

A silver metal spiral binding is visible on the left side of the notebook cover, consisting of a series of loops that hold the pages together.

**BIOMASS CONVERSION  
FOR  
ENERGY UTILIZATION**

**BIOFUELS  
GENERATION FROM BIOMASS**

# **Biomass Conversion Contents**

- Energy Crisis: Inefficient use of biofuels
- Objectives of Bio-energy Program
- Biomass to Energy Conversion Methods
- Biomethanation: Rural applications
- Biogas Technology: Topics
- Biofuel: Combustion of solid fuels

## **Energy Crisis: Inefficient use of biofuels**

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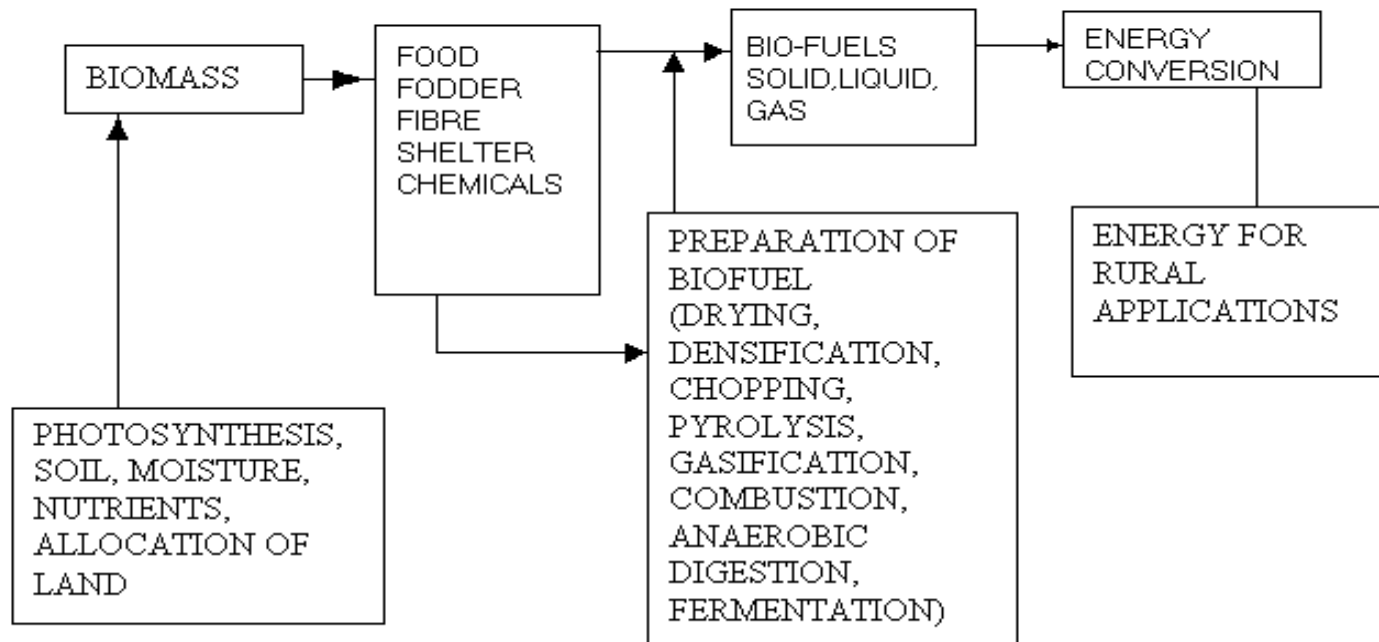
- o Nearly 75% of the rural Indians depend on bio-fuels (firewood, agricultural residues, and cow dung-cake) for 80% of their energy needs.
- o Similarly 25 – 30% of the urban poor, the slum dwellers depend heavily on bio-fuels.
- o Biomass is used as: People's purchasing power is low, & commercial fuels: kerosene and LPG are not available adequately.

