Overview of cogeneration technology and application

Cogeneration Week

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Melia Hotel, Hanoi

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Cogeneration or Combined Heat and Power (CHP)

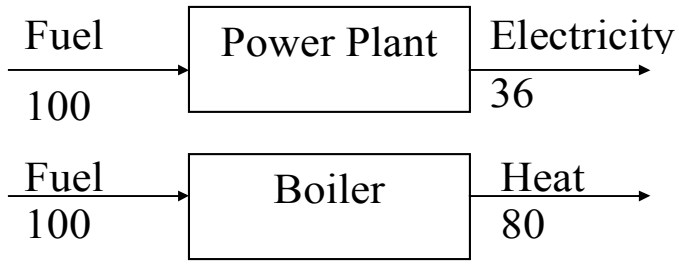
- **Sequential generation of two different forms of useful energy using a single primary energy source**
- **Most usual:**
  - **electrical (or mechanical)**
  - **thermal: heating or cooling**

Benefits of Cogeneration

- Lower primary energy consumption
- Reduced energy bills
- No transmission and distribution losses
- Less burden on national government for power generation
- Less environmental pollution

Efficiency Comparison between Cogeneration and Separate Production of Electricity and Heat

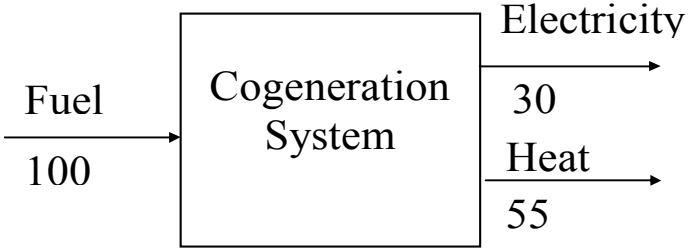
Separate Production of Electricity and Heat



Total efficiency:

$$\eta = \frac{36 + 80}{200} = 0.58$$

Cogeneration



Total efficiency:

$$\eta = \frac{30 + 55}{100} = 0.85$$

(Numbers below arrows represent units of energy in typical values)
Source: The European Educational Tool on Cogeneration, 2nd ed., December 2001

Ideal Conditions for Cogeneration

- **Reliable power requirement**
- **Utilisation of higher thermal energy (kW_{th}) than electricity (kW_e)**
- **Quite stable load patterns of thermal energy and electricity**
- **Long operating hours**
- **High price of grid electricity or inaccessibility to grid**

Typical Cogeneration Performance Parameters

Prime Mover in Cogeneration Package	Nominal Range (Electrical)	Efficiencies %	
		Electrical Conversion	Overall Cogeneration
Steam Turbines	10 – 100 MW	17 – 34	Up to 80*
Smaller Gas Turbines	800 – 10,000 kW	24 – 31	74 – 81
Larger Gas Turbines	10 – 20 MW	26 – 31	78 – 81
Smaller Reciprocating Gas Engines	10 – 500 kW	20 – 32	74 – 82
Larger Reciprocating Gas Engines	500 – 3,000 kW	26 – 36	76 – 86

NOTE: Adapted from *Cogeneration Handbook* California Energy Commission, 1982

* taken from *Cogeneration Guide* Cogen Europe

Typical Cogeneration Applications

- **Industrial cogeneration**

  wood and agro-industries, food processing, pharmaceutical, pulp and paper, oil refinery, textile industry, steel industry, cement industry, glass industry, ceramic industry

