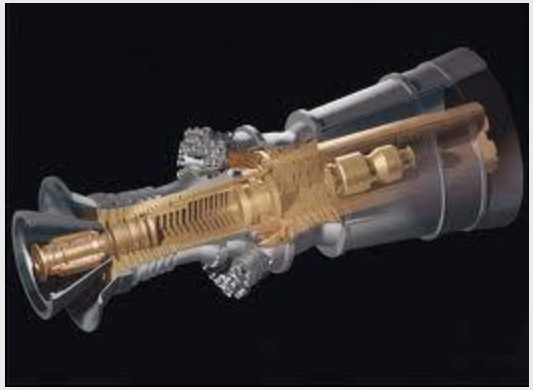



CHAPTER 7

GAS UTILIZATION EQUIPMENT

Equipment for Electricity Generation

Gas Turbine



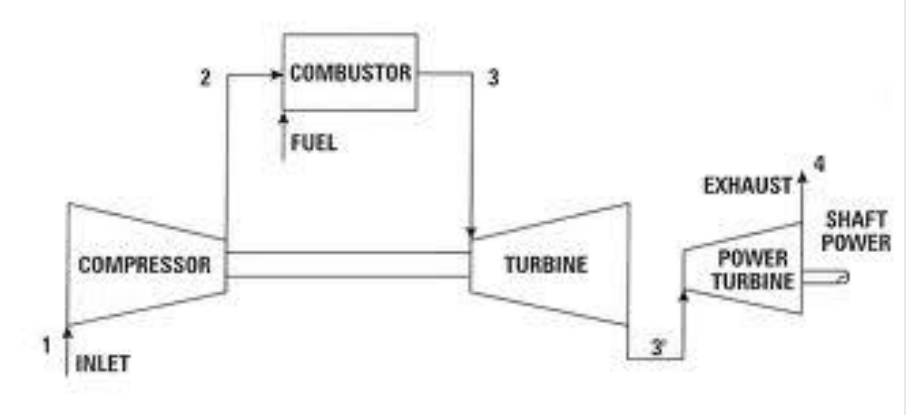
Introduction

- The earliest patent on gas turbine was that of the Englishman, John Barber, in year 1879.
- Early designs were unsuccessful due to some factors.
- Serious development of the gas turbine began only after the second world war with the shaft power in mind.

Gas Turbine Cycle – Brayton Cycle

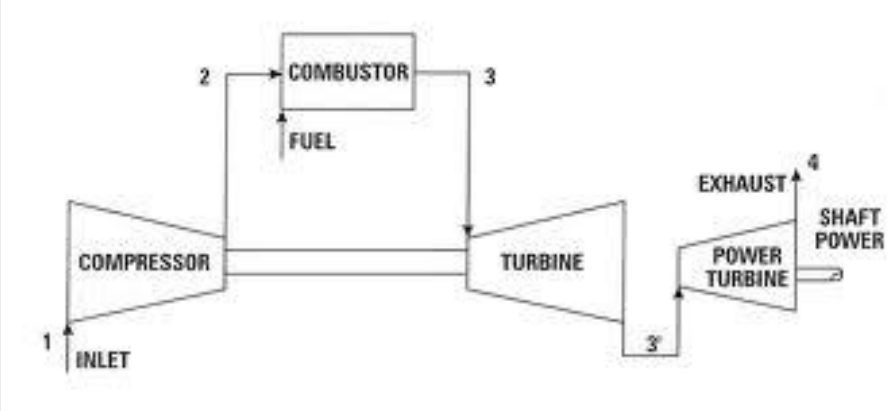
3 segments;

