COGENERATION POWER PLANTS (CHP)
AND
DISTRICT HEATING SYSTEMS

Preface

With this document ***MGM Engineering & Contracting*** wishes to provide a brief overview on the advantages that cogeneration and district heating solutions can offer.

What is cogeneration

Cogeneration (often referred to as CHP – Combined Heat and Power) is defined as the simultaneous production of electrical power and heat in a single process.

It is based on the simple principle that, in a plant dedicated to electricity production alone, only a portion of the primary energy of fuel is actually converted into electrical power, ranging typically from 35% to 55%. The remaining part is lost in the form of heat dissipated to the environment.

Cogeneration allows **increasing the conversion efficiency of the primary energy of fuel by means of heat recovery** for industrial or civil uses (for example, for district heating). In other terms, **cogeneration grants a significant energy saving** in comparison with separate production of electricity (in a traditional power station) and heat (in a traditional heat station).

Heat can be fed to users through various fluids, such as steam, hot water (also suitable for use in absorption cooling systems), diathermic oil, hot air, etc.

Cogeneration is a suitable solution for all industrial and public fields of use where consumption of both heat and electricity is significant.

How does cogeneration work

Cogeneration stations are based on proven and reliable technologies. They can be ideally split in the following parts:

- A prime mover
- A power production system
- A heat recovery system

A possible classification of cogeneration systems, based on the prime mover technology, is presented in the following.

<u>Steam turbine cogeneration systems</u>

They are traditional thermo-electric power stations, where fossil fuels or biomass are used in direct-flame boilers to produce steam. Steam is then partially bled from the turbine and sent to heat users, or it is used to heat a secondary fluid, usually hot water.

<u>Turbogas cogeneration systems</u>

In such plants the heat from natural gas-fired turbines is recovered to produce steam or to heat water or diathermic oil.

Reciprocating engines cogeneration systems

Cogeneration systems based on reciprocating engines are similar to those based on turbogas units, with the addition of a significant heat recovery from the engine's cooling circuits. Reciprocating engines can be fuelled with natural gas or liquid fuels, such as diesel oil, vegetable oil, biodiesel.

Combined cycle cogeneration systems

A combined cycle consists in coupling a gas turbine with a steam turbine. The hot gas from the turbogas exhaust is used to produce steam, which drives the steam turbine. Heat is provided the same way as described for steam turbine cogeneration systems.

Matching a reciprocating engine and a steam turbine results in a combined cycle as well, but such configuration is far less widespread.

The advantage of combined cycles over other cogeneration systems consists in the higher electrical efficiency they can achieve.

What is district heating

District heating is the most innovative technology for urban heating, i.e., for civil usage.

Heat is produced in the thermal section of the cogeneration plant in the form of hot water. Duly dimensioned pumps drive the hot water through a network of underground pipes to the houses, where it is used for heating or for production of hot sanitary water.

District heating makes it unnecessary to keep a separate boiler for each building or apartment, yet allows for separated accounting of consumption.

The district heating network consists mainly of the following equipment:

- The transport and distribution network itself, made up of two of pipes, both the same diameter, one for outgoing hot water, one for return.
- A complex of substations, one for each user or group of users, where heat transfer from the district network (primary circuit) to the heating circuit of the building (secondary circuit) is controlled and measured.

As for inserting the district heating network in an urban setting, it must be noted that this kind of heat *distribution* is by its own nature **closely tied to the planning of the settlement**.

District heating thus shows the typical characters of a *service*, capable of developing through a coherent planning in conjunction with the other services. This makes **district heating not only a subsequent instrument, but very often a leading one, in development management and planning**.

View of a building substation.

Workers laying a main trunk of the network.

Detail of a branching point.

Advantages of district heating

Advantages of district heating are numerous and very relevant:

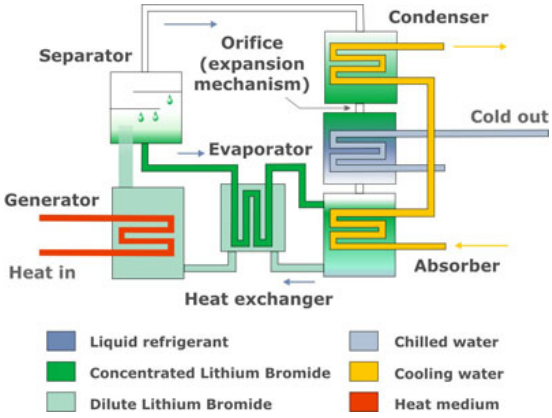
- Heat is delivered to the building through a heat exchanger, which is a static device, longer lasting and **not as subject to controls and maintenance as a traditional boiler is**.
- The only energy carrier is water, which will be directly brought from the cogeneration station. There is **no chance of gas loss or spilling of gas, diesel oil or other dangerous substances**.
- The equipment for heat exchange **takes up less space than traditional boilers** and can be installed in underground rooms, besides making easier the conversion from diesel oil systems.
- Heat exchange is flameless, thus inherently safe. Moreover, in absence of combustion **a chimney is no longer necessary**.
- **Heat from the district network can be used all year long**, without the limitations imposed by current regulations for other fuels.
- **The distribution system is remotely controlled**, allowing real-time management of heat production and distribution. This grants the customer both comfort and reduction of energy waste.