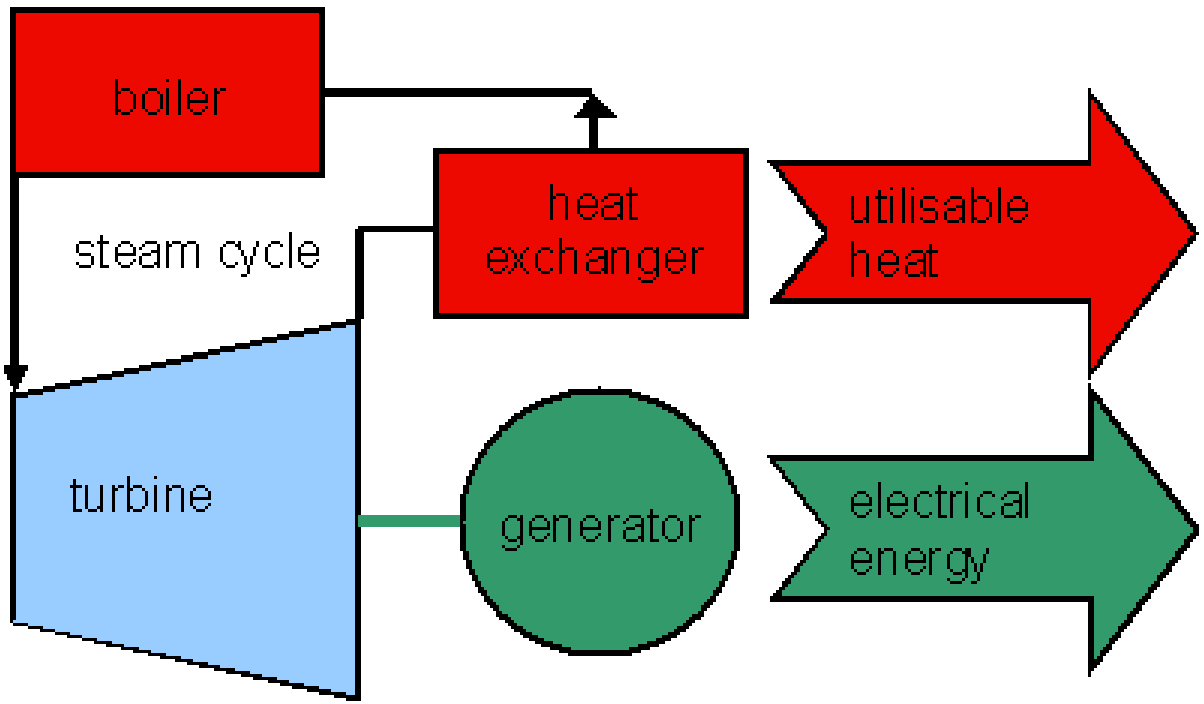
- **Residential/commercial/institutional cogeneration**

  hospitals, schools & universities, hotels, houses & apartments, stores & supermarkets, office buildings

Steam Turbine Cogeneration

Steam Turbine Cogeneration

Principle



Steam Turbine Cogeneration

Application

Appropriate for sites where

- **Electrical base load is over 250 kW_e**
- **High pressure process steam is required**
- **Cheap, low-premium fuel is available**
- **High grade process waste heat is available**
- **Existing boiler plant is in need of replacement**