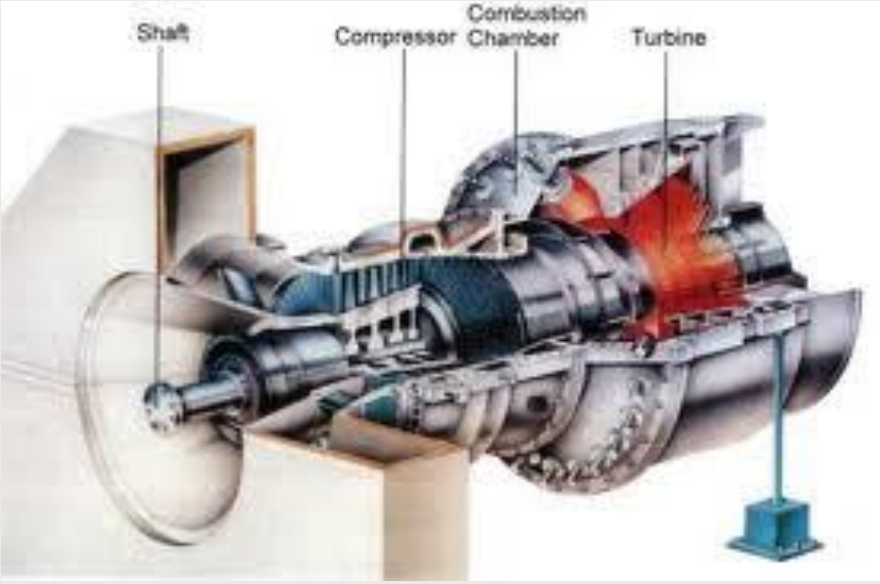
- Compressor
- Combustor
- Turbine



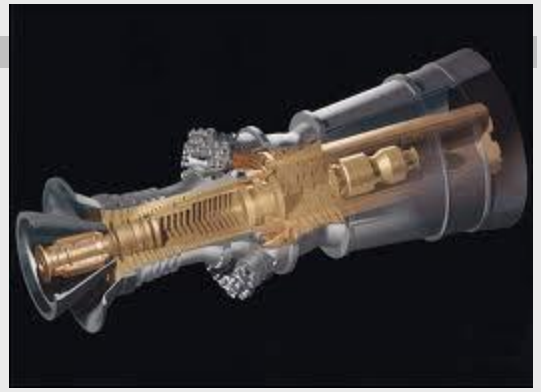
Process 1-2: Isentropic compression in the compressor
Process 2-3: Addition of heat at constant pressure
Process 3-4: Isentropic expansion of air
Process 4-1: Rejection of heat at constant pressure

Basic Components





Basic Components



1. Compressor: The compressor sucks the air from the atmosphere and compresses it and guides it to the combustion chamber.

2. Combuster: This is an annular chamber where the fuel burns and is similar to the furnace in a boiler.

3. Turbine: Stationary guide vanes of turbine direct the gases to the next set of blades. The kinetic energy of the hot gases impacting on the blades which rotates the blades and the shaft.

How Does Gas Turbine Work?

- Gas turbine functions in the same way as the Compressed Ignition Engine.
- It sucks in air from the atmosphere, compresses it.
- The fuel is injected and ignited.
- The gases expand doing work and finally exhausts outside.
- The only difference is instead of the reciprocating motion, gas turbine uses a rotary motion throughout.

Gas Turbine Application

- Turbojet engine
- Marine field
- Railway engines
- Generation of electric power
- Industry

Advantages

- Minimum cost investment
- Low maintenance cost
- Low starting torque
- Fast rate of adjustment
- On site installation
- Less installation
- Multi-fuel capability
- High power to weight ratio

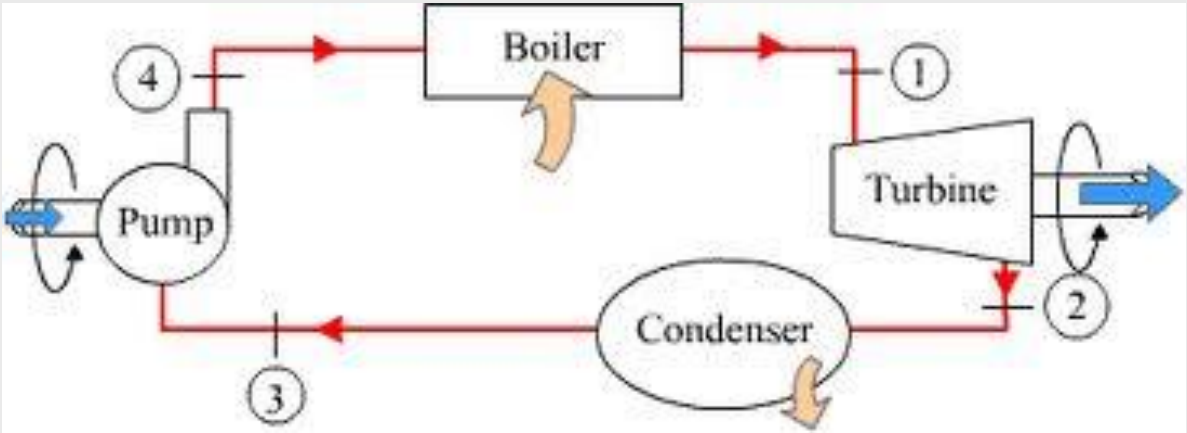
Disadvantages

- High initial capital cost (for prime mover)
- Low overall efficiency
- High frequency noise generated
- High gas pressure required

