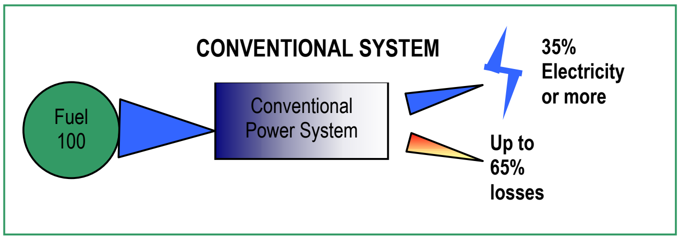
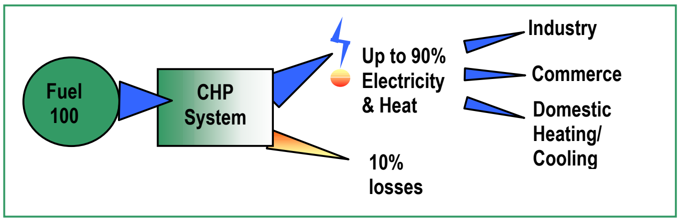
Cogeneration

Cogeneration, also known as Combined Heat and Power, or CHP, is the production of electricity and heat in one single process for dual output streams. In conventional electricity generation 35% of the energy potential contained in the fuel is converted on average into electricity, whilst the rest is lost as waste heat. Even the most advanced technologies do not convert more than 55% of fuel into useful energy.



Cogeneration uses both electricity and heat and therefore can achieve an efficiency of up to 90%, giving energy savings between 15-40% when compared with the separate production of electricity from conventional power stations and of heat from boilers. It is the most efficient way to use fuel. Cogeneration also helps save energy costs, improves energy security of supply, and creates jobs.



The heat produced by cogeneration can be delivered through various mediums, including warm water (e.g., for space heating and hot water systems), steam or hot air (e.g., for commercial and industrial uses). It is also possible to do trigeneration, the production of electricity, heat and cooling (through an absorption chiller) in one single process. Trigeneration is an attractive option in situations where all three needs exist, such as in production processes with cooling requirements.

Cogeneration schemes are usually sited close to the heat and cooling demand and, ideally, are built to meet this demand as efficiently as possible. Under these conditions more electricity is usually generated than is needed. The surplus electricity can be sold to the electricity grid or supplied to another customer via the distribution system.

In recent years cogeneration has become an attractive and practical proposition for a wide range of applications. These include the process industries (pharmaceuticals, paper and board, brewing, ceramics, brick, cement, food, textile, minerals etc.), commercial and public sector buildings (hotels, hospitals, leisure centres, swimming pools, universities, airports, offices, barracks, etc.) and district heating schemes.

Photo: Modern Cogen plant in Torup, Denmark (courtesy Wärtsilä)

The Technology

A range of technologies can be applied to cogenerate electricity and heat. All cogeneration schemes will always include an electricity generator and a system to recover the heat. The following technologies are currently in widespread use:

- Steam turbines
- Gas turbines
- Combined Cycle (gas and steam turbines)
- Diesel and Otto Engines.

These technologies are readily available, mature, and reliable. Three other technologies have recently appeared on the market, or are likely to be commercialised within the next few years:

- Micro-turbines
- Fuel cells
- Stirling engines.

Cogeneration schemes can have different sizes, ranging from an electrical capacity of less than 5 kW_e (e.g., small engines for a single dwelling) to 500 MW_e (e.g., district heating systems or industrial cogeneration).

Cogeneration can be based on a wide variety of fuels and individual installations may be designed to accept more than one fuel. Whilst solid, liquid or gaseous fossil fuels dominate currently, cogeneration from biomass fuels is becoming increasingly important. Sometimes, fuels are used that otherwise would constitute waste, e.g., refinery gases, landfill gas, agricultural waste or forest residues. These substances increase the cost-efficiency of cogeneration.