## Objectives of Bio-energy Program:

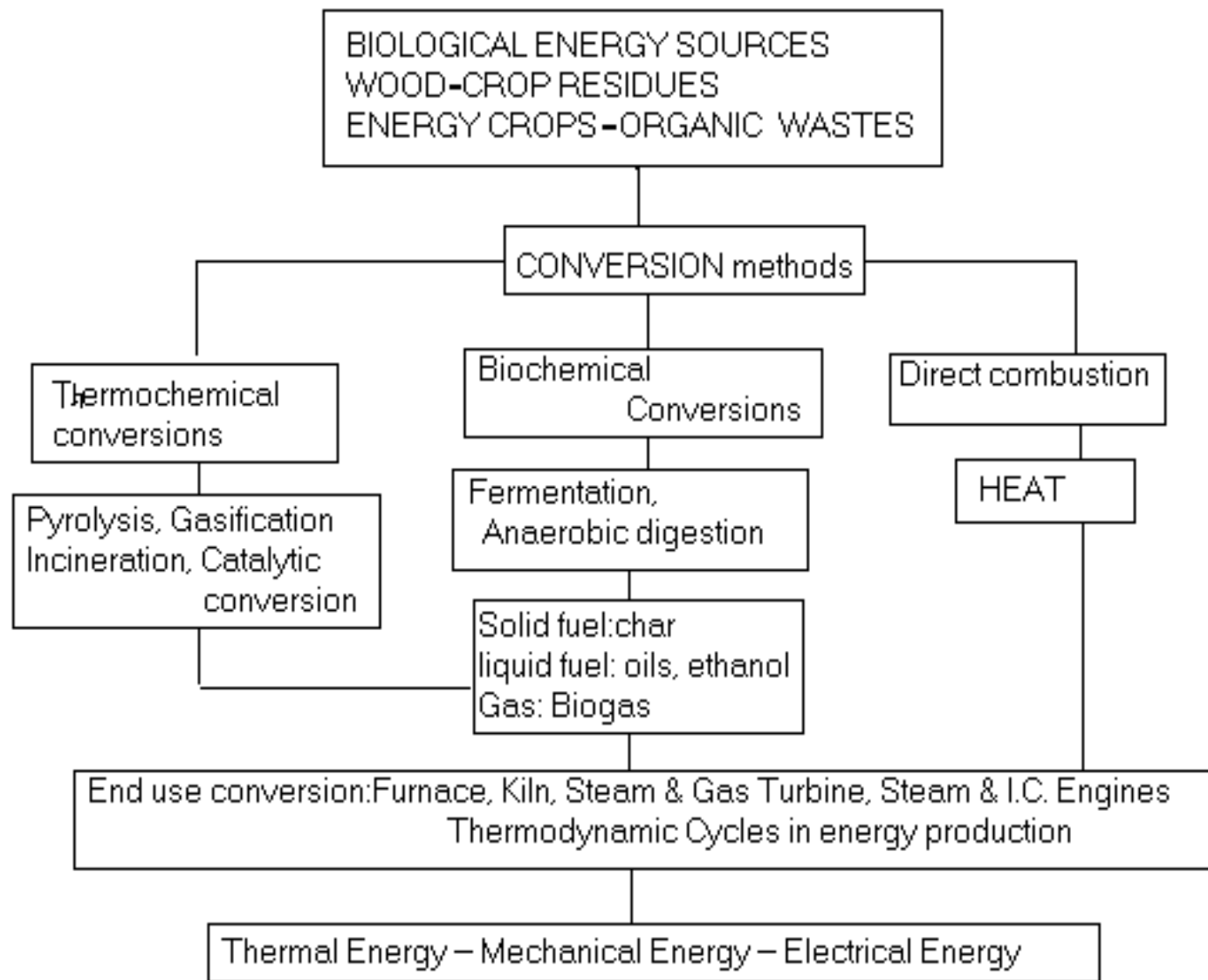
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To make bio-energy a major energy source & elevate its present status as the 'poor man's oil' into a modern energy source, use advanced techniques to produce biomass renewably and to convert it efficiently into electricity, gaseous, liquid and processed solid fuels.