What is district cooling

Hot water delivered to the buildings through the district heating network can actually serve a different purpose.

By coupling the heat exchangers with absorption chillers fed on hot water, it becomes possible to **bring cold to the buildings during hot months more safely and efficiently than with traditional electrical chillers**.

Besides sharing all advantages of district heating (that is, low maintenance needs, reduced space requirements, remote management), district cooling makes it unnecessary to keep separated air conditioners for buildings or apartments, thus saving on their heavy electrical power consumption.



Conceptual scheme of an absorption chiller.

Polluting emission

Environmental benefits brought forth by cogeneration and district heating/cooling are all easily portrayed.

On a local level, by considering the urban area served by the district heating network, emissions from the cogeneration station and separate single house boilers can be compared.

Emissions from the power station will have the following characteristics:

- Concentration of pollutants are kept low, by using the **Best Available Technologies** (BAT) for emissions control and reduction.
- The competent agency will duly **monitor emissions in continuous**, to ensure concentration of pollutants does not exceed law limits.
- The only emission points will be the station stacks, which are **dimensioned to achieve the best possible flue gas dispersion**.
- The station general features, the efficiency of emission reduction systems and the stack characteristics (diameter, height, position) are chosen after careful and **detailed flue gas dispersion models calculations**, in order to minimize impact of the power station on its surroundings.

On the other hand, traditional home or building boilers bring several disadvantages:

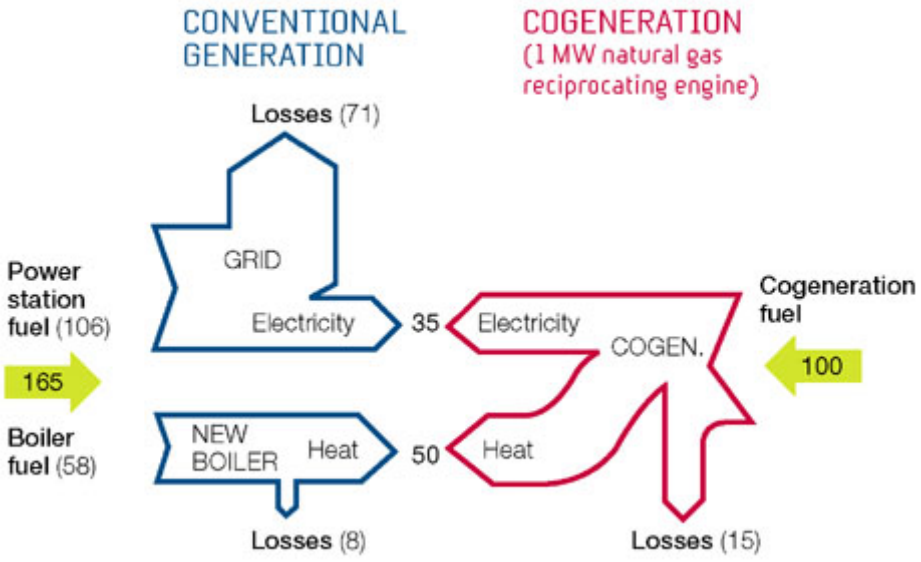
- Beyond the manufacturer's limited warranty, there is no control over emissions.
- Employed technologies are often obsolete and maintenance is not as frequent as it should be. Resulting efficiencies are far less that optimal, causing fuel waste and increase of pollutant dumped in the atmosphere.
- In urban areas 30% of single building boilers are usually fed on diesel oil, which is a much more polluting fuel than natural gas.
- Emission points are multiple and scattered. It is difficult to identify potentially dangerous sources.

Cogeneration in Europe

It is a good point to remember that development of projects for enhancement of efficiency in energy production is a **declared objective of European environmental policies**. Moreover, cogeneration is the focus of a 2002 directive proposal from the European Parliament and Council, whose aim is to increase the number of cogeneration plants across Europe.

The big interest this technology is receiving, both globally and locally, has its reason in the chance of **reducing fuel consumption (and associated pollutant emissions)** by enhancing energy production processes.

The considerable amount of waste heat associated to traditional power stations is transformed into useful heat, which can be sent through the district network to houses and buildings for heating or cooling.



Sankey diagrams of separate heat & power production in comparison with a CHP system.

MGM experience and services

MGM Engineering & Contracting can provide customers with long time experienced managers and technicians in the engineering and energy areas.

CHP and plants and district heating networks, along with trigeneration, are among the greatest assets in the company's know-how. Our vast experience in the field allows us perfectly tailoring investments on the customer's needs.

Consulting, engineering and expert services can be provided to energy and utility companies, municipalities and power plant investors.

Fields of expertise include, integrated or separately, the following:

- Technical and economical feasibility studies
- Investment cost definition
- Owner engineering
- Conceptual and basic design
- Front-end engineering
- Detail engineering, including all related technical disciplines
- Design review
- Procurement, including purchasing, sub-contracting, expediting, inspection and logistics
- Tender evaluation, negotiation and contract preparation
- Construction management, including field supervision and testing
- Plant commissioning and start-up, including personnel training
- Project management, planning and cost control
- Proposal management and bid document preparation
- Energy audit and services
- Permits, authorizations and certifications