TRIGENERATION UNITS

Dušan Medveď

ABSTRACT

This paper deals with the brief description of trigeneration units for simultaneous production of cooling, heating and power (CHP). These units can be properly applied to increasing the efficiency of energy production and reducing the needs of primary energy sources.

1. INTRODUCTION

Tri-generation is the simultaneous production of three forms of energy: electricity, heating and cooling. A trigeneration system can provide power, hot water, space heating and air conditioning from a single system.

Generators lose heat as they create electricity. A tri-generation facility captures this heat that would otherwise be lost and uses it to generate both hot and cold water.

The chilled water is created by an absorption chiller, which is generated by the excess heat and which operates like a refrigerator. It creates water at sufficiently low temperatures to be used for air conditioning. [2]

2. DEPLOYMENT OF TRIGENERATION UNITS

As it was mentioned above, the trigeneration is the simultaneous production of three forms of energy – typically, cooling, heating and power (CHP), from only one fuel input. Put another way, trigeneration power plants produce three different types of energy for the price of one. In general, the trigeneration energy systems reach overall system efficiencies of 86 % to 93 %. Typical “central” power plants, that do not need the heat generated from the combustion and power generation process, are only about 33 % efficient.

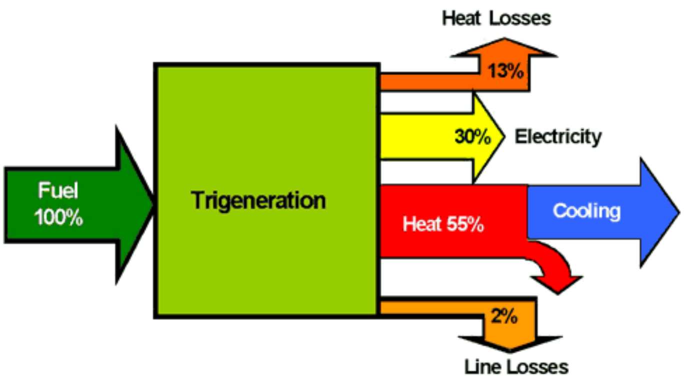

Figure 1 – Trigeneration Diagram and Description [1]
(The trigeneration power plants have the high system efficiencies and are about 300 % more efficient than typical central power plants)

Trigeneration plants are mostly installed at locations that can benefit from all three forms of energy. These types of installations that install trigeneration energy systems are called “onsite power generation” and are also referred to as “decentralized energy.”

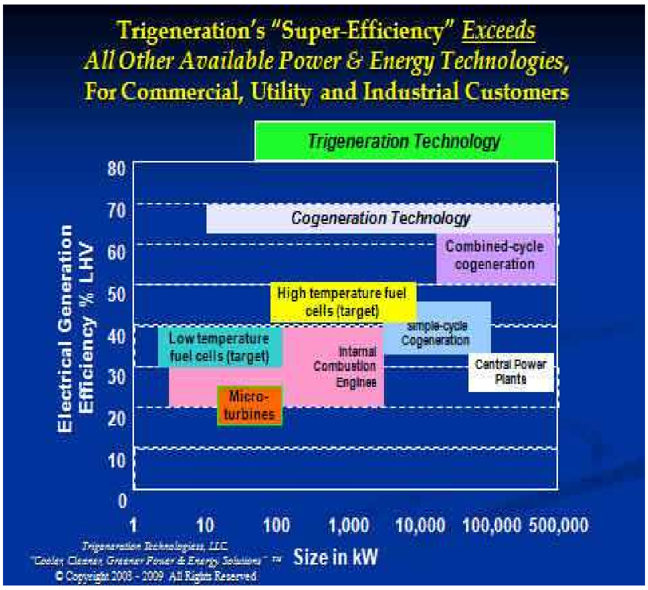

Figure 2 – Trigeneration Chart [1] (Trigeneration’s “Super-Efficiency” compared with other competing technologies)

The Company EPC (Engineering Procurement Construction) contractor installed in 1987 a 4 MW Ruston gas turbine for the power plant. Rice University selected an EPC company that installed the trigeneration power plant, along with waste heat recovery boilers and absorption chillers. A “waste heat recovery boiler” captures the heat from the exhaust of the gas turbine. From there, the recovered energy was converted to chilled water – originally from 3 Hitachi Absorption Chillers – 2 were rated at 1000 tons each, and the third Hitachi Absorption Chiller was rated at 1500 tons. The Hitachi absorption chillers were replaced shortly after their installation by the EPC company.

The first trigeneration plant at Rice University was so successful, they added a second 5 MW trigeneration plant, so today the Rice University is now generating about 9 MW of electricity, and also producing the cooling and heating that university needs from the trigeneration plant and circulating the trigeneration energy around its campus. [1]

3. MAIN BENEFITS OF TRIGENERATION

Absorption chillers provide an economic and environmental alternative to conventional refrigeration. Combining high efficiency, low emission power generation equipment with absorption chillers allows for maximum total fuel efficiency, elimination of HCFC/CFC (freons) refrigerants and reduced overall air emissions. [4]

3.1. Possibilities for refrigeration

- *Absorption chillers:*
  - Operation with hot water
  - Operation with steam
  - Direct heat through combustion
- *Compression-type refrigeration machines:*
  - Direct drive power
  - Electrical drive power