# BIOMASS TO ENERGY



**EXCESSIVE COMBUSTION OF FOSSIL FUELS  
(BY DEVELOPED COUNTRIES)  
DESPERATE OVEREXPLOITATION OF BIO-RESOURCES  
(BY DEVELOPING COUNTRIES).....HAS ADVERSE IMPACT ON ENVIRONMENT**



# BIOMASS CONVERSION METHODS

DIRECT COMBUSTION-

COGENERATION-

BIOMETHANATION-

PYROLYSIS-

THERMAL GASIFICATION-

FERMENTATION-ETHANOL-

TRANSESTERIFICATION:

BIODIESEL

*THERMO-  
CHEMICAL*

*BIO-  
CHEMICAL*

*CATALYTIC  
CONVERSION*

PYROLYSIS

ANAEROBIC  
DIGESTION

HYDROGENATION

GASIFI  
CATION

FERMENT  
-ATION

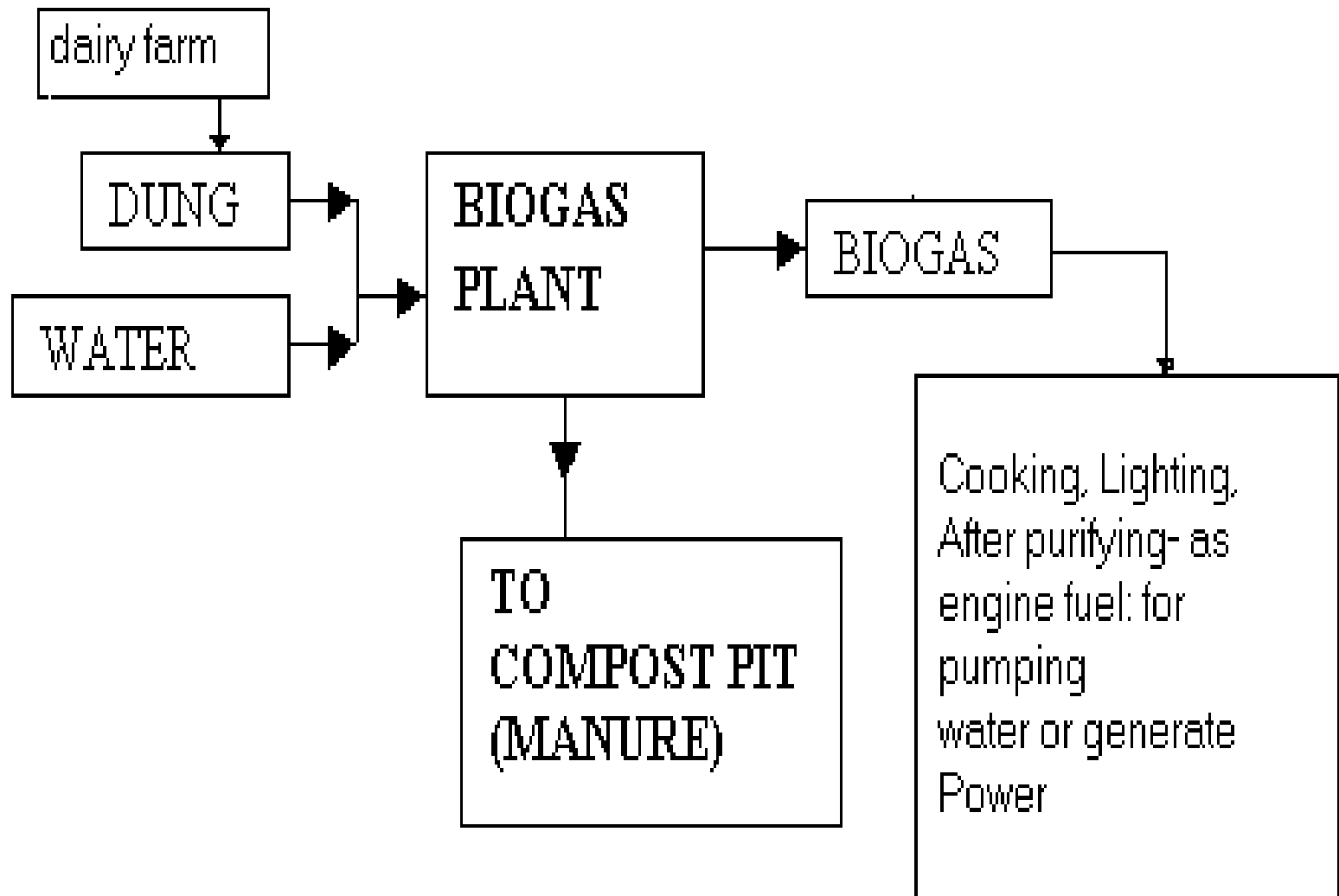
TRANS-  
ESTERIFICATION

COMBUSTION

HYDROLYTIC  
ENZYMES

SYN.GAS  
PROCESS

# WHY Biomethanation in villages?



# Biogas Technology: Topics-1

- **Microbial and biochemical aspects.**
- **Operating parameters for biogas production by anaerobic digestion.**
- **Kinetics and mechanism of biomethanation.**
- **Dry and wet fermentation.**

# Biogas Technology: Topics-2

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- **Digesters for rural application.**
- **MNES Recognized biogas-plant models.**
- **High rate digesters for industrial waste water treatment.**
- **Biogas as a fuel for stationary dual fuel engines.**

# BIOMASS COMBUSTION

- RURAL DOMESTIC: COOKING
- HEAT & STEAM: SMALL SCALE
- ELECTRIC POWER GENERATION:
- COGENERATION / COMBINED  
CYCLE

# Burning Wood Better

- Inefficient burning of wood causes an air pollution problem as well as less efficient use of wood fuel.
- The operator of a wood burning device needs to maintain a hot fire with an adequate supply of air to burn the volatile gases as they are released from the wood.
- Control heat output primarily by fuel load size rather than by air control only.
- Burn only dry and properly seasoned wood in a stove. Never burn trash, coal, railroad ties, plastics or wrapping paper.

