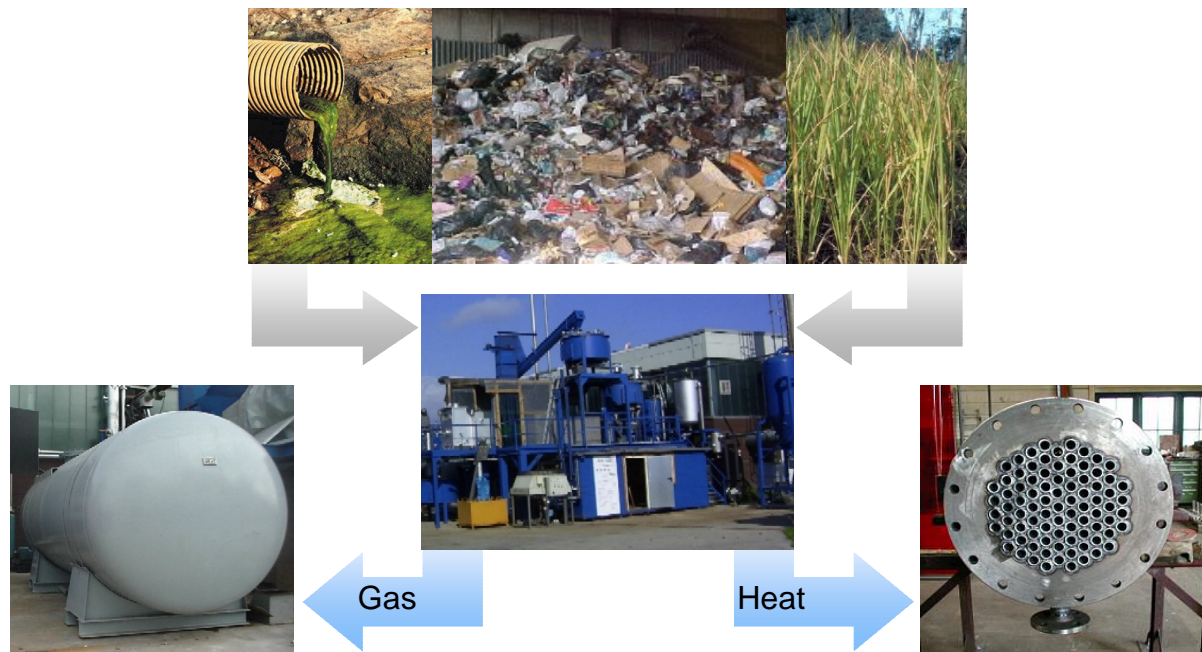
BETWEEN PYROMEX GASIFICATION AND INCINERATION

Infeed Material: Wood Chips

Calorific Value: approx. 4'200 kcal/kg (= 17.6 MJ/kg or 8000 BTU/lb)

Description	Pyromex Ultra-High Temperature Gasification	Standard Incineration
Gas volume	830 Nm ³ /t	6'000 Nm ³ /t
Thermal loss	10%	20%
Efficiency	40%	24%
Total energy available	1754 kWh/t	935 kWh/t
Own use	330 kWh/t	24 kWh/t
Net electricity	1424 kWh/t	911 kWh/t
Off-heat	2630 kWh/t	2962 kWh/t
Air consumption	1000 Nm ³ /t	5000Nm ³ /t
Net electricity	1424 kWh/t	911 kWh/t
Net off-heat	2630 kWh/t	2962 kWh/t

ENERGY UTILIZATION



Pyromex offers the following energy recovery possibilities:

- ∅ Utilization of the syngas with an afterburner, subsequent steam turbine and electricity generator respectively
- ∅ Utilization of the syngas with a gas motor, combined with an electricity generator
- ∅ Utilization of the off-heat with the Pyromex-Henze cell for electricity production
- ∅ Utilization of the off-heat with a conventional heat-exchanger for heating or cooling
- ∅ Utilization of the syngas for industrial applications to substitute oil and gas
- ∅ Liquefying the syngas to synthetic petroleum
- ∅ Conversion of the syngas to hydrogen and subsequent production of electricity with a fuel cell

Gas Utilization



- ∅ Steam turbine
- ∅ Gas motor
- ∅ Sterling motor

Off-Heat Utilization



- ∅ Steam turbine
- ∅ Sterling motor
- ∅ Pyromex-Henze cell

Industrial Utilization

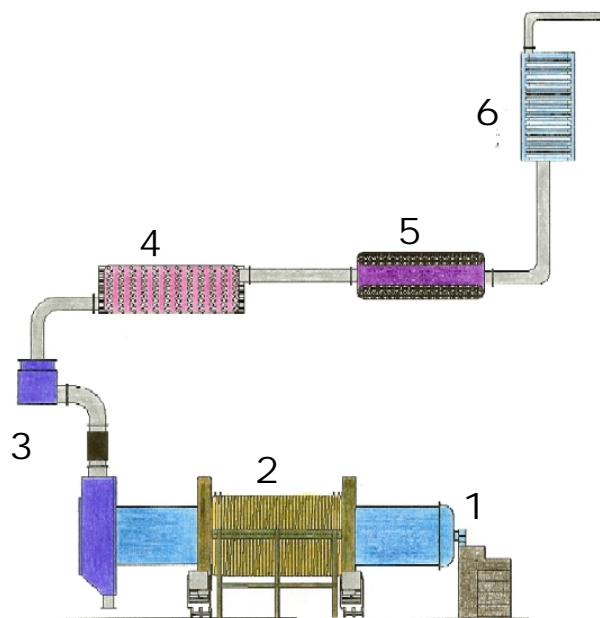


syngas

- ∅ Utilization of the gas to substitute oil and natural gas
- ∅ Liquefying the syngas to synthetic petroleum
- ∅ Utilization of the syngas and off-heat for waste pretreatment (drying, sterilization etc.)
- ∅ Operation of the Pyromex sea water desalination
- ∅ Production of hydrogen
- ∅ Recovery of industrial valuables from the produced

PYROMEX

THE ULTIMATE SOLUTION



- 1. Energy source:**
 - Ø Waste or biomass
- 2. Pyromex UHT gasification unit:**
 - Ø Syngas production
- 3. Pyromex steam converter:**
 - Ø Hydrogen production
- 4. Standard heat exchanger:**
 - Ø Energy utilization
- 5. Pyromex-Henze cell:**
 - Ø Energy utilization
- 6. Standard fuel cell:**
 - Ø Energy utilization

Electric energy recovery above **70%**!

SUMMARY

The patented ultra-high temperature gasification system developed by Pyromex represents a revolutionary solution for the conversion of waste or biomass to energy.

Because optimum use is made of the energy contained in the organic part, the process is commercially highly attractive and more important still, produces no harmful emissions or residues.