Heat and power from the same plant

Challenges of Cogeneration

JACEK MARECKI
Gdańsk University of Technology
Committee for Energy Studies
Polish Academy of Sciences
jmarecki@ely.pg.gda.pl

The benefits for consumers of network-supplied heat generated in combination with electric power include not only a lower price, but also more convenient use, a reliable supply, and no pollutant emissions

It is hard to imagine life in today's world without electric power, yet for many of us it would be equally difficult to survive in our homes without heat supplied from outside, through district heating networks. These two types of energy can be produced independently of each other, in separate heat-generating plants and electric power plants, yet they do quite frequently come to us from a single, common source, called a CHP (Combined Heat and Power) plant. Generation systems that work to produce heat and electric power at the same time, i.e. through what is termed "cogeneration," are nowadays becoming increasingly popular. Such combined systems

Elektrociepłownie Wybrzeże S.A., Archiwum

The control room of the combined heat and power plant in Gdańsk

are not only more efficient than two separate production plants and harness the energy in the consumed fuel more fully, they are also better suited to comply with ever-more-stringent environmental protection regulations. This is why cogeneration systems should be expected to take on increasing significance in the years to come, especially in countries undergoing market economy transformations, such as Poland.

Energy, heat, and refrigeration

In a cogeneration system, the chemical energy of fuel is transformed into heat contained in hot steam produced in high-pressure boilers. Further conversion of this heat into mechanical and electric energy, and into heat contained in low-pressure steam, takes place in turbine sets that consist of steam turbines and electric generators. Hot water, in turn, is obtained from heating units supplied with low-pressure steam, or from separate hot-water boilers.

Cogenerated heat reaches consumers through networks, and for this reason is called "network heat." It usually reaches homes in the form of hot water pumped through district heating networks, whose temperature rises to 130-150°C in winter depending on the outside temperature, and to about 70°C in summer. Industrial consumers, in turn, can receive heat for process purposes in the form of steam, with a pressure range of 0.5-1.5 MPa.

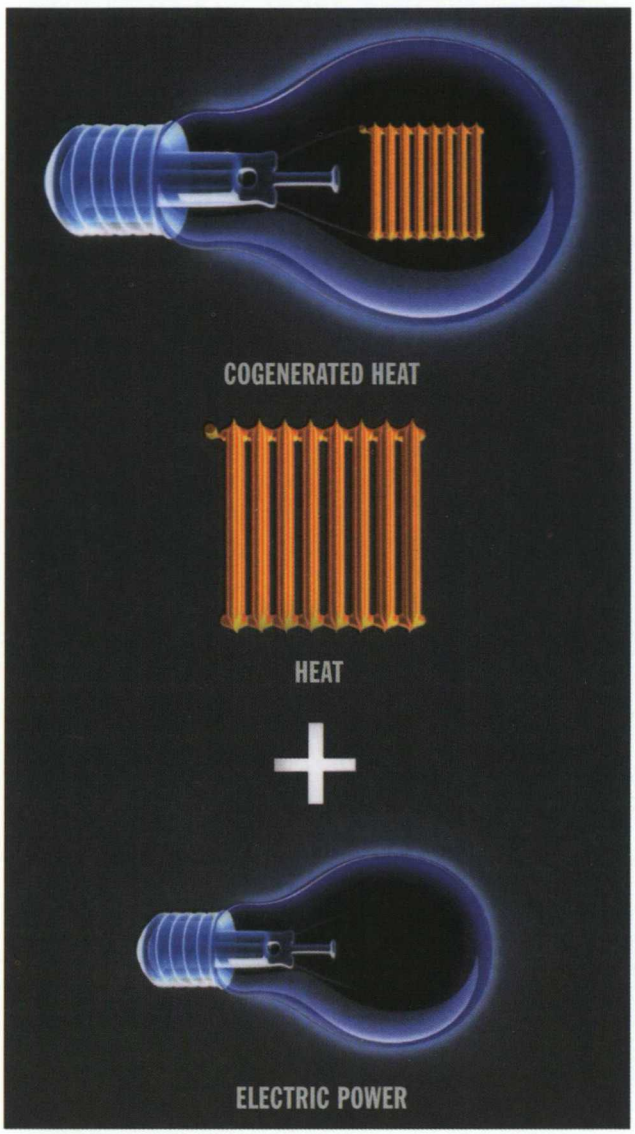
Network heat is also sometimes used for cooling - hot-water refrigeration units or adsorption dehumidifiers can be employed for this purpose. All in all, this means that three related types of energy can be produced via a single combined process: electric power, heat, and refrigeration; "cogeneration" thus becomes in a certain sense "tri-generation."

