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Biomass Energy Utilization & Environment Protection

Commercial Reality and Outlook

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- Biomass Gasification
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- Other Biomass related Fuels
- Commercial Aspects
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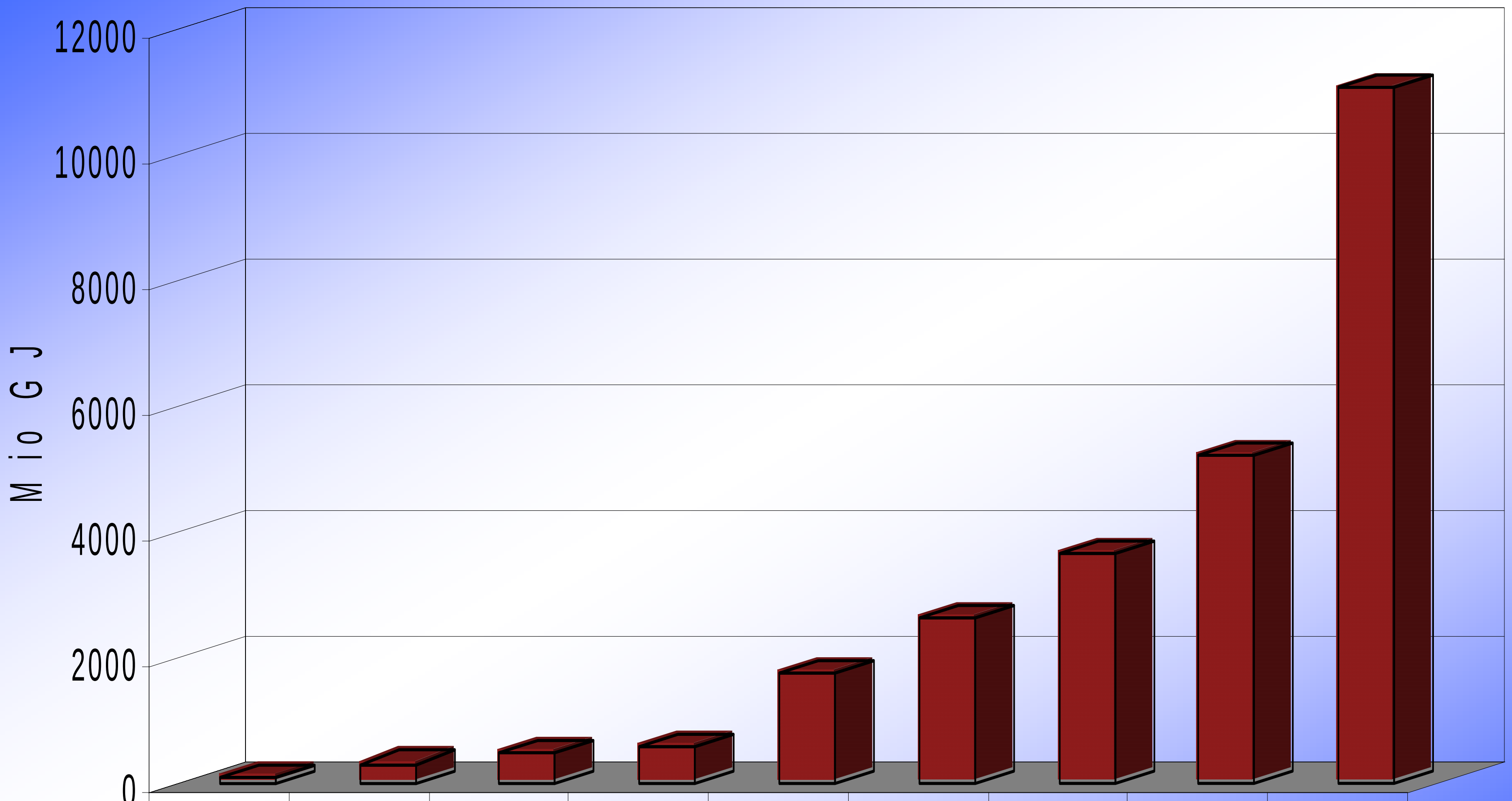
‘Rapid rate at which fossil and residual fuels are releasing CO_2 into the atmosphere has raised international concern and has spurred intensive efforts to develop alternative, renewable, sources of primary energy’

- Biomass absorbs the same amount of CO_2 in growing that it releases when burned as a fuel in any form.
- Biomass contribution to global warming is zero.
- Biomass fuels contain negligible amount of sulphur, so their contribution to acid rain is minimal.

Typical biomass resources include:

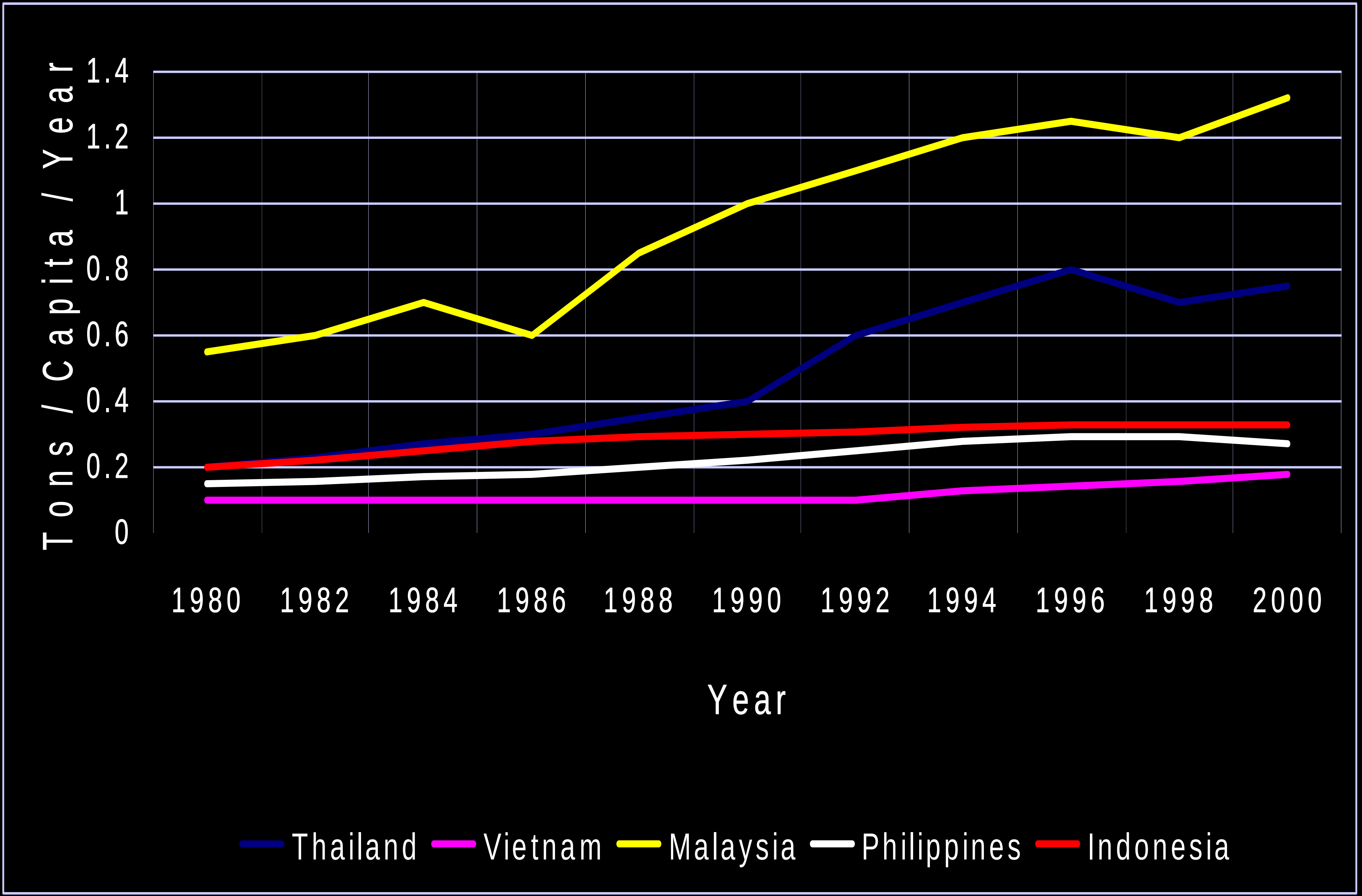
- The forest
- Waste from wood processing industry
- Agricultural waste
- Urban wood waste
- Wastewater & landfill
- Other natural resources (straw, peat, bagasse, etc.)

Biomass consumption in Asia



	Malaysia	Vietnam	Philippines	Thailand	Indonesia	China	India	Rest of Asia	Asia Total
Mio GJ	117	315	478	605	1758	2623	3671	5196	11092

CO production in SEA



Biomass utilization technologies

- Direct Combustion
- Gasification
- Anaerobic Digestion
- Methanol & Ethanol Production

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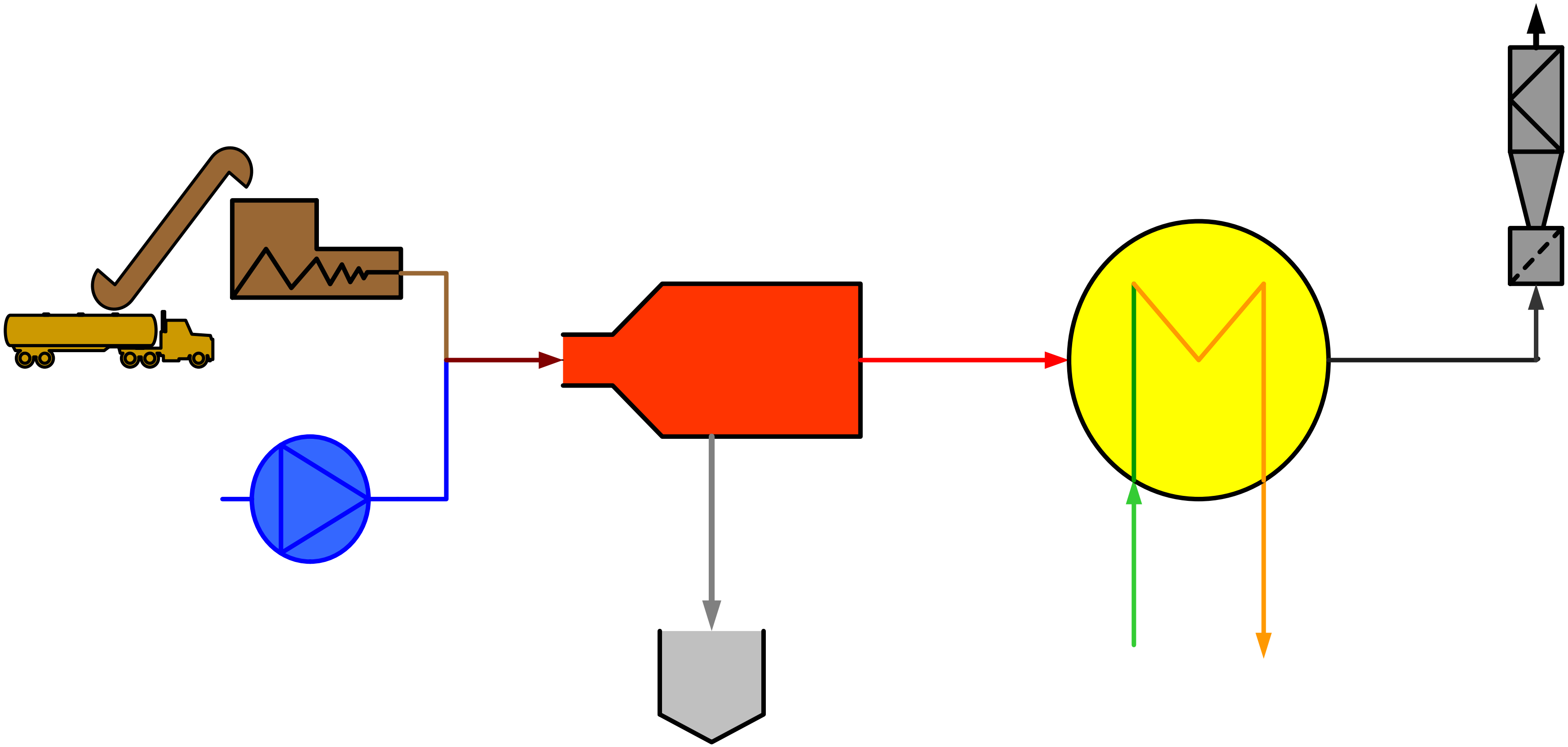
Principal scheme of direct combustion system