# Solid fuels

- Peat
  - Coal (moisture, volatiles, fixed carbon, ash)  
( $\text{CH}_{0.8}$ )
  - Wood (moisture, volatiles, fixed carbon, ash)
  - Charcoal (devolatilized wood)
  - Coke (devolatilized coal or petroleum)
- 
- Key difference among fuels: the quantity of  $\text{CO}_2$  formed per unit of energy released. Natural gas releases ~ 42% less  $\text{CO}_2$  than coal

## **Table Av. Comp. & properties of hardwood:**

GroupWise Composition, air dried	%
Cellulose	45-55
Lignin	25-35
Hemi-cellulose	4-6
Fats, waxes, and resins	0.5-2
Water	10-15

### **Ultimate Analysis and other properties, dry basis**

Carbon %	50
Hydrogen %	6
Oxygen, %	43.5
Ash, %	0.5
Density, kg/m <sup>2</sup>	650
Calorific value, kcal/kg	4,600

**TABLE 3. TYPICAL COMPOSITIONS OF SOLID FUELS**

Types	Proximate Analysis				Ultimate Analysis					HH V, dry basis, kcal/ kg
	Moisture	Volatile	Fixed carbon	Ash	C	H	O	N	S	
Wood Oak (dry)	-----	85.6	13.0	1.4	58.2	6.0	43.3	0.1	-	4622
Pine (dry)	-----	87.0	12.8	0.7	52.2	7.0	40.2	0.2	-	5338
Peat	56.8	26.0	11.2	6.0	23.1	9.6	59.6	1.3	0.4	4625
Lignite	34.8	28.2	30.8	6.2	42.4	6.7	43.3	0.7	0.7	6110
Coal (Range Of property)	3-20	16- 40	40- 80	3.0- 40	60- 50	3.0- 6	3.0- 6	1- 1.5	0.3- 4.3	4000 to 8000
Bagasse	-----	80.5	17.0	2.5	48	6.0	43.2	0.3	0.1	4430
Coke	0.8	1.4	87.1	10.7	85	0.8	1.2	1.3	1.0	7105
Char coal	12.0	1.9	83.1	3.0	84	2.3	10.7	--	--	7130


# Conditions for efficient Combustion-1

- Sufficient air to provide oxygen needed for complete burning; higher than stoichiometric amount of air is supplied.
- Free and intimate contact between fuel and oxygen by distribution of air supply.
- Secondary air to burn the volatile mass leaving the fuel bed completely before it leaves the combustion zone.