3.2. Absorption chillers

Absorption chillers produce chilled water by heating two substances (e.g., water and lithium bromide salt) that are in thermal equilibrium to separation, then reuniting them through heat removal. The heat input and removal, achieved in a vacuum at varying pressure conditions (approximately 8 mbar and approximately 70 mbar), brings the materials into imbalance, thereby forcing them to undergo desorption or absorption. Water (refrigerant) and lithium bromide salt (absorbent) are generally used for generation of chilled water in the temperature range from 6 to 12 °C. Ammonia (refrigerant) and water (absorbent) are used for low temperature chilling down to – 60 °C. *CHCP* (combined heat, cooling, and power) *systems* – also called trigeneration systems – are the combination of cogeneration plants with absorption chillers and offer an optimal solution for generating air conditioning and/or refrigeration. [4]

3.3. The Jenbacher concept

Combining a cogeneration plant with an absorption refrigeration system allows utilization of seasonal excess heat for cooling. The hot water from the cooling circuit of the cogeneration plant serves as drive energy for the absorption chiller. The hot exhaust gas from the gas engine can also be used as an energy source for steam generation, which can then be utilized as an energy source for a highly efficient, double-effect steam chiller. Up to 80 % of the thermal output of the cogeneration plant is thereby converted to chilled water. In this way, the year-round capacity utilization and the overall efficiency of the cogeneration plant can be increased significantly. [4]

CHCP systems supply energy in three forms:

- Electricity
- Heat
- Chilled water

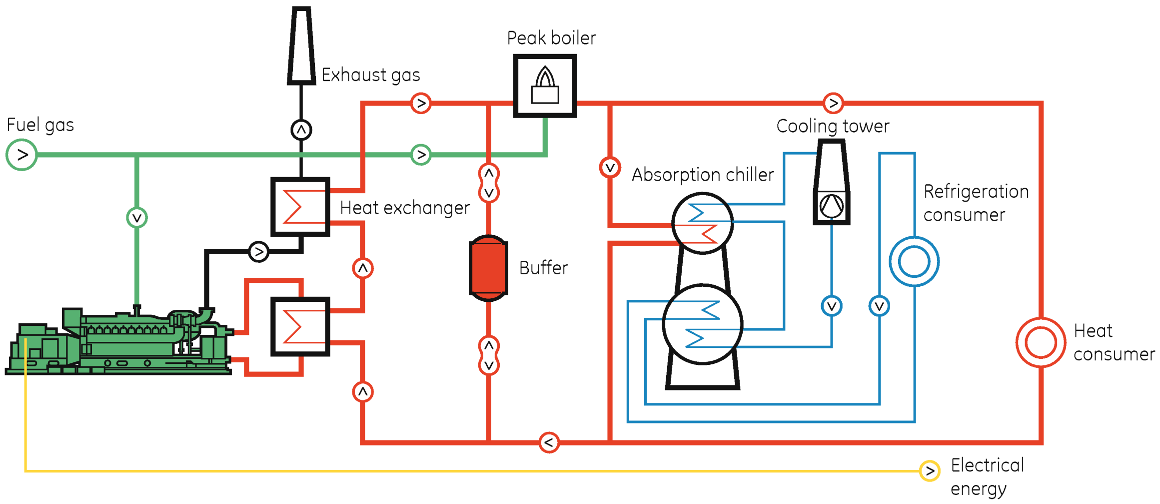

Figure 3 – Principal scheme for trigeneration of heat, cooling, and power (producers and customers) [4]

3.4. Advantages of trigeneration systems over conventional refrigeration technology

- Operated with heat, utilizing relatively inexpensive “excess energy”
- Produced electricity can be fed into the public grid or used to cover electricity requirements of the plant
- During cold seasons the heat can be utilized to cover heat requirements
- No moving parts in absorption chillers, no wear and therefore low maintenance expenses
- Noiseless operation of the absorption system
- Low operating costs and life-cycle costs
- Water as refrigerant, no use of ozone-damaging substances

Absorption-type refrigeration technology offers the most established and economic solution for reduced emission, air conditioning systems. [4]

3.5. Key figures

- Approximately 150 to 170 kW of cold output is required per 1000 m^2 of office space
- The term, tons of refrigeration (TR), is generally used as the unit of cold energy: 1 TR (US) = 3,52 kWh, 1 TR (metric) = 3,86 kWh

- The term, coefficient of performance (COP), is used for referring to the efficiency of an absorption chiller. For a hot water chiller, the COP lies between 0,6 and 0,8 and for a double-effect steam chiller between 1,2 and 1,3
- Cold water temperatures down to 4,5°C can be achieved with lithium bromide salt; with ammonia, temperatures down to – 60°C can be achieved. [4]

4. CONCLUSIONS

The advantages of Trigeneration system over conventional generation system using of LPG were confirmed after of number of trials of current Micro-Trigeneration system according to [3] as below:

1. Increased reliability and security of energy supply. Lower energy cost: the 75 % saving of operation cost compared to conventional unit.
2. Higher overall efficiency: 24 % higher than conventional unit.
3. Fuel energy losses reduced to approximately 4 % as against around 28 % in case of conventional system.
4. Recovered waste heat provides "free fuel" for heating water. 60 % of fuel input which otherwise would have lost to ambient in form of exhaust gas is used for water heating.
5. Clean energy supply with reduced Emission with LPG as fuel.

REFERENCES

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Author:

Ing. Dušan Medveď, PhD.
Technical University of Košice
Faculty of Electrical Engineering and Informatics
Department of Electric Power Engineering
Mäsiarska 74, 042 01 Košice, Slovak Republic
E-mail: Dusan.Medved@tuke.sk
Tel: +421 55 602 3555
Fax: +421 55 602 3552