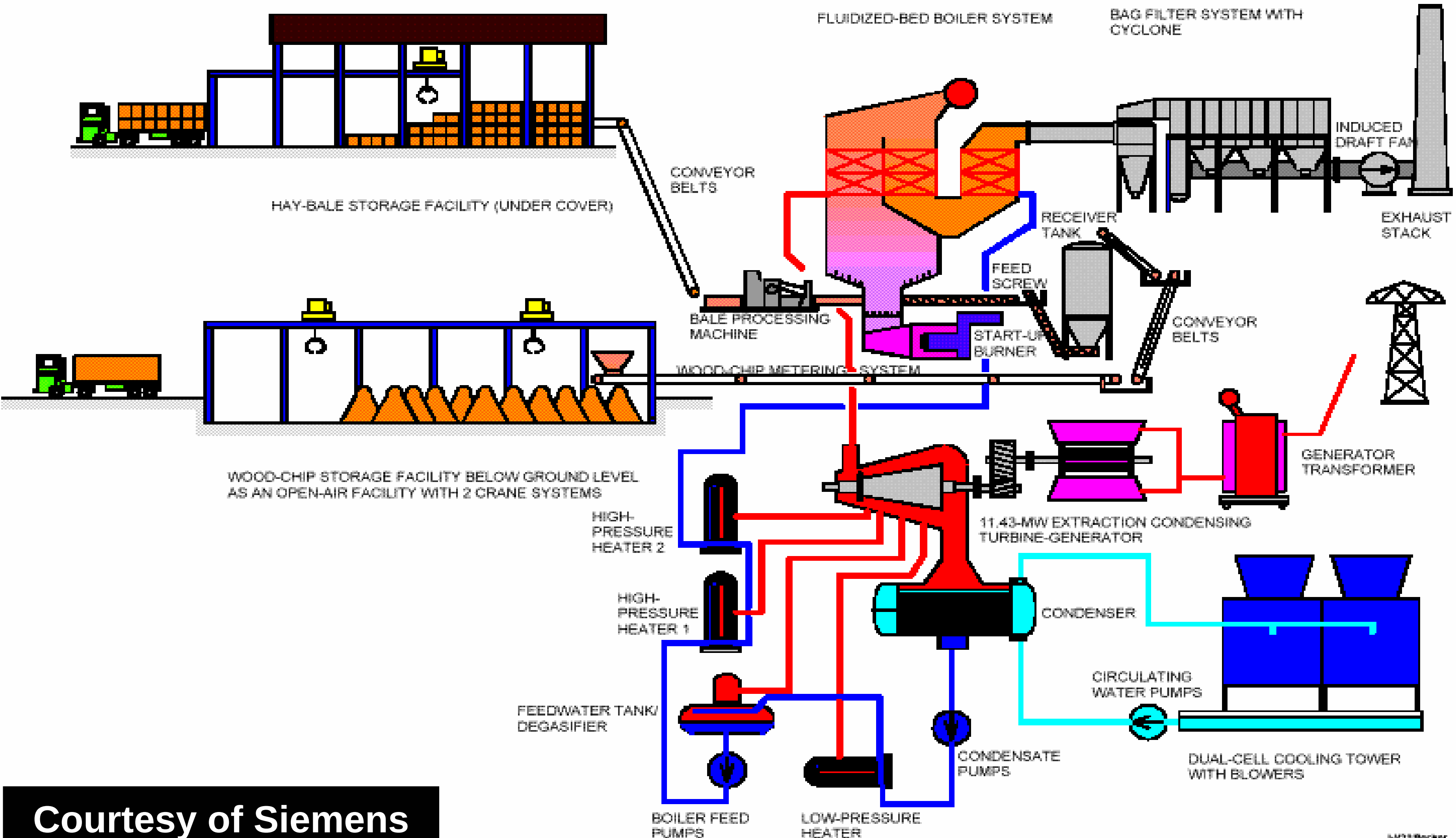


POWER-GEN ASIA

Fixed bed combustion systems

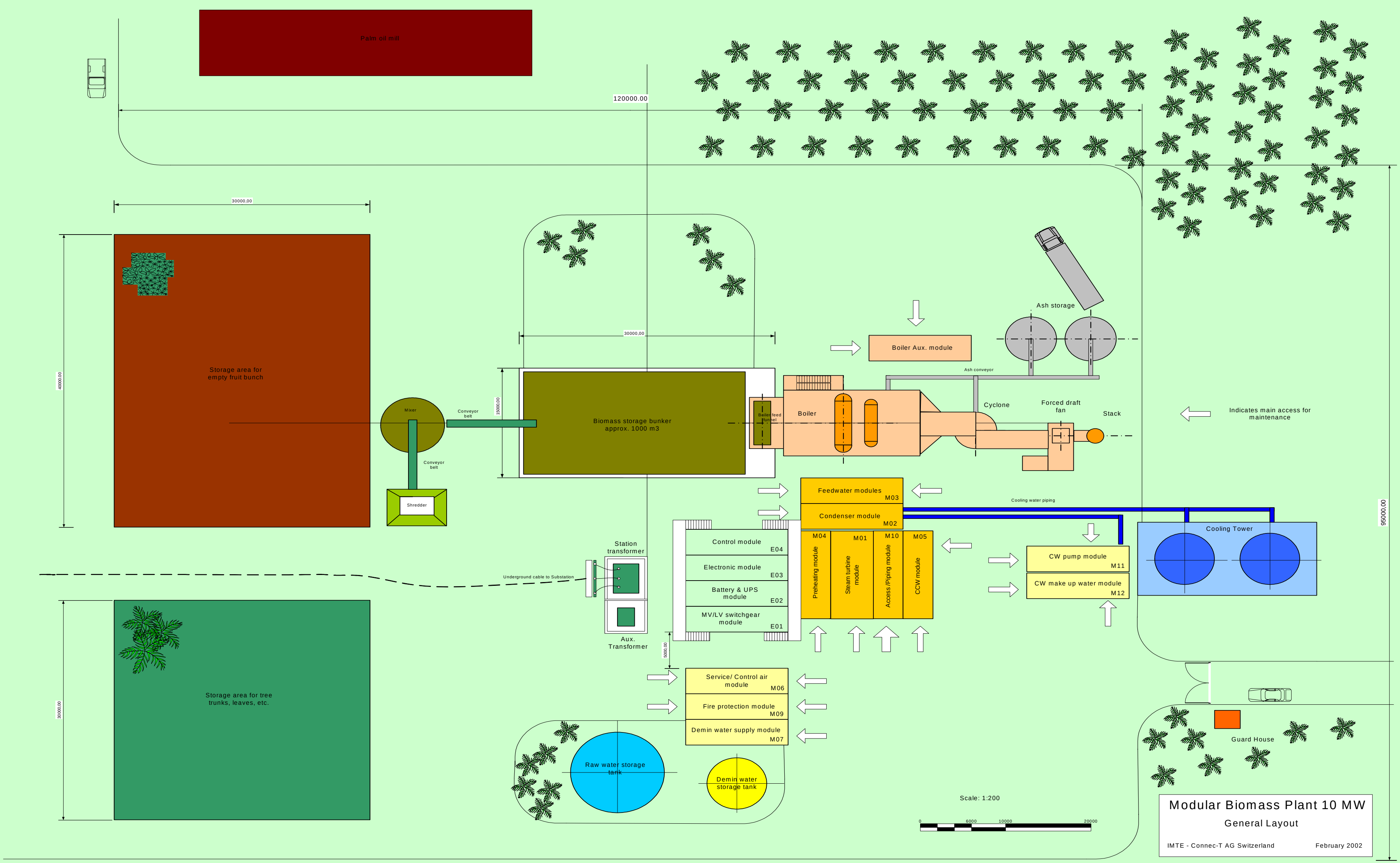
System	Fuel size mm	Max. Moisture Content in %	Fuel Supply	Ash Removal
Static Grate	∅ 100 x 300	50	Manual/automatic	Manual/automatic
Underscrew	< 40x 30 x 15 >20 x 20 x 10	40	Automatic	Manual/automatic
Through Screw	< ∅ 50 x 100	40	Automatic	Automatic
Inclined Grate	< 300x100x50	50	Automatic	Automatic
Sloping (moving) Bed	< 300x100x50	50	Automatic	Automatic
Suspension Burning	< 5 x 5 x 5	20	Automatic	Manual/automatic
Spreader-stocker	< 40 x 40 x 40	50	Automatic	Manual/automatic