Steam Turbine Cogeneration

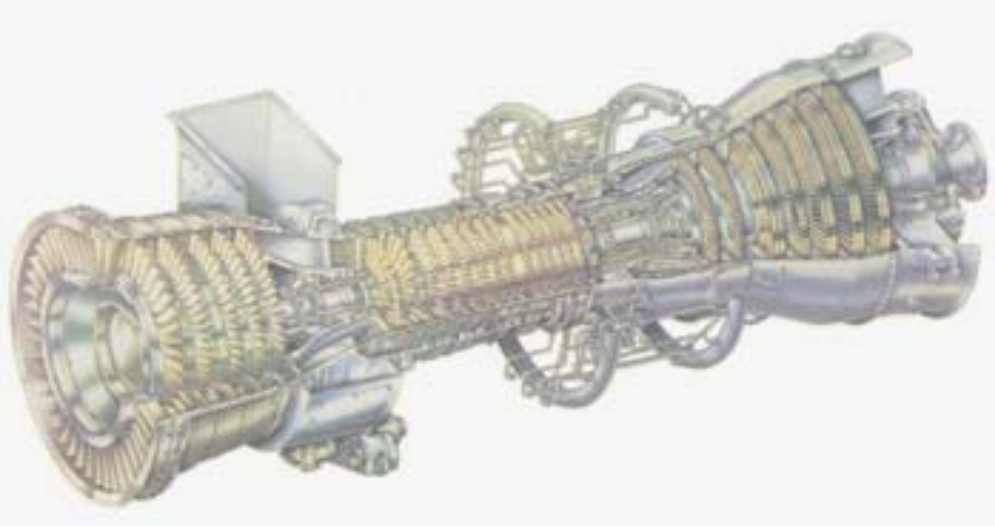
Advantages

- Versatility of fuel
- Well-established technology
- Flexibility in the size of plants

Disadvantages

- Low electrical plant efficiency
- Low part load performance
- High operating cost