Cogeneration in Poland

Heat is generated together with electric power at municipal power/CHP plants, as well as at industrial CHP plants. The latter produce heat mainly for the needs of their host industrial facilities, only supplying part of it through external networks. Municipal CHP plants, on the other hand, chiefly serve the community through district heating networks.

Production of cogenerated heat in Poland has risen systematically over the years, particularly in 1970-1980. In connection with the economic changes and industrial restructuring, industrial CHP plants did experience a downturn following 1990, but owing to greater activity on the part of municipal CHP plants the total amount of heat generated in combination with electric power was sustained on a similar level.

The years 1995-2000 saw a drop in production in connection with diminished demand for network heat, but the first years of this decade have seen a renewed rise. Studies carried out by the Committee for Energy Studies of the Polish Academy of Sciences have shown that forthcoming years will bring further development of cogeneration systems, not only in large municipal and industrial CHP plants, but also in smaller-scale, more dissipated plants.



Elektrociepłownie Wybrzeże S.A. Archiwum

The advantages of cogenerated heat: reliable supply, convenient use, environmental protection

Efficient and cost-effective

Heat can be produced together with electric power using various configurations and technological systems, which include:

- CHP plants with steam turbines: back-pressure turbines, pass-out turbines, or heat-producing turbines situated in parallel to a main condensing turbine,
- CHP plants using gas turbines with waste heat recovery,
- CHP plants employing a combined gas-steam system,
- small CHP plants outfitted with combustion engines,
- fuel cells harnessing waste heat.

Heat and power from the same plant

All cogeneration systems are characterized by high energy efficiency, expressed as the ratio of the useful energy produced to the primary energy supplied to the system, and this is obviously one of the advantages of cogeneration. However, it must be borne in mind that increased energy efficiency should not be sought at all costs: the overall cost-efficiency of production hinges not only upon the prices of the fuel consumed, but also on the costs of supplying heat and electric power to where it is used.

Most important for consumers is how the price of heat supplied through the network compares to heat produced from local sources – network heat suppliers do not, after all, have a monopoly and must compete on market terms. Consumers purchase network heat in view of its stabile price, convenience, safety, reliability, and low on-site investment costs.

The ecological aspect is also significant: no pollution is released on location where consumers connect to the district heating network, while emissions at the source, i.e. at the CHP plant itself, are subject to strict environmental protection regulations.

Marek Preś

Combined systems that produce heat and energy at the same time are not only more cost-effective but also more environmentally friendly

Problems to solve

The further development of heat supply systems faces many problems of both a technological and economic nature. To a significant extent they are the result of the new market economy conditions in which heat production systems now function. A team led by the present author at Gdańsk University of Technology has recently carried out a series of studies to investigate such issues as: identifying what limits there are on the cost-efficiency of cogeneration, optimizing the parameters of CHP plants employing back-pressure turbines, and the interaction between base-load and peak-load heat sources in heat generation systems.

There are still quite a few "burning" unresolved problems in the energy industry. What is the best way to capture the factors that affect the demand for heat under current economic conditions? How should the competitiveness of various sources of heat be compared on local markets? What poses the greatest barrier to cost-effective cogeneration at various sorts of CHP plants? All of these questions require urgent answers. Moreover, numerous technical issues are also waiting to be solved.

The further intensive development of heat supply systems hinges on these problems being successfully tackled. It is also crucial for these systems to continue to be modernized and adapted to the new economic conditions. The overarching goal is to provide a reliable supply to meet the demand for heat, while working to maximize the efficiency of generation systems, minimize supply costs, and curb the negative environmental impact. ■

Further reading

Marecki J. (1988). *Combined heat and power generating systems*. London: P. Peregrinus Ltd. on behalf of the IEE.

Marecki J.(1991). *Economics of combined heat and power generation* [in Polish]. Third edition, Warszawa, WNT.

Marecki J. (2000). *Basics of energy conversions* [in Polish]. Second edition. Warszawa, WNT.

Kamrat W. (2001). Modeling the structure of local energy markets. *IEEE Computer Applications in Power*, vol. 14, no. 2, pp. 30-35.

Marecki J. (2005). Cogeneration of heat and electric power [in Polish]. *Wokół energetyki*, 1(23).