Typical Scheme of Biomass Fired Power Generation Plant



Courtesy of Siemens

Biomass Power Plant Layout



Oil Palm Biomass Waste Specifications

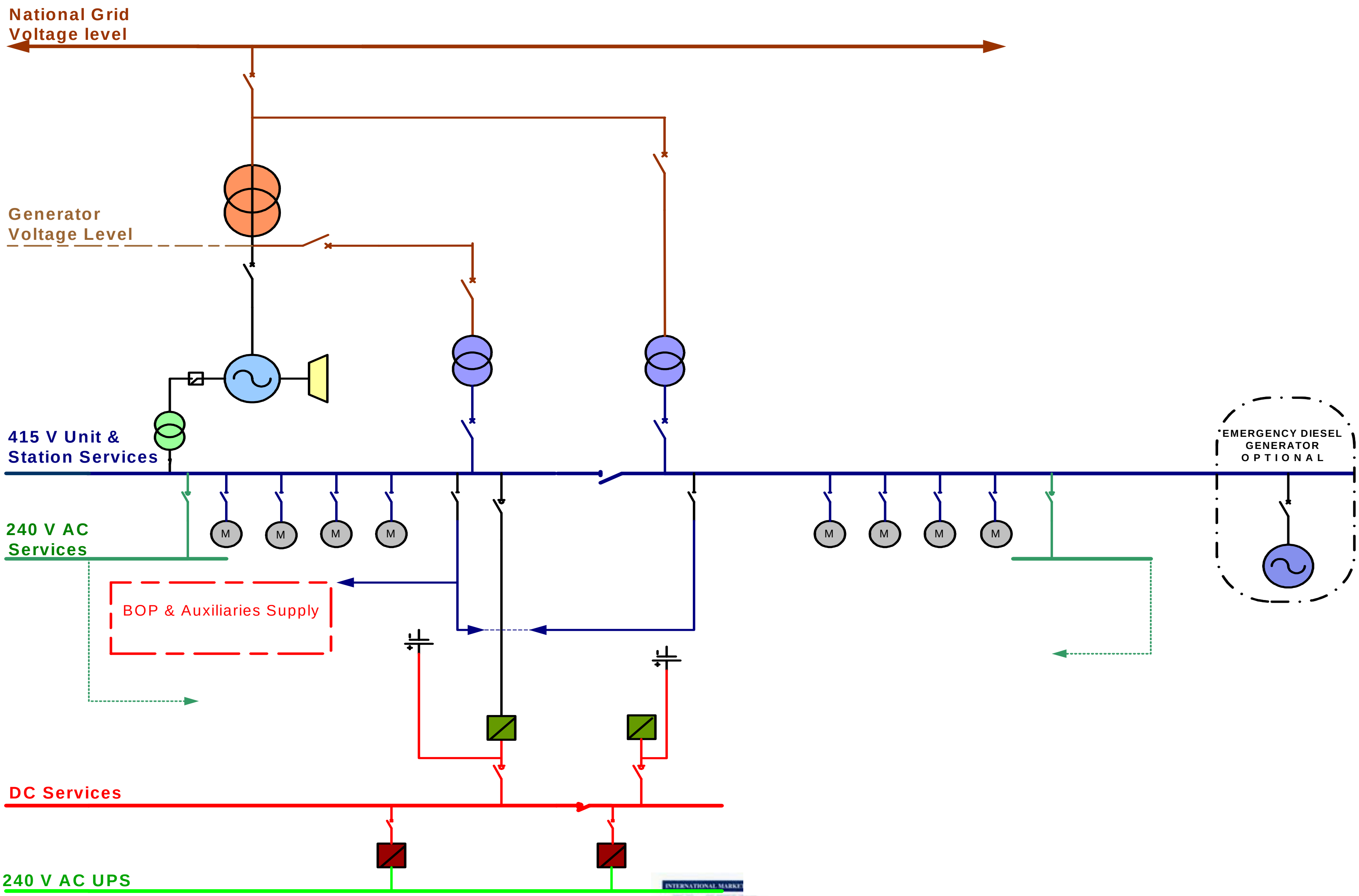
Industrial Analysis of Mill Oil Palm Waste

	Unit	Shell	Dry-Shell	Fibre	Dry-Fibre
Volatile matter	%	71	78.05	75.8	83.4
Fixed carbon	%	19.3	21.2	12.1	13.33
Ash	%	0.7	0.75	3.0	3.27
Moisture	%	9.0	-	9.1	-
Gross calorific value	MJ/kg	18.90	20.77	16.68	18.38
Low calorific value	MJ/kg	17.60	-	15.42	-

Moisture Content (%) and Low Calorific Value of Mill Oil Palm Waste (MJ/kg)

