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ScienceDirect

Energy Procedia 45 (2014) 482 – 491

Energy Procedia

68th Conference of the Italian Thermal Machines Engineering Association, ATI2013

A case study of technical and economic comparison among energy production systems in a complex of historic buildings in Rome

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Abstract

Recently, great attention has been given to the transition from centralized to distributed generation energy production systems. There is a growing potential regarding the use of trigeneration systems in the residential sector because they have the ability to produce thermal energy and electricity from a single source of fuel.
This study has the goal to determine the best systems able to satisfy the demand for electricity and thermal energy for a complex of historic buildings in Rome. Such analysis has been conducted using a specific tool conceived for energetic and financial analysis: the RETScreen software.

Keywords: reliability; maintenance; plant; hospital; MTTR; MDT.

1. Introduction

Nowadays the energy consumed by buildings placed in developed countries is the 20-40% of the total value of energy consumption and has even a higher value than the one reached by industries and transportation in the European Union and in the United States [1]. Some research projects led in Europe give a specific attention to the technical potential represented by the implementation of the trigeneration in the residential and tertiary sector in countries of the Mediterranean area [2]. In these countries the heating necessities is confined to just a few months in

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doi:10.1016/j.egypro.2014.01.052

the wintertime, and this is why the use of cogeneration systems is limited. Nevertheless there is a high need of cooling process for those months belonging to the summertime. Thanks to the combination of cogeneration and absorption refrigerators, the energy requirements demanded by the cogeneration could be extended and include summer months in order to fulfill some necessities represented by the cooling process.

Those cogeneration systems (CHP) enable the simultaneous production of electric (and/or of the mechanic one) and thermal energy through one combustion process. This brings several advantages concerning the generation of the very same energy amount, having its starting point in separated production processes. The advantages are evident. Comparing the total amounts of energy produced, it can be discovered that the CHP systems use less primary energy. The heat generated by machines, those fitting for the electric production, is recovered during the cogeneration. The heat recovery can occur in the form of hot water or steam, in order to be used in situ for the fulfillment of those thermal requirements connected to the air conditioning of the environment with the purpose to produce hot water needed by healthcare systems. When too much heat is produced a solution could be to use it for generating a cooling process in absorption refrigerator machines. The electric energy produced by the cogenerator can guarantee the cooling process. Hence it has been introduced the idea of trigeneration, that is the simultaneous supplying of mechanic energy (or electric) and thermal energy in hot and cold circumstances, by using just one source of energetic provision. In these cases it is possible to increase the whole efficiency of the energetic production system to the 80% with consequential benefits both for the environment and the economy [3]. The traditional plant producing electric energy, can partially transform the energy of the fuel used in electric energy, the left-over energy is lost and considered as the heat which must be discarded. To increase the whole efficiency system, the observation of those requirements demanded by electricity and heating is vital. While the electric energy can be distributed until reaching long distances, the heating must be furnished to relatively close users. This can occur only if the thermal users are close to the cogeneration system [4]. The idea of trigeneration represents an extension of the CHP (cogeneration) which is the production in situ of a triple vector of energy demanded by the user through the use of just one fuel source. A proper cooling demand during the summertime and thermal demand in the wintertime are essential for making the trigeneration feasible from an economic point of view. About this point, it can be said that the potential use can affect entire residential neighborhoods, in small-scale, and individual buildings, in micro-scale.

There is an increase of potential use for the cogeneration systems in the field of residential area because they can produce usable thermal energy and electricity originated by one fuel source, such as natural gas. In those cogeneration systems, the energy conversion efficiency increases of the 80% respect to an average value of the 30-35% for conventional fossils in generating systems of electric energy fed by fuel gas [5]. These technologies are used with a specific goal, that is: to satisfy the electric and thermal demands of a building, the generation of hot water and, maybe, the absorption cooling. Capital costs depend on those components which are part of the system and their technical specifications. These components are: the prime engine and generating set; heat recovery and expulsion system; exhaust fumes and the stack; fuel supply; control cards; piping, ventilation and combustion air systems; delivery costs and taxation. Installation costs are formed by such elements as: installation licenses, acquisition of a piece of land followed by preparation, construction of the building and the installation of the equipment. Some of these expenses cannot be applied to the residential field and to the field of small commercial cogeneration systems. Costs regarding the running expenses include: fuel cost, personnel cost, the maintenance and insurance costs.

This study wants to focus its attention on trigeneration systems generating electric and thermal energy for a complex of buildings in a XIX century villa placed in Rome. These buildings represent an interesting type of user, both in the residential and tertiary sector, whose features are particularly suitable for being exposed to a process that will make them energetically more efficient. That process will be based on these systems.

2. Description of the technological system

These conditions are essential for a right use of the cogeneration systems:

- the simultaneous production of thermal and electric energy must be demanded (heating and/or cooling). It is also important the stack of heat and cold and the act of furnishing the electricity to the network weather with exchange and/or through selling.