Continued...

## Conditions for efficient Combustion-2

- Volatile matter leaving the fuel bed should not cool below combustion temperature by dilution with the flue gas. Flow path should assure this.
- Volume of the furnace should be arranged so as to provide for expansion of gases at high temperature and complete burning of volatile matter before flowing away.

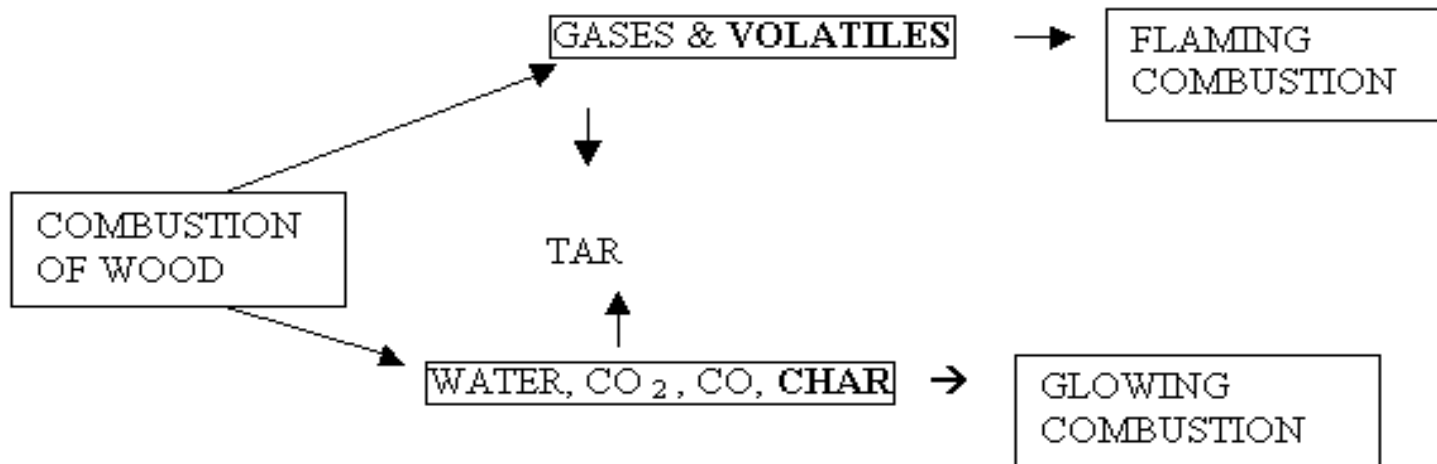


DRAFT: The pressure difference required to make the air flow through the fuel bed and to the flue gas discharge height is called draft of air in a furnace and is expressed in millimeters of water.

The draft is produced either naturally by means of a chimney or mechanically by a fan. Mechanical draft can be either induced draft or a forced draft depending on whether the fan is used to suck the gases away from the furnace or to force the air required for combustion through the grate

# COMBUSTION PROCESS

Combustion of solid biomass like wood involves heating and drying, pyrolysis of solid particle, forming volatiles and char; Pre-combustion gas phase reactions and char oxidation reactions.