Moisture	Shell		Fibre		Bunch stalk	
(%)	Pure	Oily	Pure	Oily	Pure	Oily
10	20.72	20.93	19.68	20.72	17.58	18.84
20	17.25	18.84			-	-
30	-	-	10.78	11.35	-	-
40	-	-	8.37	9.1	-	-
50	-	-	-	-	7.54	8.16
60	-	-	-	-	5.52	6.03

Typical Single Line Diagram



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Biomass gasification

- **Stage I ⇨ Gasification process starts as autothermal heating of the reaction mixture. The necessary heat for this process is covered by the initial oxidation exothermic reactions by combustion of a part of the fuel**
- **Stage II ⇨ In the second – pyrolysis stage, combustion gases are pyrolyzed by being passed through a bed of fuel at high temperature. Heavier biomass molecules distillate into medium weight organic molecules and CO_2.**
- **Stage III⇨ Initial products of combustion, CO_2 and H_2O are reconverted by reduction reaction to CO, H_2 and CH_4.**

Biomass gasification

Gasification Stage	Reaction formula	(Reaction number) / Reaction type	Reaction heat kJ/kmol
Stage I Oxidation and other exothermic reactions	$C+½O_2$ --- CO	(1) Partial oxidation	+110,700
	$CO+½ O_2$ --- CO2	(2) CO oxidation	+283,000
	$C+O_2$ ---- CO_2	(3) Total oxidation	+393,790
	$C_6H_{10}O_5$ --- xCO_2+yH_2O	(4) Total oxidation	>>0
	$H_2+½O2$ --- H_2O	(5) Hydrogen oxidation	+241,820
	$CO+H_2O$ ---- CO_2+H_2	(6) Water-gas shift	+ 41,170
	$CO+3H_2$ --- CH_4+H_2O	(7) Methanation	+206,300
Stage II Pyrolysis	$C_6H_{10}O_5$ --- CxHz+ CO	(8) Pyrolysis	<0
	$C_6H_{10}O_5$ --- CnHmOy	(9) Pyrolysis	<0
Stage III Gasification (Reduction)	$C+H_2O$ ---- $CO+H_2$	(10) Steam gasification	-131,400
	$C+CO_2$ ---- 2CO	(11) Boudouard reaction	-172,580
	CO_2+H_2 ---- $CO+H_2O$	(12) Reverse water shift	- 41,170
	$C+2H_2$ ---- CH_4	(13) Hydrogenation	+ 74,900

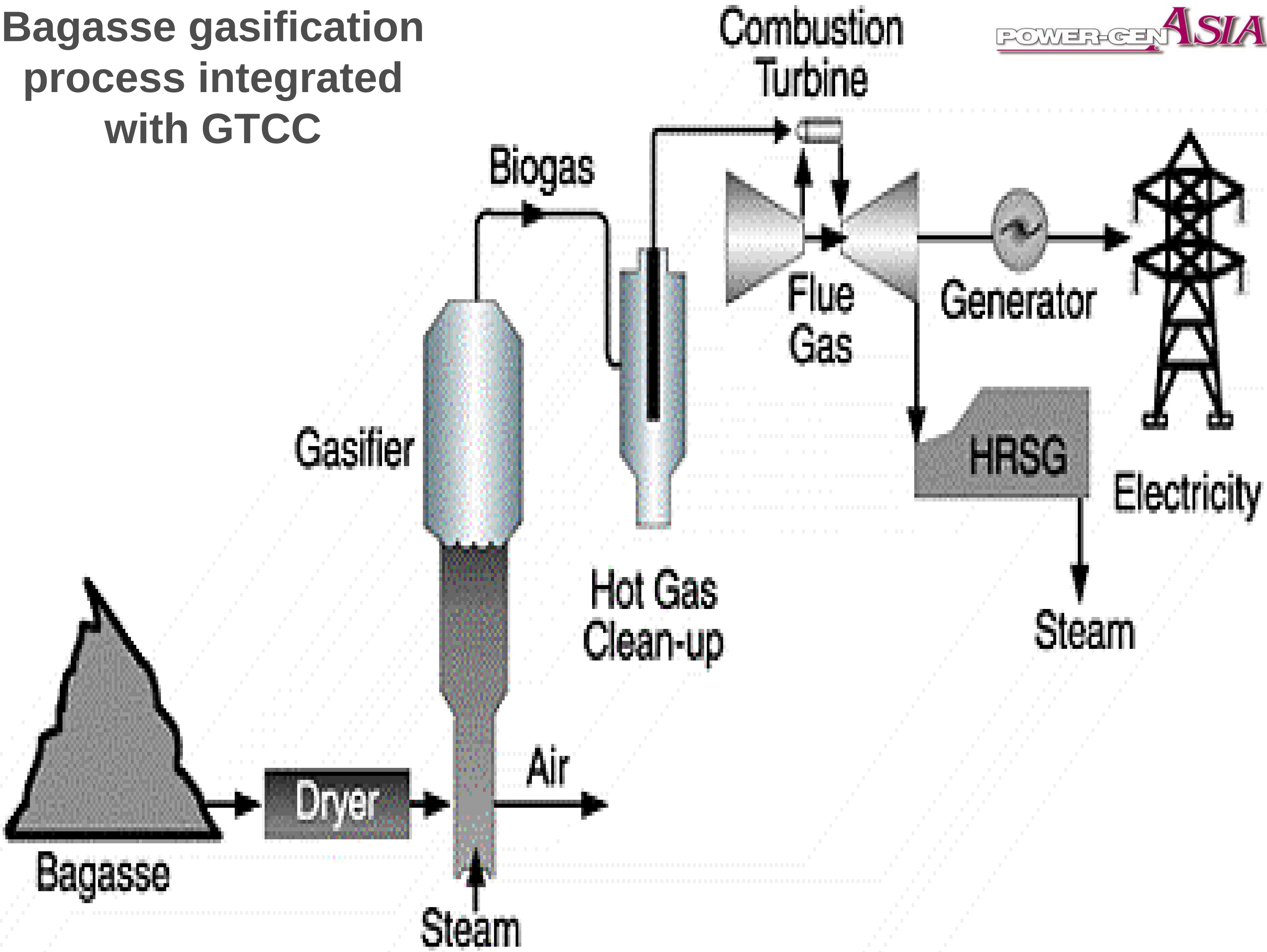
Typical characteristics of biomass fuels for gasification

Biomass Fuel	Moisture % wet	Ash % dry	Volatile Matter % dry	Bulk density kg/m³	Average HHV MJ/kg dry
Charcoal	2-10	2-5	5-30	200-300	30
Wood	20-40	0.1-1.0	70-80	600-800	20
Rice Husks	3-5	15-25	60	100	15
Coconut Shells	25	0.8	79	400	20

Fuel requirements for different gasifier types

Gasifier Type	Updraft	Downdraft	Open Core	Cross draft
Fuel	Wood	Wood	Rice Husks	Charcoal
Size, mm	20-100	5-100	1-3	40-80
Moisture, %	<25	<60	<12	<7
Ash, %	<6	<25	Approx. 20	<6

Bagasse gasification process integrated with GTCC



Advanced integrated biomass gasification and combined heat and power concepts are promising but still not fully demonstrated.