Steam Turbine

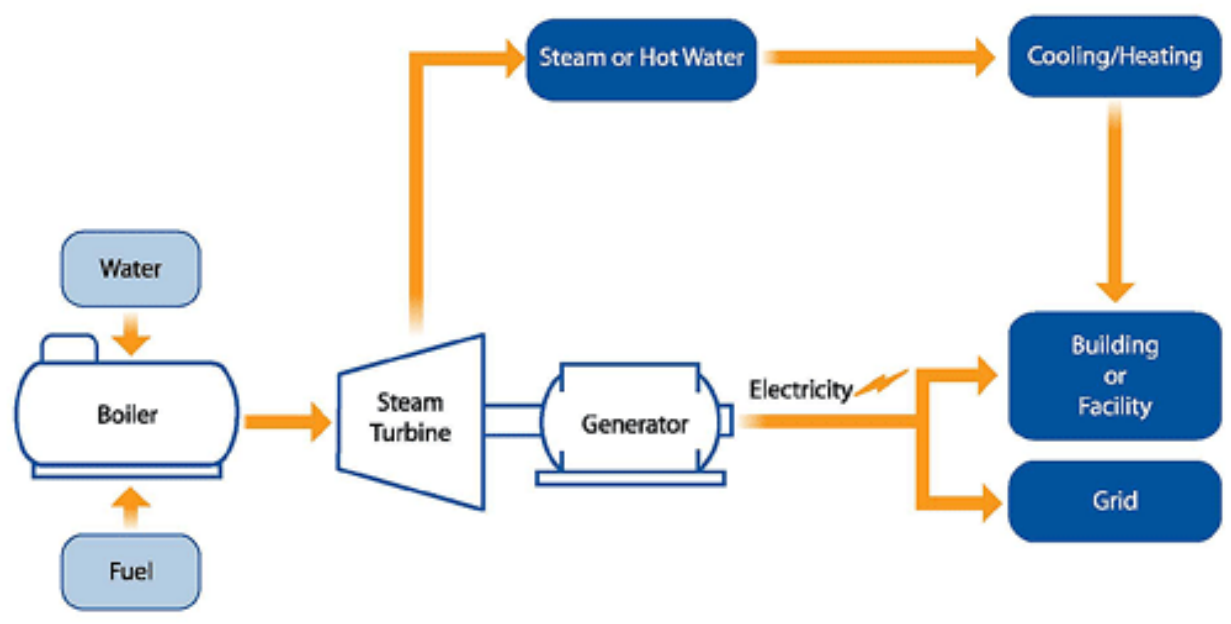
A steam turbine based power plant consists of raising high pressure steam in a boiler from the thermal energy and expanding the steam in a turbine to generate shaft power which in turn is converted into electricity in the generator.

Steam Turbine –Rankine Cycle



Process 1-2: Reversible adiabatic expansion in the turbine
Process 2-3: Constant pressure transfer of heat in the condenser
Process 3-4: Reversible adiabatic pumping process in the pump
Process 4-1: Constant pressure transfer of heat in the boiler