**Fig: General pathways for pyrolysis and combustion of Wood**

## To determine the quantity of air required for complete combustion

- To determine the air, the ultimate analysis is useful.
- $C + O_2 = CO_2 + 97644 \text{ cal /mole}$  [[15 o C]
- $H_2 + O_2 = H_2O + 69000 \text{ cal / mole}$  [15 o C]
- Excess air % =  $(40 * MC_g) / (1 - MC_g)$  where  $MC_g$  is moisture content on total wt basis (green). For typical biomass fuels at 50 % moisture content, for grate firing system about 40% excess air may be required.
- For suspension fired and fluidized bed combustion, air required may be 100 % excess
- Distribution of air and whether it is pre-heated is also important

# **Combustion equipment for solid biomass**

## **For wood:**

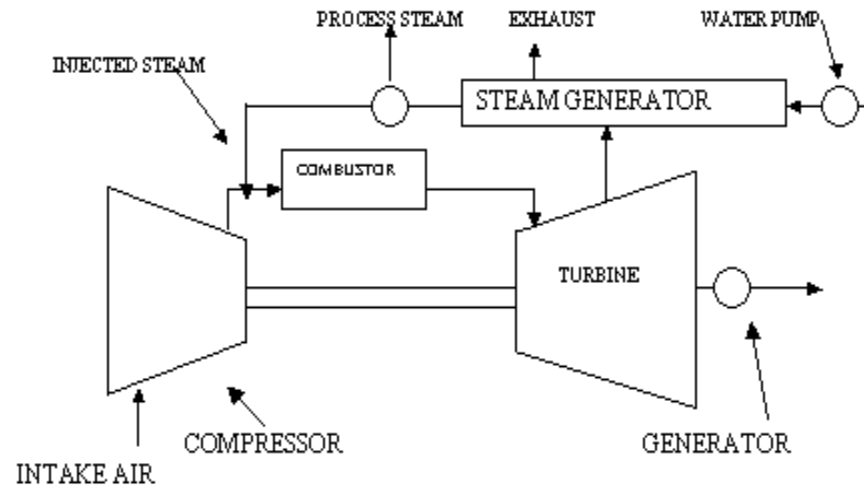
- **Inclined step grate furnace**
- **Spreader Stoker**

## **For solid biomass particulates- (agro-residues):**

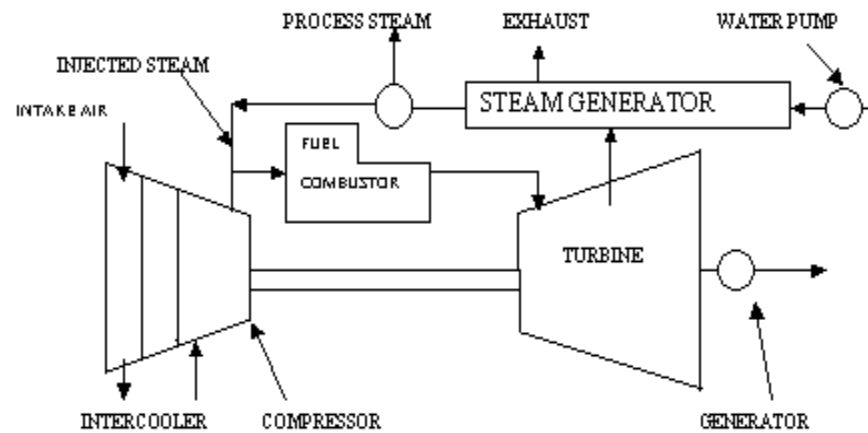
- **Cyclonic, Suspension Fired Combustion System**
- **Fluidised Bed Combustion System**

# BIOMASS INTEGRATED GASIFIER /GAS TURBINE (BIG/ GT) TECHNOLOGY

- HIGH THERMODYNAMIC CYCLE EFFICIENCY
- GAS TURBINES TECHNOLOGY IS MADE AVAILABLE NOW AT REASONABLE COSTS
- LOW UNIT CAPITAL COST AT MODEST SCALES FEASIBLE
- IT IS EXPECTED THAT THIS TECHNOLOGY WILL BE COMMERCIALY SUCCESSFUL IN THE NEXT TEN YEARS.