The main difficulties are the requirements set by gas turbine manufacturers in adapting gas turbines to low BTU gases and to fulfil the gas quality specifications applicable for syngas utilization in gas turbines.

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Anaerobic Digestion

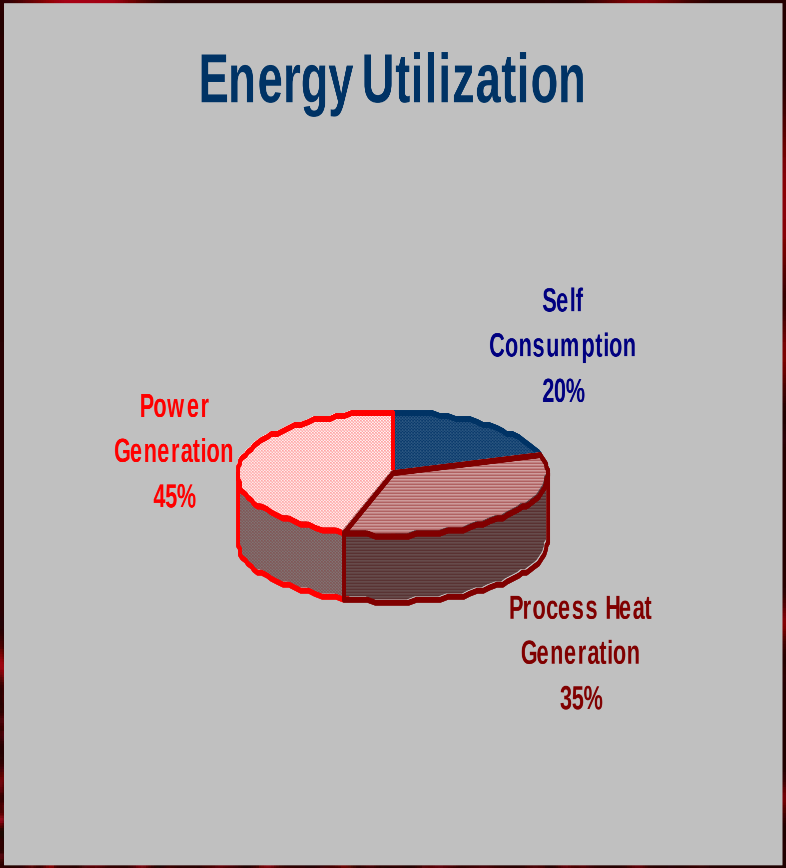
- **Biogas was first discovered by Alessandro Volta in 1776 and Humphery Davy was the first to pronounce the presence of combustible gas Methane in the Farmyard Manure in as early as 1800.**

- **Anaerobic digestion is a biological process that produces a gas principally composed of methane (CH_4) and carbon dioxide (CO_2) otherwise known as biogas.**