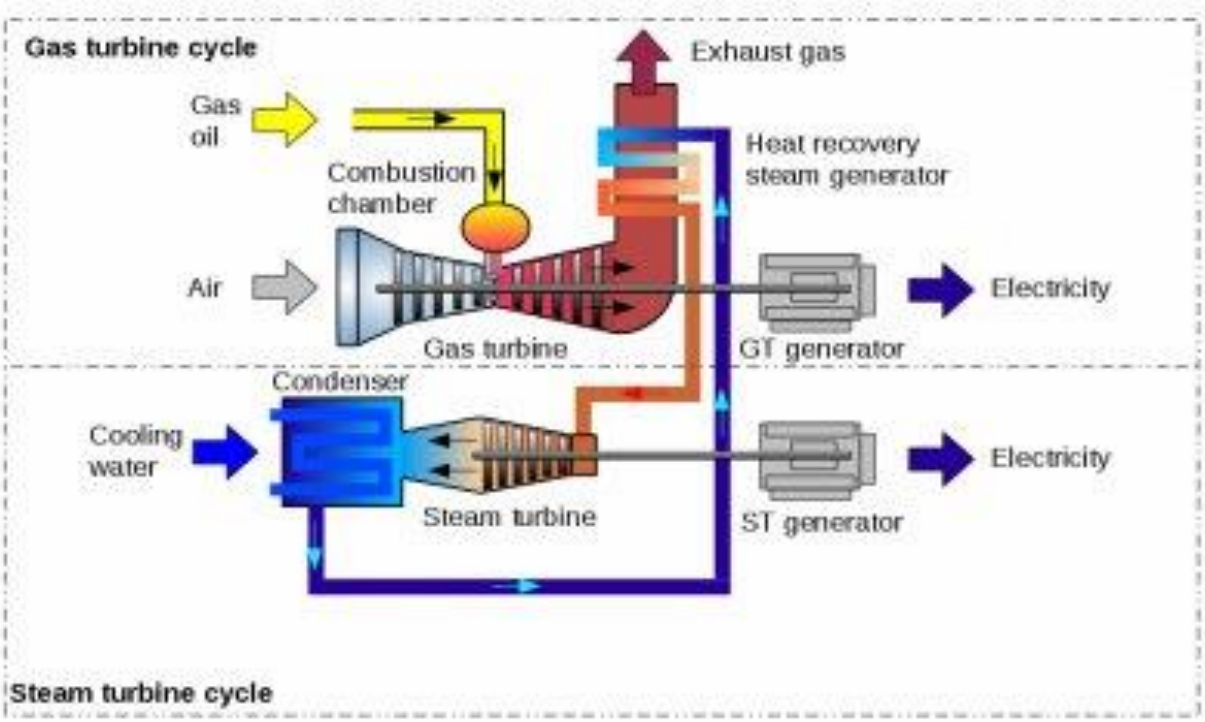
How electricity is generated?



Boiler: NG and air are burned produce steam

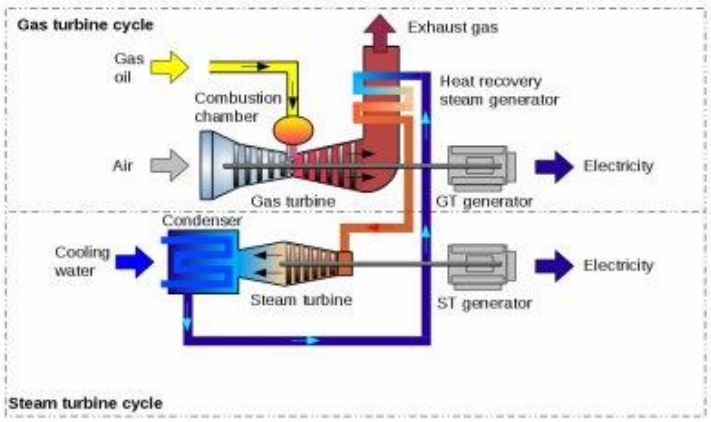
Steam produced is expanded through the power turbine producing mechanical power

Combined Cycle Power Plant (CCPP)



CCPP : Combined cycle power plant

How CCPP work?



CCPP : Combined cycle power plant

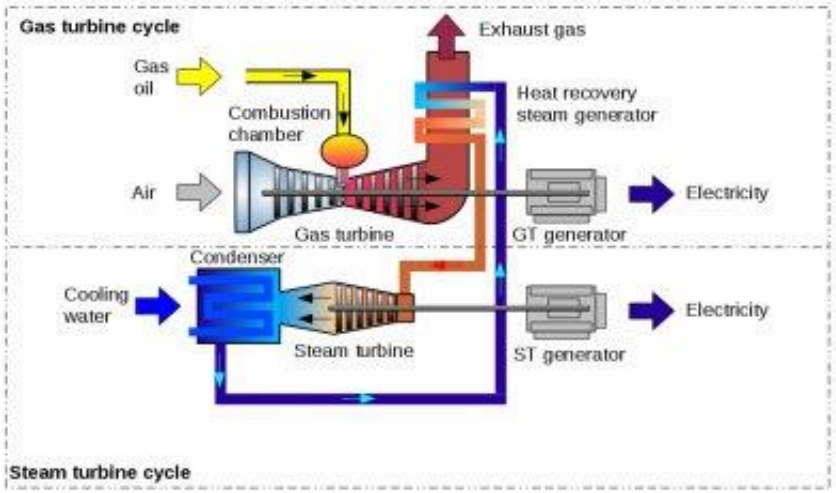
2 cycles involve:
steam cycle, SC and the gas cycle, GC

In the SC, fuel is burned to boil water and create steam which turns a steam turbine driving a generator to create electricity

In the GC cycle, gas is burned in a gas turbine which directly turns a generator to create electricity

Combined cycle power plants operate by combining the gas cycle and the steam cycle for higher efficiency

How CCPP work?