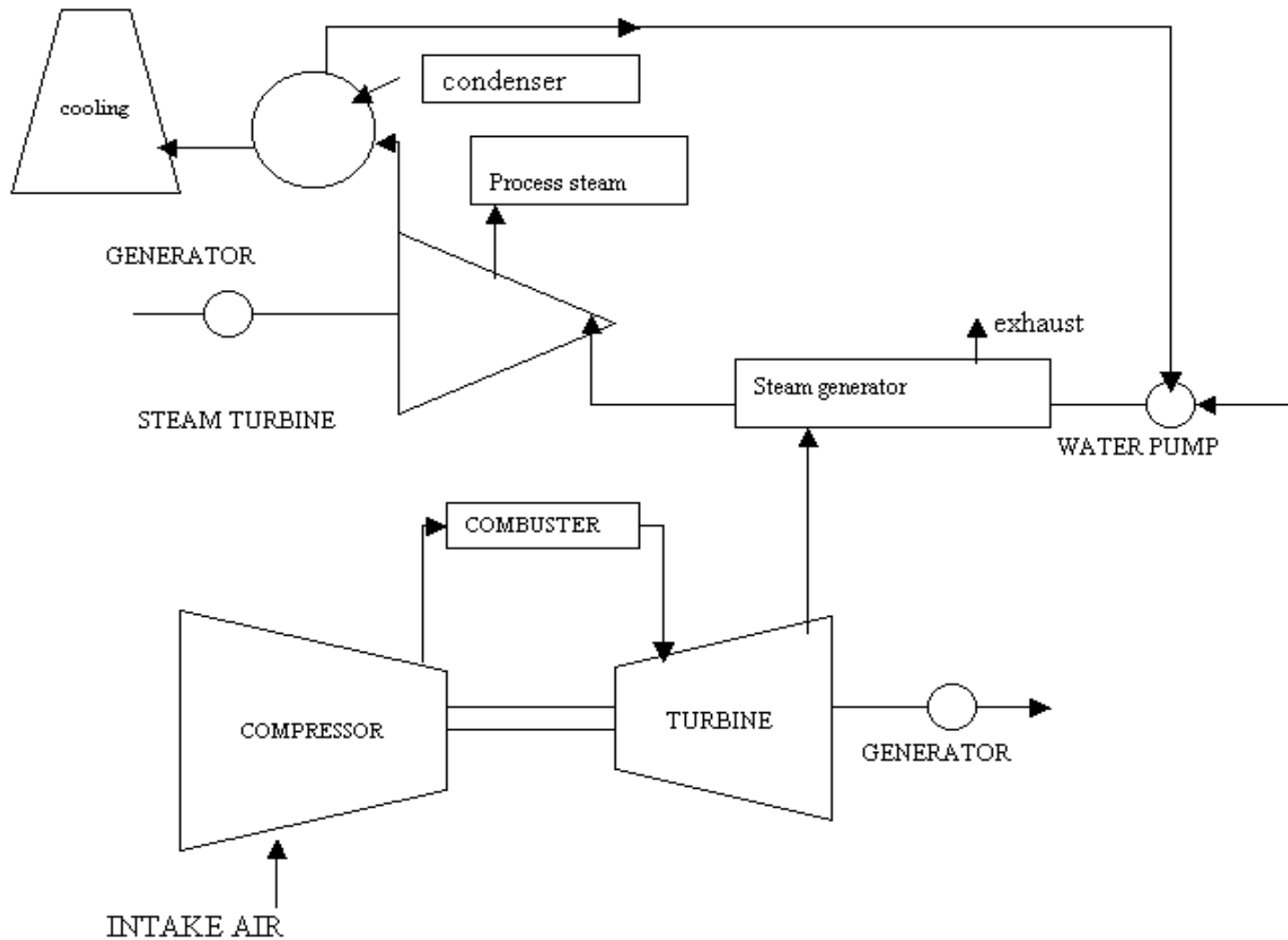


**FIG: STEAM INJECTED GAS TURBINE (STIG)**



**FIG: INTER-COOLED STEAM INJECTED GAS TURBINE (ISTIG)**

FIG: GAS TURBINE / STEAM TURBINE COMBINED CYCLE



Combined cycle: Steam from HRSG is used to produce extra power in a condensing steam turbine, from which some steam might be bled for process applications.