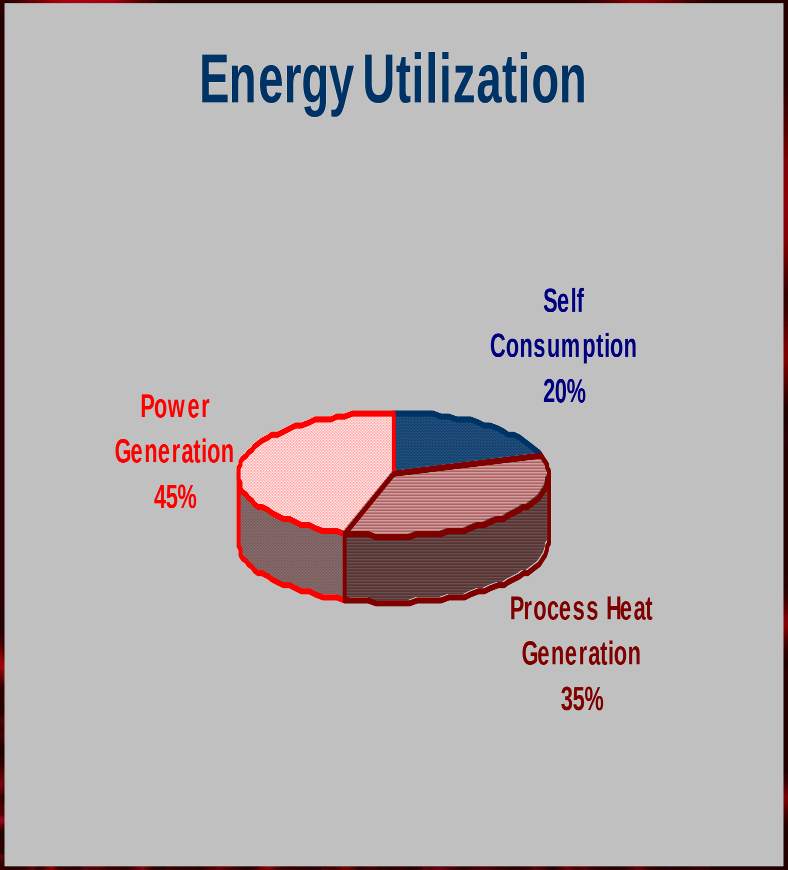
Biogas Production

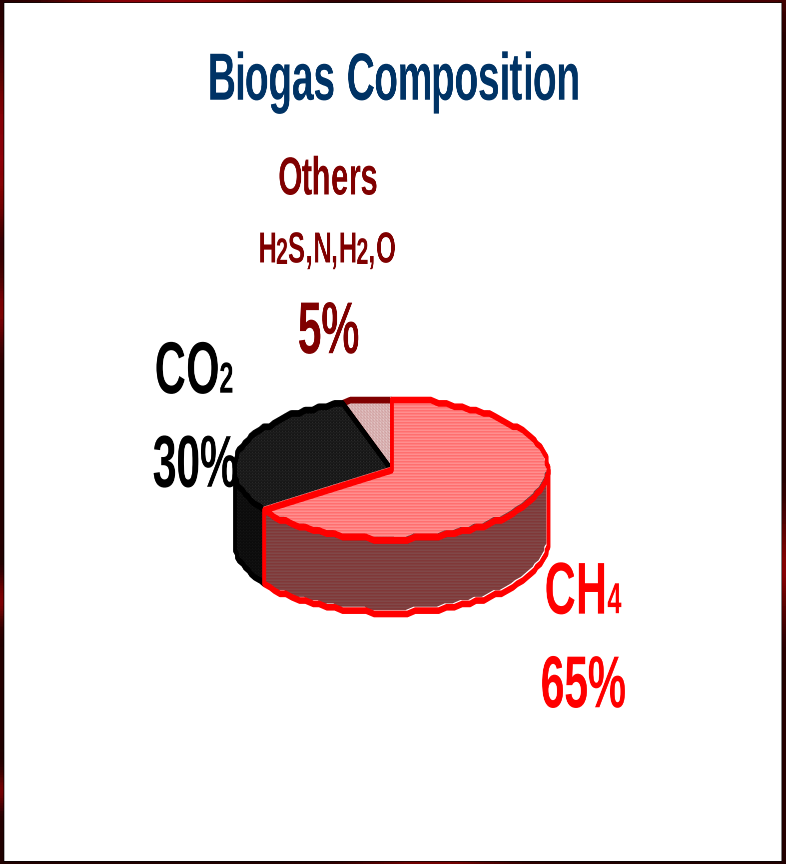
- The biogas-production is normally in the range of 0.3 - 0.45 m^3 of biogas per 1kg of solid substances for a well functioning process with a typical retention time of 20-30 days.
- The lower heating value of this gas is about 22 MJ/m^3 = 0.55kg of light diesel oil.
- The amount of biogas produced varies with the amount of organic waste fed to the digester and temperature influences the rate of decomposition.

Typical Biogas Utilisation



Typical Biogas
Utilisation & Composition

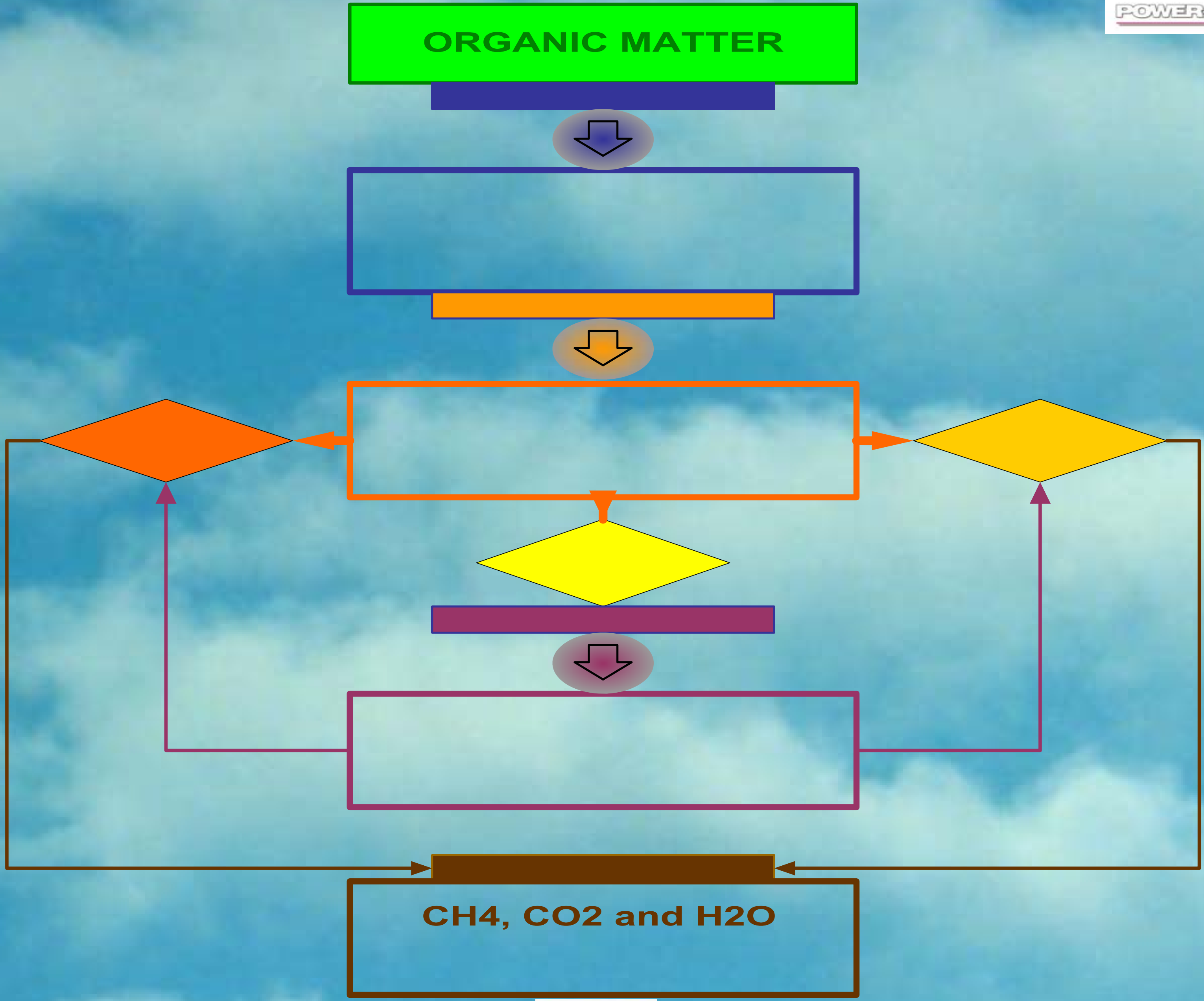




- Biogas can substitute for natural gas or propane in space heaters, refrigeration equipment, cooking stoves or other equipment

- Compressed digester gas can be used as an alternative transportation fuel

- **Anaerobic digestion is a complex biochemical reaction carried out in a number of steps by several types of micro-organisms that require little or no oxygen to live.**
- **To promote bacterial activity, the digester must maintain a temperature of at least 20°C (ideal 25°C - 35°C).**
- **Higher digester temperatures, above 50°C - 65°C, shorten processing time, allowing the digester to handle a larger volume of organic waste**