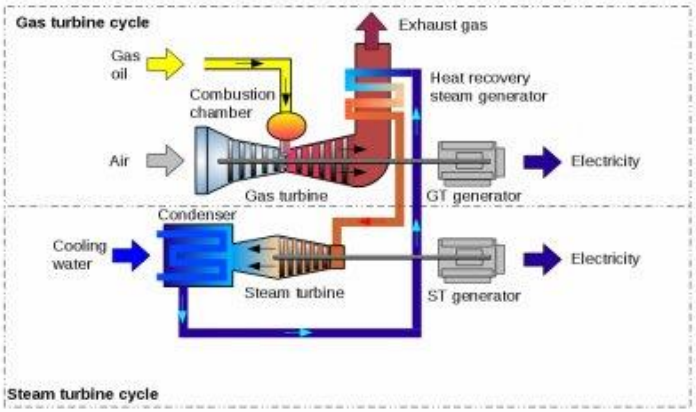


CCPP : Combined cycle power plant

The principle is that the exhaust of one heat engine is used as the heat source for another, thus extracting more useful energy from the heat

(The hot exhaust gases exiting the gas turbine are routed to the steam cycle and are used to heat or boil water)

How CCPP work?



This works because heat engines are only able to use a portion of the energy their fuel generates (usually less than 40%).

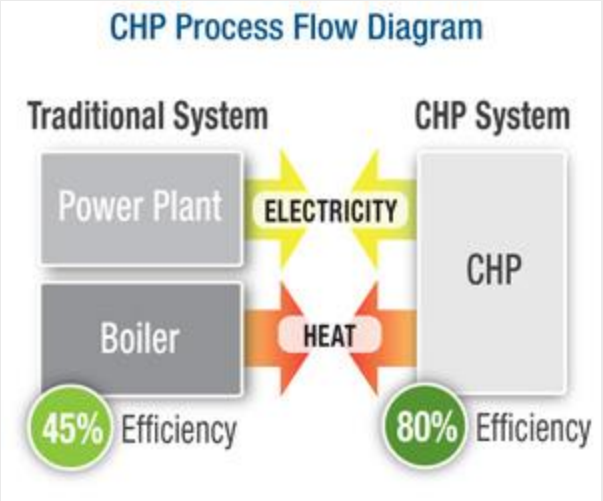
In an ordinary (non combined cycle) heat engine the remaining heat (e.g., hot exhaust fumes) from combustion is generally wasted.

Combined Heat and Power (CHP)

Also known as cogeneration

CHP is the simultaneous production
of electricity and heat from a single fuel source.