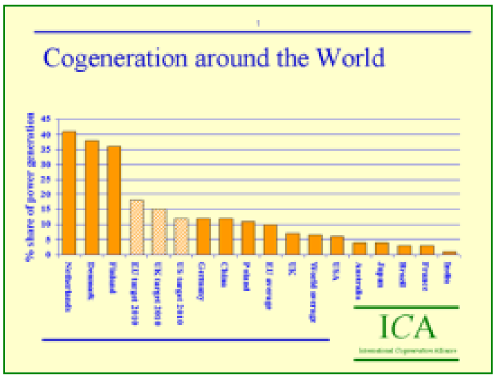


Chart: % market share of cogeneration (Source: International Cogeneration Alliance, ICA)

Technology	Fuel	Size (MW_e)	Electrical efficiency	Overall efficiency	Average capital cost in $/$kW_e$	Average Maintenance in $/kWh
Steam Turbine	Any	0.5-500	7-20%	60-80%	900-1800	0.0027
Gas Turbine	Gaseous and liquid fuels	0.25-50+	25–42%	65–87%	400-850	0.004-0.009
Combined cycle	Gaseous and liquid fuels	3-300+	35–55%	73-90%	400-850	0.004-0.009
Diesel and Otto engines	Gaseous and liquid fuels	0.003-20	25–45%	65-92%	300-1450	0.007-0.014
Micro turbines	Gaseous and liquid fuels		15-30%	60-85%	600-850	<0.006-0.01
Fuel cells	Gaseous and liquid fuels	0.003-3+	App 37-50%	App. 85-90%	?	?
Stirling engines	Gaseous and liquid fuels	0.003-1.5	App. 40%	65-85%	?	?

Table 1: Cogeneration Technology Characteristics

Costs and profitability

A well-designed and operated cogeneration scheme will always provide better energy efficiency than a conventional plant, leading to both energy and cost savings.

Cost savings depend on both the cost of the primary energy fuel and the price of electricity that the scheme avoids. However, although the profitability of a cogeneration project generally results from its cheap electricity, its success depends on using recovered heat productively, so a prime criterion is a suitable heat requirement. As a rough guide, cogeneration is likely to be suitable where there is a fairly constant demand for heat for at least 4,500 hours in the year.

The total investment in a CHP project depends upon the size of the installation and its design and characteristics. Under favourable conditions, payback periods of three to five years can be achieved on most cogeneration installations. Their operating life can reach 20 years.

Industry and Market Trends

Cogeneration accounts for around 7% of total global power production and more than 40% in some European countries. This potential is far from being achieved in most countries. There are many suppliers of conventional cogeneration technologies, but newer technologies (micro turbines, fuel cells, Stirling engines) are produced by a few companies only.

An expansion of the market for small-scale cogeneration schemes is likely to occur in the years to come. The micro turbine market is expected to grow over the forthcoming years. Fuel cell applications will be on the market probably not before 2004-2005.

In many countries the current situation of cogeneration in the market could be better. The European experience shows that rising gas and falling electricity prices make it difficult for cogenerators to operate profitably. Uncertainties created through reforms in the energy sector can be an important barrier.

Global policies to reduce greenhouse gas emissions, liberalisation of energy markets, and emerging needs for decentralised energy in emerging markets will improve the prospects for cogeneration.

Project Risks

Technology: CHP is a mature technology. With proper engineering, risks such as downtimes, failures, and reduced efficiency are not greater than for most combustion technologies.

Environmental: Environmental problems such as air emissions, noise, raw material and residue handling, can all be mitigated through proper siting, design, and operation of the CHP facility. In many cases CHP retrofits to existing installations may bring environmental improvements.

Planning: The ratio between electricity and fuel prices may change (price risk); regulatory frameworks may change unfavorably (regulatory risk); the heat demand may change, making the CHP project less suited to meet the site's needs (energy consumption risk); or the organization that uses the CHP scheme may close, relocate, or go bankrupt (host risk).

Key Points

- Cogeneration is the most efficient way of generating electricity, heat and cooling from a given amount of fuel. It saves between 15-40% of energy when compared with the separate production of electricity and heat.
- Cogeneration helps reduce CO_2 emissions significantly. It also reduces investments into electricity transmission capacity, avoids transmission losses, and ensures security of high quality power supply.
- A number of different fuels and proven, reliable technologies can be used.
- A concurrent need for heat, electricity and possibly cooling indicates suitable sites for cogeneration.
- The initial investment in cogeneration projects can be relatively high but payback periods between 3-5 years might be expected.
- The payback period and profitability of cogeneration schemes depends crucially on the difference between the fuel price and the sales price for electricity.
- Global environmental concerns, ongoing liberalisation of many energy markets, and projected energy demand growth in developing countries are likely to improve market conditions for cogeneration in the near future.