ORGANIC MATTER
CH4, CO2 and H2O

Anaerobic digestion process parameters

Digestion Process	Description	Advantages	Disadvantages
Dry	Dry solids content of > 25-30%	Compact, lower energy input, better biogas quality (<80% CH_4), maintenance friendly	Restricted mixing possibilities
Wet	Dry solids content of < 15%	Better mixing possibilities	Higher energy input, lager reactor
Mesophilic	Digestion temperature between 25°C and 35°C	Longer process time, slower rate	Low energy input
Thermophilic	Digestion temperature between 50°C and 70°C	Shorter process time, higher degradation, faster rate	Higher energy input
Batch	Substrate in closed reactor during whole degradation period	Suitable for small plants with seasonal substrate supply	Unstable biogas production
Continuous	Reactor is filled continuously with fresh material	Constant biomass production through continuous feeding	

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Other biomass related fuels

- Ladfill Gas, typically 50% CH_4 and 45% CO2*5-6 GJ per 1tonne of waste
- Organic waste and municipal sewage; 60% - 70% HC_4, an average energy content of about 22 MJ/m^3, Average digestion retention time is 80 days at 20°C and 20 days at 50°C .
- Ethanol; corn, potatoes, beets, sugarcane, wheat, barley, and similar can be converted by fermen-tation process into ethanol. Fermentation takes place in the presence of air and is, therefore, a process of aerobic digestion.
- Methanol; Potential feedstock includes wood, agricultural residues and also natural gas. Methanol does not have all the environmental benefits.

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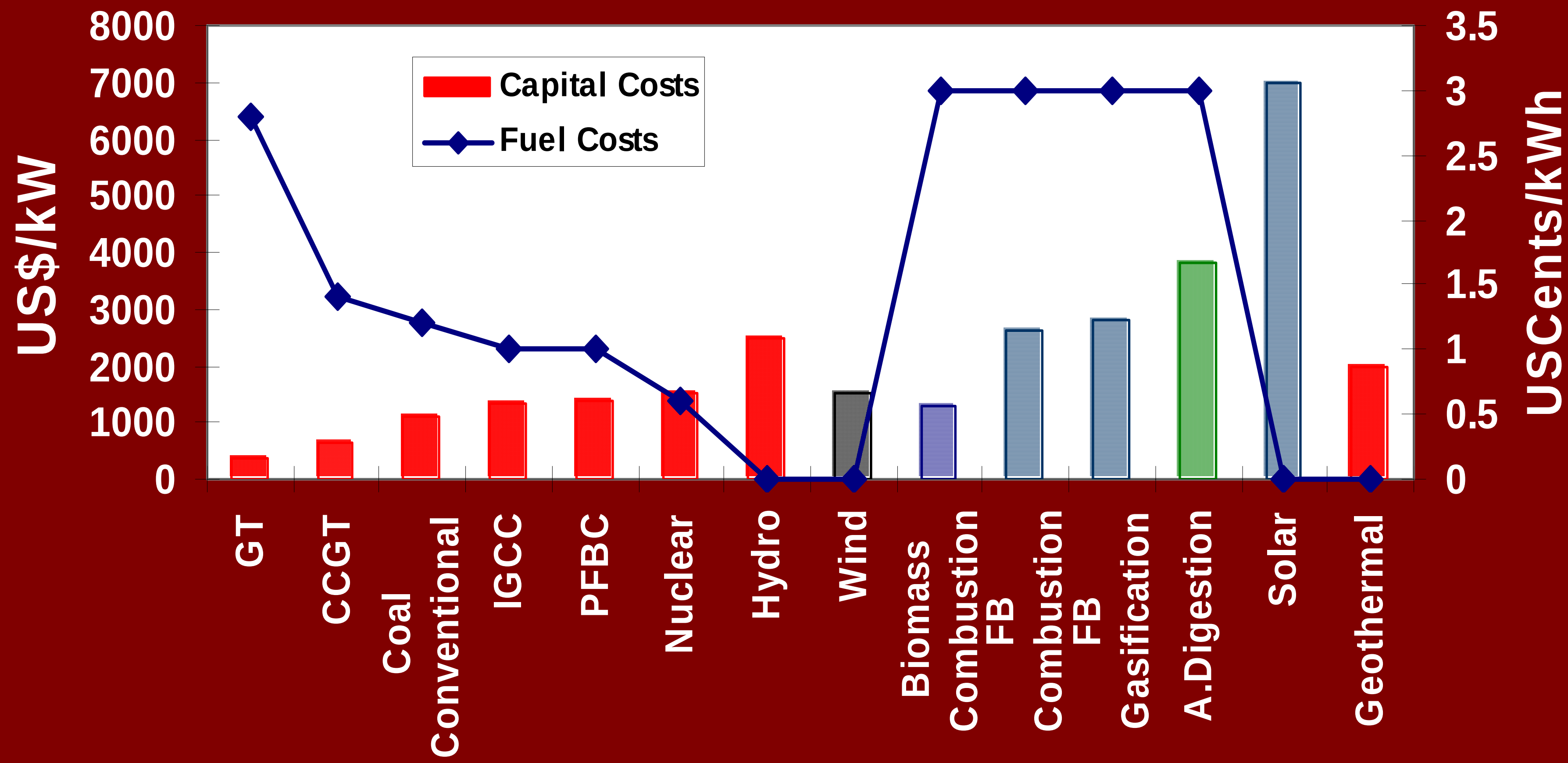
Comparison between gasification systems

Type	Technology	GT Power Output MWe	ST Power Output MWe	Fuel Input Ton/hour	Specific Costs US$/kW
FBC	Fluidized Bed Combustion	0	5	5-10	2600
FBG	Fluidized Bed Gasification	3.3	1.7	4-8	2800
ADB	Anaerobic Digestion-Biogas	<1.0	<0.9[1)]	2.5[2)]	3000-4500

1) 0.9 MW_{th} (Net Available Heat Energy) 2) Assumptions: Biomass LHV=8 MJ/kg, 35% Power / 45% Heat Generation / 20% Internal Consumption

Specific Capital Costs vs. Fuel Costs for Miscellaneous Power Generation Systems



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Numerous biomasses fuelled cogeneration plants are already in operation worldwide.

Many of the more than 2.5 billion people who live without reliable electricity inhabit areas where large amounts of biomass are available for power generation.

Small size distributed biomass power plant systems can provide them with reliable power and thermal energy for heating and cooling purposes.

However, the real environmental benefit of biomass utilization will come when we can use large amounts of biomass-based fuel to generate electricity, thereby considerably reducing consumption of fossil fuels.

Thank You

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Technical Paper
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