CHP/Cogeneration

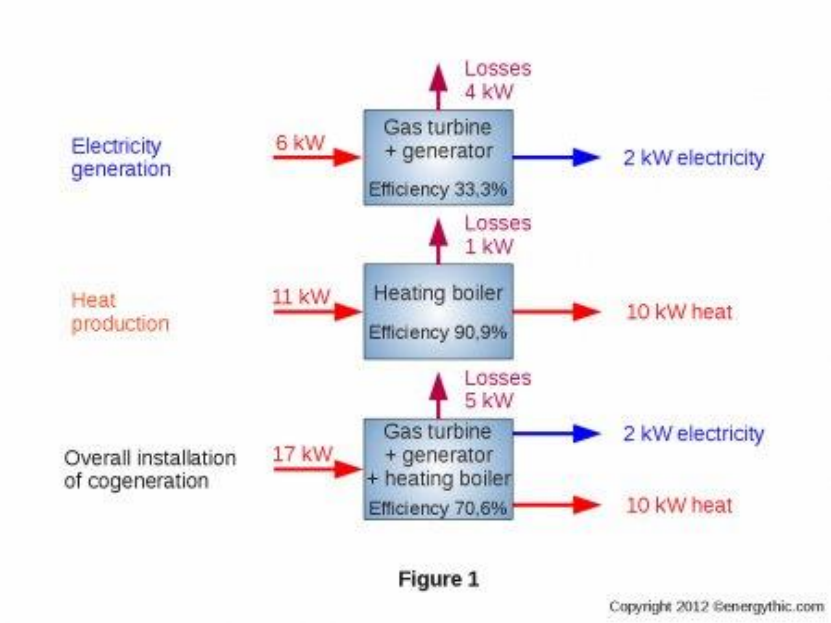


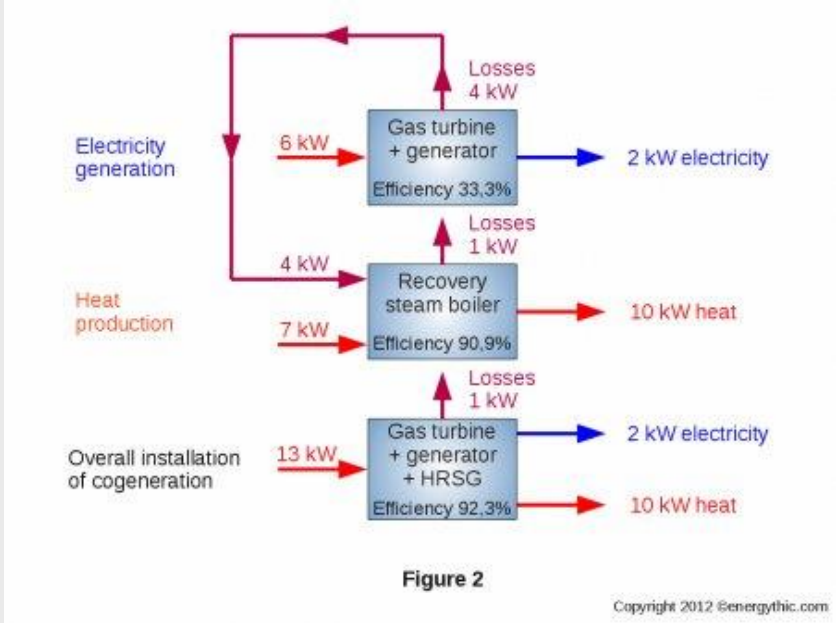
A CHP system recovers the heat normally lost in electricity generation for use in cooling, heating, dehumidification, and other processes. Compared with separate generation of electricity and heat, CHP systems can operate at more than 80% efficiency.

Coal power plant

In today's coal and gas fired power stations, up to two thirds of the overall energy consumed is lost in this way, often seen as a cloud of steam rising from cooling towers.

Combined Heat and Power (CHP)





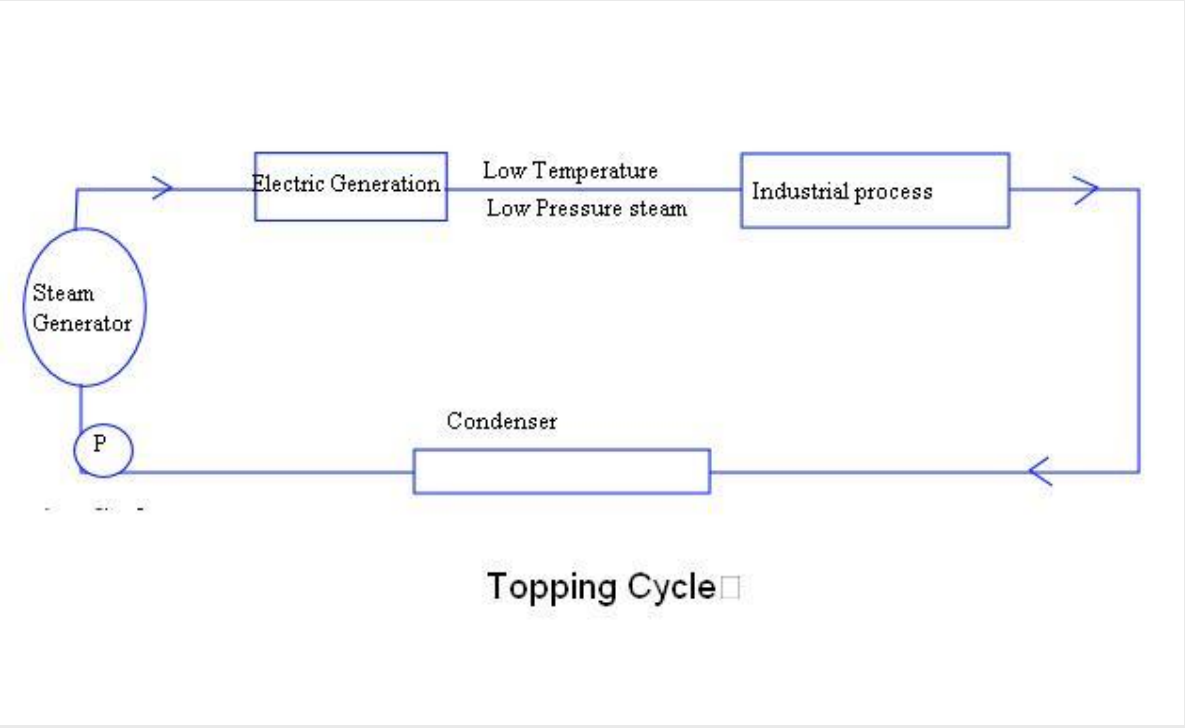
In Figure 1, we have two facilities: one to generate electricity, another to produce heat. The overall performance of the system in this case is 70.6 %.