Gas Turbine Cogeneration



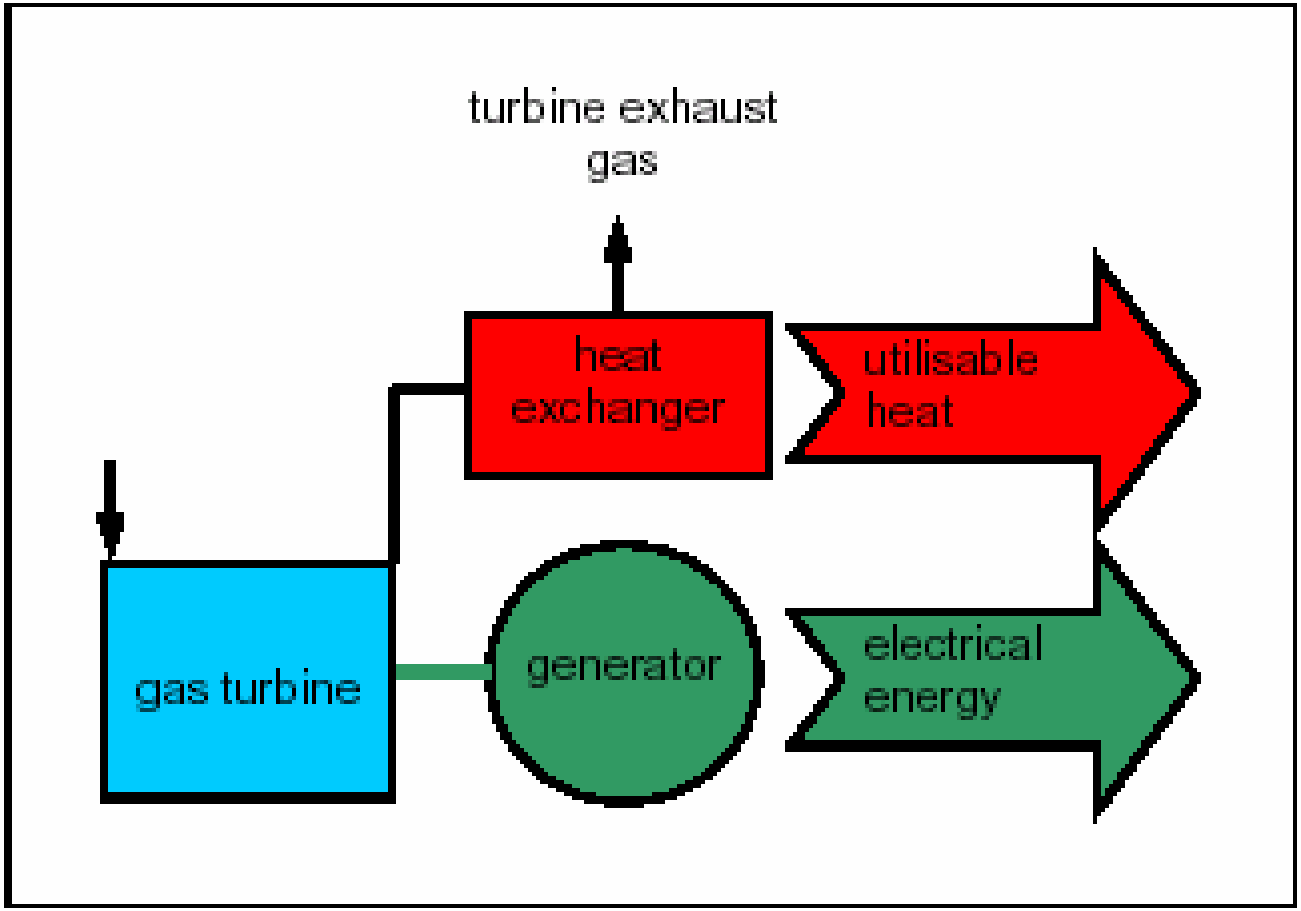
Gas Turbine Cogeneration

Basics

- **Fuel is burnt in a pressurised combustion chamber using combustion air supplied by a compressor**
- **Conversion of mechanical energy (turbine) into electrical energy with the help of the generator.**
- **Utilisation of gases escaping from the turbine for heat supply.**

