DIRECT COMBUSTION

Direct Combustion, oldest solid waste conversion technology, is the most direct process for converting solid biomass into usable energy.

Combustion technologies convert solid waste into several energy forms for commercial and/or industrial applications. Combustion is a thermo-chemical conversion process utilizing the following major feedstock:

- Wood;
- Agricultural & Farming Solid Waste;
- Selected (non-toxic) Components from Municipal Solid Waste.

Direct combustion process produces thermal energy which can be converted to steam, hot water hot air or utilized for cooling processes.

Despite its apparent simplicity, direct combustion is from a technological point of view a complex process. High reaction rates and high heat release and many reactants and reaction schemes are involved.

In order to analyze the combustion process a division is made between the place where the waste fuel is burned (the furnace) and the place where the heat from the flue gas is exchanged for a process medium or energy carrier (the heat exchanger).

Proper designed industrial and nutrient waste combustion facilities can burn various types of solid waste. In combustion process, volatile hydrocarbons (C_xH_y) are formed and burned in a hot combustion zone.

In a furnace, the solid waste is converted via combustion process into heat energy.

The heat energy is released in form of hot gases to heat exchanger that switches thermal energy from the hot gases to the process medium (steam, hot water or hot air). The efficiency of the furnace is defined as follows:

$$\eta_{COMBUSTION} = \frac{\text{CHEMICAL ENERGY AVAILABLE IN FURNACE EXHAUST GAS}}{\text{CHEMICAL ENERGY CONTAINED IN SOLID WASTE}}$$

Depending on feedstock **L**ow **H**eating **V**alue (LHV), typical combustion efficiencies varies in the range of 65% in poorly designed furnaces up to 99% in high sophisticated, well maintained and perfectly insulated combustion systems.

Generally direct combustion systems include either fixed-bed or fluidized-bed technology.

Fixed-bed technology is basically distinguished by types of grates and the way the feedstock is supplied to or transported through the furnace. Fluidized beds suspend solid fuels on upward-blowing jets of air during the combustion process.

The result is a turbulent mixing of gas and solids. The tumbling action, much like a bubbling fluid, provides more effective chemical reactions and heat transfer. Additional factor that determines the system efficiency is the efficiency of the heat exchanger, which is defined as follows:

$$\eta_{\text{HEAT EXCHANGER}} = \frac{\text{AVAILABLE PROCESS THERMAL ENERGY}}{\text{CHEMICAL ENERGY AVAILABLE IN FURNACE EXHAUST GAS}}$$

Typical heat exchanger efficiencies based on biomass LHV range between 60% and 95%, mainly depending on design and kind of operation and maintenance. The main losses are in the hot flue gas exiting from the stack.

In the industrial practice, the furnace and heat exchanger form together biomass-fired boiler unit.