In Figure 2, we want the same result in terms of electricity and heat produced amounts, but with a cogeneration facility. Heat losses associated to the production of electricity from the gas turbine is reused in the production of heat. It is explicit that the efficiency has increased from 70.6 to 92.3% while the heat energy supplied to the boiler has dropped from 17 kW to 13 kW.

2 Types of Co-generation cycle

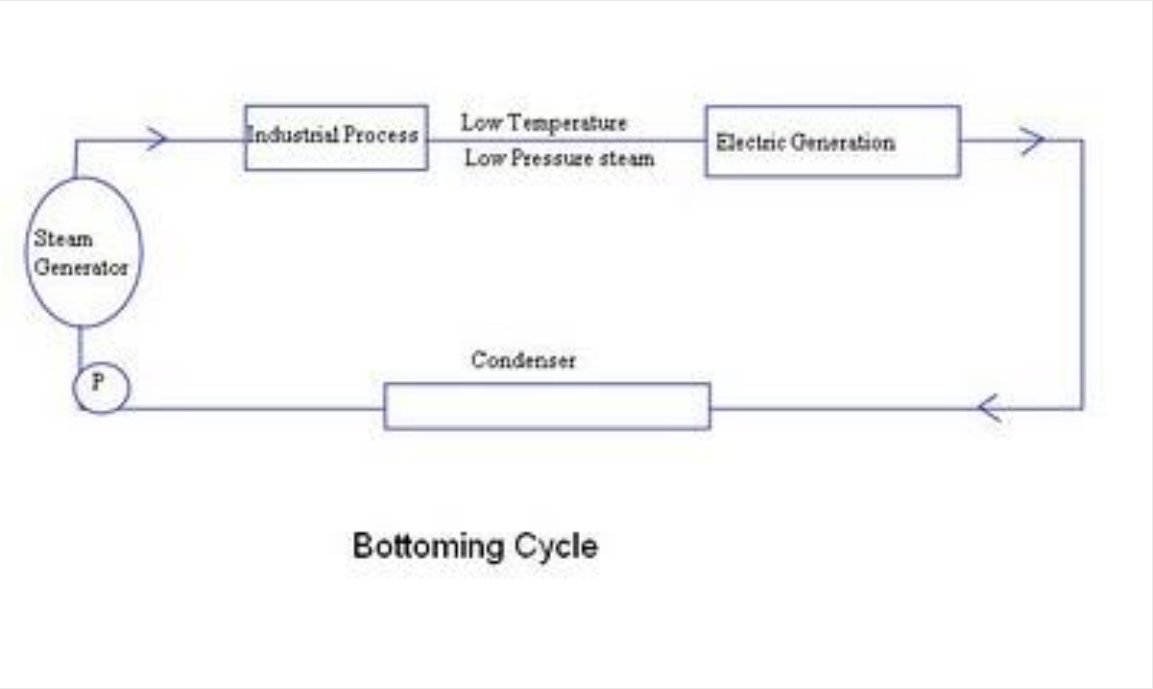
- Topping cycle
- Bottoming cycle

Topping cycle



It is cycle where main emphasis is on the production of electricity. High grade steam is used to generate power and then low grade steam is used in industrial process.

Bottom cycle



Bottoming Cycle

Steam generated by the steam generator is mainly utilized in the Industrial process and then the steam from the discharge of industrial process is used to generate electricity.

Equipment for Space Cooling

Steam Absorption Chiller

Use thermal input to produce cooling for space conditioning or for refrigeration

Thermal input (heat source):

→ direct source (usually natural gas burner)