Gas Turbine Cogeneration

Principle



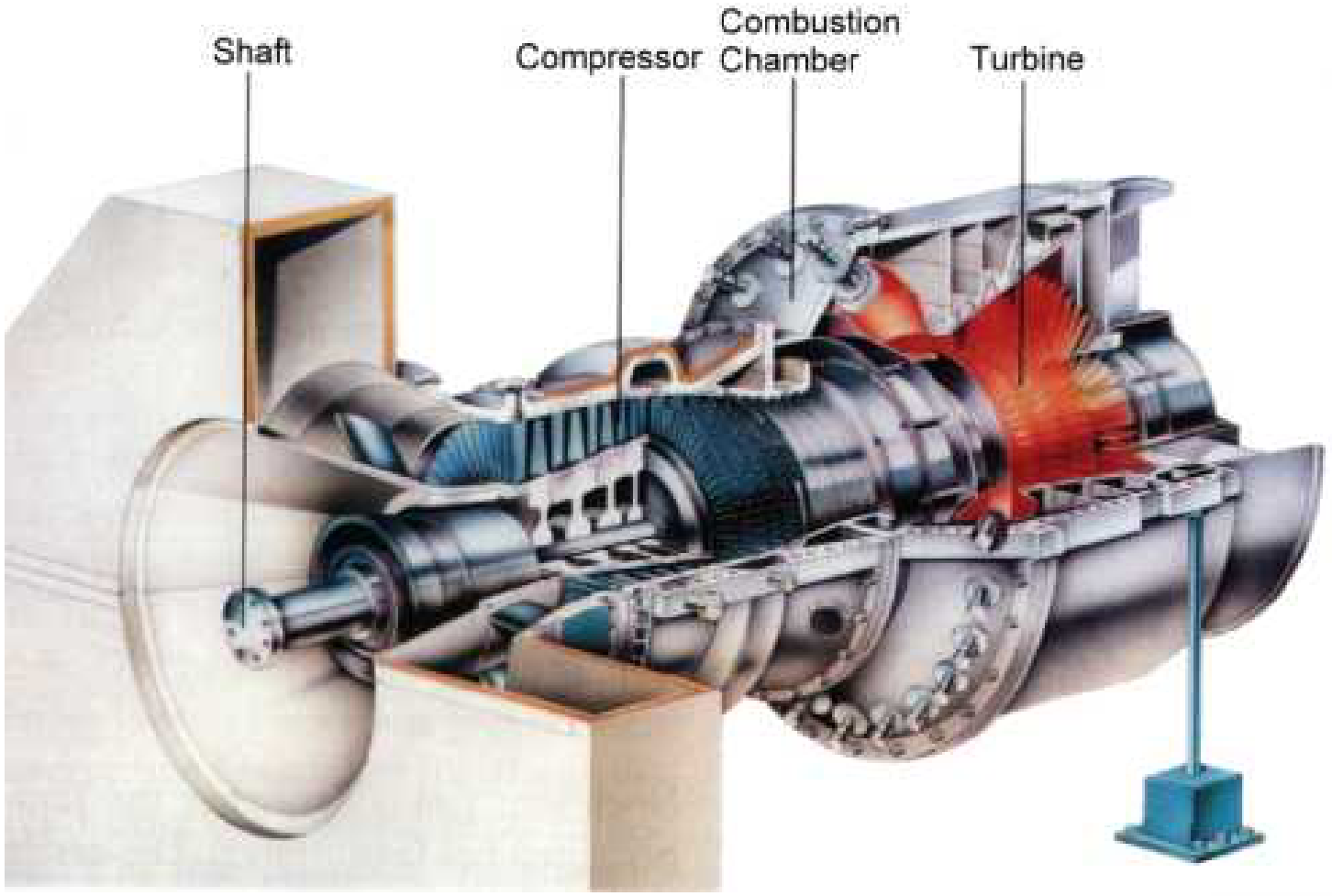
Gas Turbine Cogeneration

Application

Suitable if

- **Power demand is continuous and over 1 MW_e**
- **Natural gas is available (though not a limiting factor)**
- **There is high demand for medium/high pressure steam or hot water, particularly at temperature higher than 140 °C**

Section Through of a Gas Turbine of Higher Output



Gas Turbine – Cogeneration

Advantages

- High reliability
- Wide fuel range capability, gas, petroleum, light oil
- Relatively low investment cost per kW electrical output
- Low emission