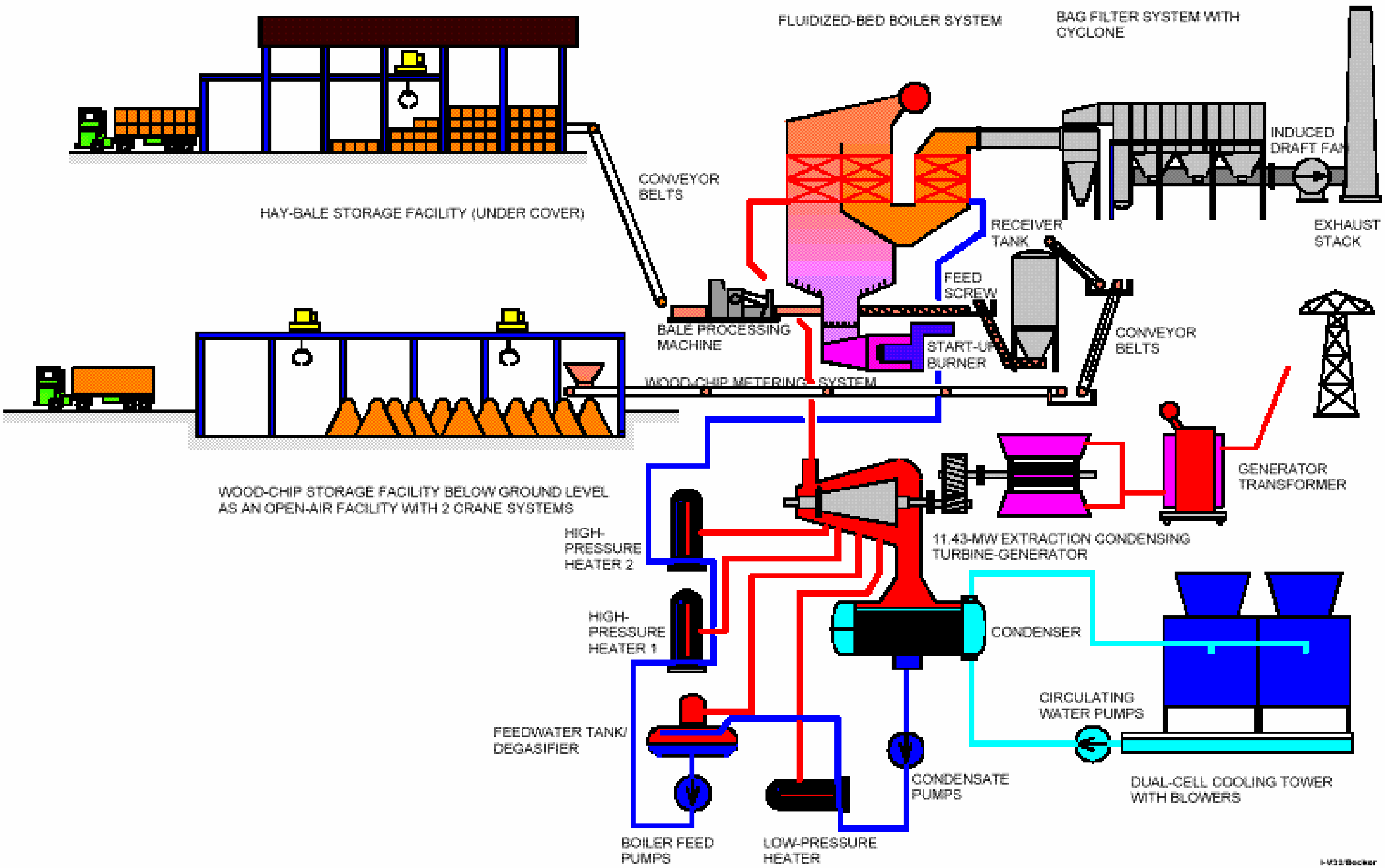
The boiler is a more adaptable direct combustion technology because the boiler transfers the heat of combustion directly into the process medium. Overall boiler efficiency is defined as follows:

$$\eta_{\text{BOILER}} = \eta_{\text{COMBUSTION}} \times \eta_{\text{HEAT EXCHANGER}}$$

Overall boiler efficiency varies between 50% and 95%. Very common and most efficient are biomass systems with direct combustion for electrical power generation and co-generation.

Such system can achieve an overall efficiency between 30% (power generation systems) and 85% (co-generation systems).

Typical flow diagram of biomass fired (mixture of wood chips and hay) 10 MW_{el} power plant with fluidized-bed boiler system, designed by SIEMENS AG is shown in the following picture.



FLUIDIZED-BED BOILER SYSTEM
BAG FILTER SYSTEM WITH CYCLONE
INDUCED DRAFT FAN
EXHAUST STACK
CONVEYOR BELTS
HAY-BALE STORAGE FACILITY (UNDER COVER)
RECEIVER TANK
FEED SCREW
BALE PROCESSING MACHINE
START-UP BURNER
CONVEYOR BELTS
WOOD-CHIP METERING SYSTEM
GENERATOR TRANSFORMER
WOOD-CHIP STORAGE FACILITY BELOW GROUND LEVEL AS AN OPEN-AIR FACILITY WITH 2 CRANE SYSTEMS
HIGH-PRESSURE HEATER 2
11.43-MW EXTRACTION CONDENSING TURBINE-GENERATOR
HIGH-PRESSURE HEATER 1
CONDENSER
CIRCULATING WATER PUMPS
FEEDWATER TANK/ DEGASIFIER
CONDENSATE PUMPS
DUAL-CELL COOLING TOWER WITH BLOWERS
BOILER FEED PUMPS
LOW-PRESSURE HEATER