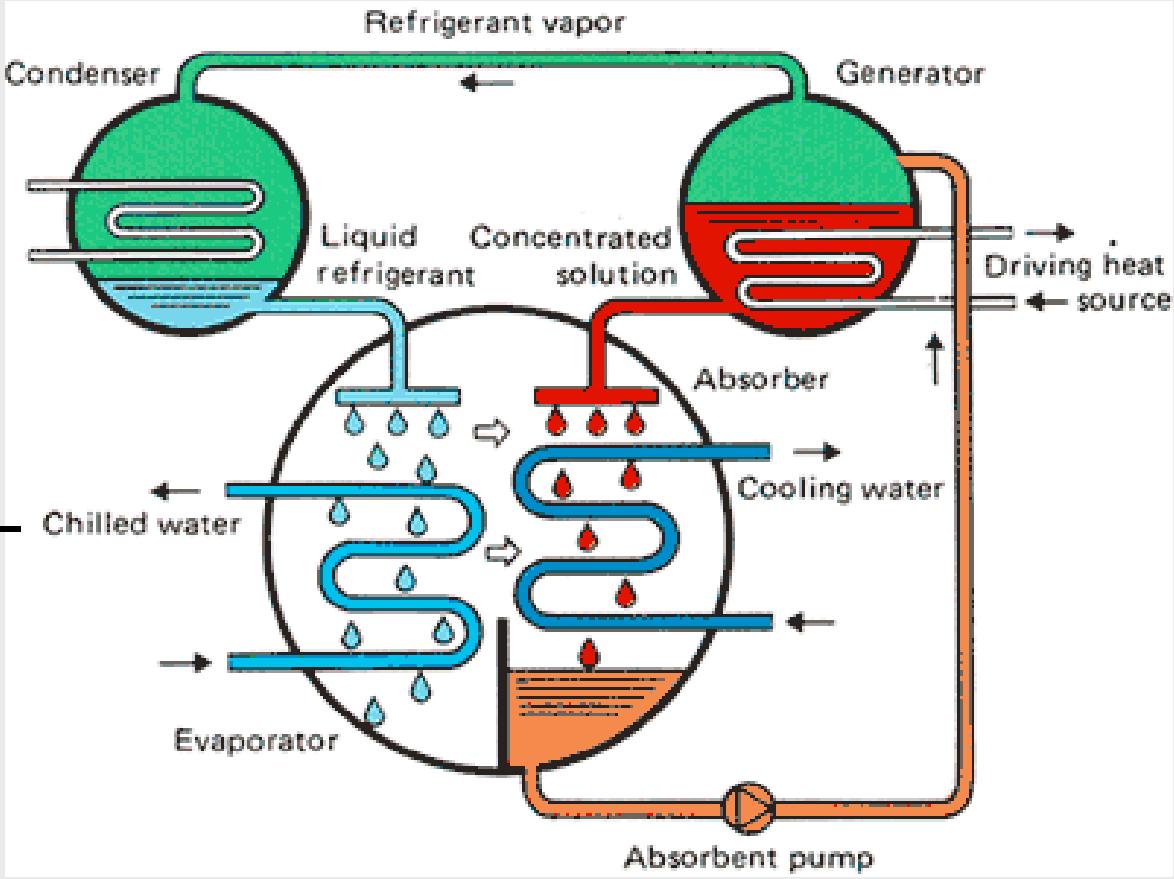
→ indirect fired source (low pressure steam, hot water or waste process heat).

<u>Most common working fluids (refrigerant/absorbent)</u>

Water/lithium bromide (H_2O/LiBr)

Ammonia/water (NH_3/H_2O)

Steam Absorption Chiller



NH_3/H_2O

Chilled water circulating the building for air-conditioning

Comment on Natural Gas Cooling

Downfalls….
Coefficient of Performance (COP) of 1.1 vs. electrical centrifugal units can obtain COPs up to 6.0.
Cost 1.5 to 2.5 times that of electric chillers
Often require larger cooling towers and pump modifications

Natural gas absorption chillers are only economically feasible at:

- areas with high electrical demand rates
- low natural gas summer rates
- rebate and incentive plans are offered

Please complete tutorial

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Equipment for Furnace

Furnace

A type of heat exchanger where the fuel is burned in an enclosure to heat a process material contained in tubular coils, tubes or in an enclosure itself

Mostly used in high temperature industries such as ceramic, ferrous or non-ferrous, glass and refining industries

Main Components in Refining Furnace

Burner – deliver heat to furnace
Capable of providing uniform heating environment

Radiant - hottest area in furnace
Heat from flame and flue gases

Convection – preheat materials before entering radiant section

Furnace Characteristic

Furnaces are sometimes grouped by the following characteristic:

- orientation of the tubes in the radiant section – horizontal or vertical
- types of air supply and flue gases removal methods – induced, forced or natural draft

Gas Furnace - Refractory

A type of heat exchanger where the fuel is burned in an enclosure to heat a process material contained in tubular coils, tubes or in an enclosure itself

Mostly used in high temperature industries such as ceramic, ferrous or non-ferrous, glass and refining industries

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Question?

THE END

Thank You for the Attention