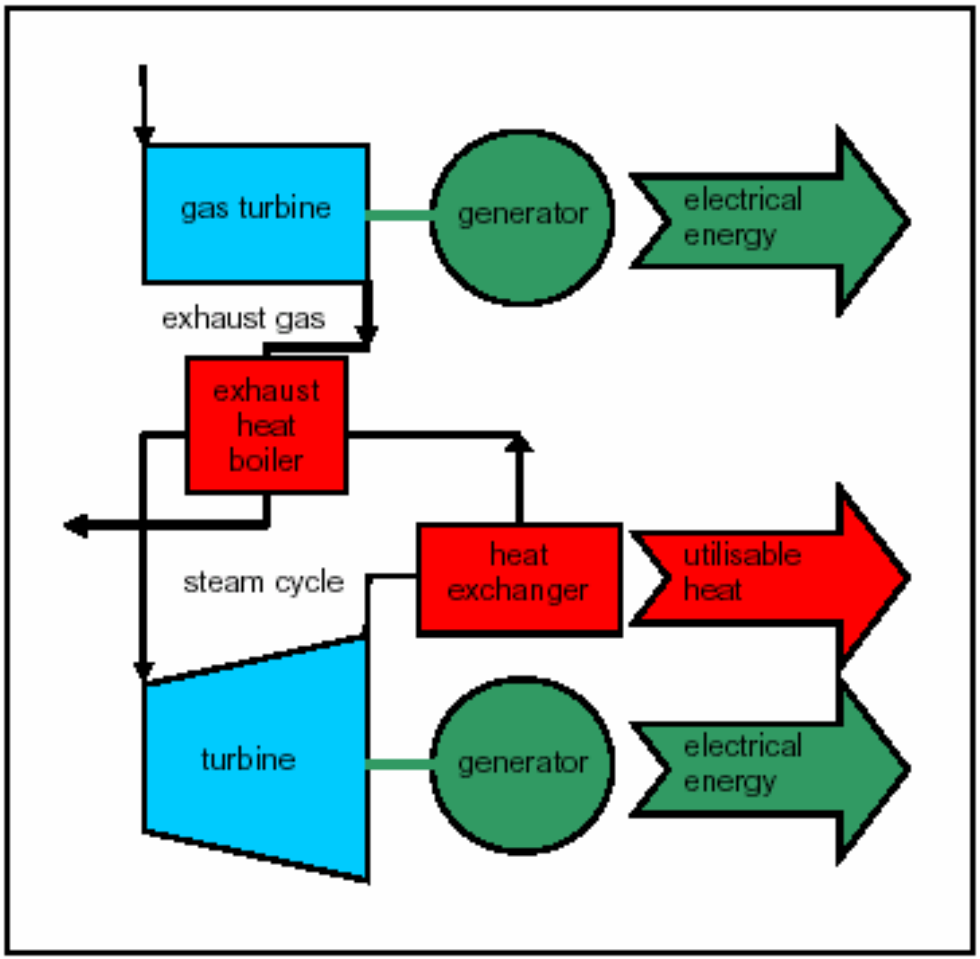
Disadvantages

- Poor efficiency at low loading (but can operate continuously at low loads)
- High maintenance cost
- High fuel cost

Combined Cycle Cogeneration

Combined Steam-and-Gas Cycle Cogeneration

Principle



Combined Steam-and-Gas Cycle Cogeneration

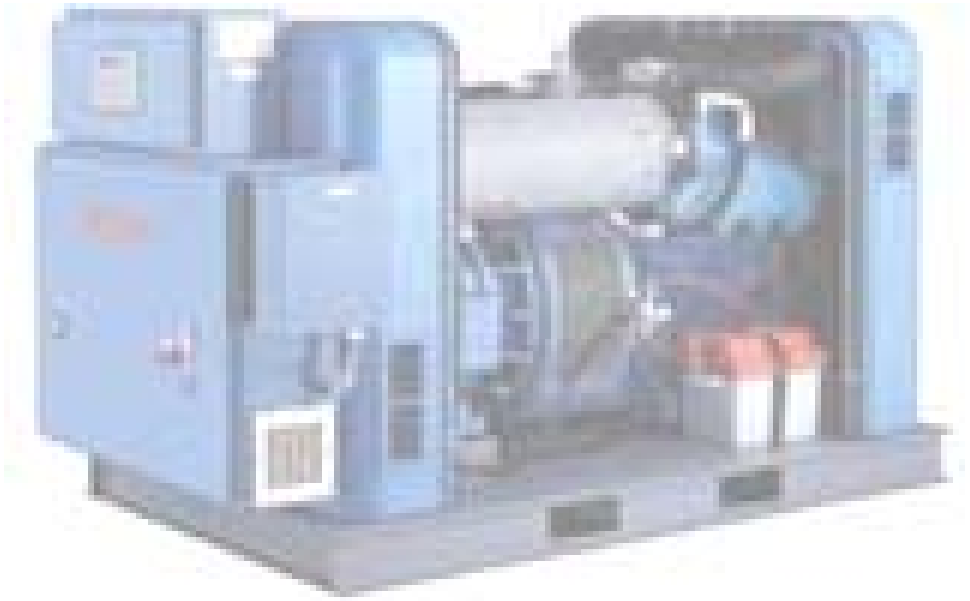
Advantages

- High electrical efficiency

Disadvantages

- Only suitable for high electrical output
- High operating cost

Gas Engine Cogeneration



Gas Engine Cogeneration

Application

Suitable for sites where

- **Power or processes are cyclical or not continuous**
- **Low pressure steam or medium or low temperature hot water are required**
- **Low heat to power demand ratio**

Gas Engine Cogeneration

Main types

1. Compression-ignition (diesel) engines [100 kW_e to 20 MW_e]

2. Spark-ignition engines [3 kW_e to 10 MW_e]

Gas Engine Cogeneration

Advantages

- High power efficiency over a wide load range
- Relatively low investment cost per kW_e electrical output
- Multi-fuel capability
- Low exhaust emission

Disadvantages

- High levels of low frequency noise
- High maintenance cost

For more information,
please visit COGEN 3 Web Site at:-

http://www.cogen3.net