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Technical-Economic Feasibility Study of a Tri-Generation System in an Isolated Tropical Island

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ABSTRACT

Over the years, and despite the energy efficiency measures and possibilities, there has been an increase in energy consumption worldwide. However, the resources and primary energies are limited and short stocked, and the energy production technologies have environmental and social impacts on production and exploration. One alternative is to reuse the energy waste in the processes. In this study, a trigeneration system in a large scale out of grid consumption is analyzed and a technical-economic feasibility is elaborated. The case study is based on an isolated tropical island. For the baseline scenario, two traditional energy production systems that does not contain energy recovery in the engines are assumed to be implemented. For the improved scenario, a trigeneration system absorption chiller is analyzed. An economic analysis of this project was given the indicators obtained, it was possible to conclude that the use of a trigeneration system on an isolated large scale out of grid energy consumption system, is feasible and preferable.

KEYWORDS

Absorption Chiller, Cogeneration, Economic Analysis, Energy efficiency, Technical-Economic Feasibility, Trigeneration

1. INTRODUCTION

The economic globalization has been wider over the years and is accompanied by an increase in energy demand and energy consumption. According to the International Energy Agency (IEA), energy consumption has increased dramatically (almost doubled) from 1975 to 2015 (Chen 2018). To traditional response to face the increase in consumption by producing more amount of energy is no longer environmentally, economic and social acceptable. Therefore, new ways to capture energy loses and reuse them in an efficient way is on focus. For example, the gases released in the energy generation processes in the thermoelectric plants, still have energy content. This energy content is normally lost by the chimneys of the plants to the atmosphere in the form of heat. If the heat is harnessed, the efficiency of the processes is improved, and losses are avoided (Feidt, Dupont et al. 2017). Conventionally, the production of heat energy and electricity is carried out in different systems. With the development of cogeneration systems, it is possible to produce electricity and heat through the same process. In the generation of electrical energy, heat is released into the atmosphere, part of

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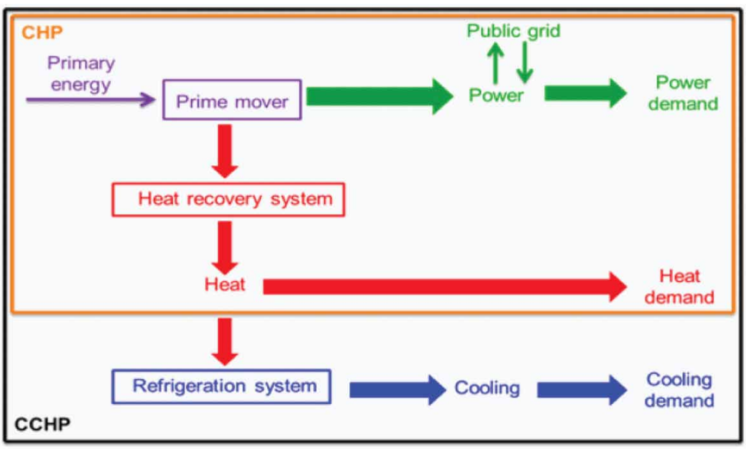
which can be used to satisfy the heat needs of consumers. Being a typically decentralized process, Cogeneration allows to satisfy the consumer's heat and electrical needs, guaranteeing a efficiency of 80 to 95% (Consulting). The use of systems that allow the production of heat and electricity separately guarantee a lower efficiency, this is due to the amount of energy that is lost in these systems when compared to Cogeneration systems (to satisfy a determined energy demand, Cogeneration uses a smaller amount of fossil fuels) (Consulting). The technologies normally used in Cogeneration are based on: Alternative Internal Combustion Engine, External Combustion Engine, Steam Turbine, Gas Turbine, Fuel Cells and Hybrid Photovoltaic Thermal Solar Collectors.

The concept of trigeneration is an extension of the working of cogeneration, where exists the production of cold in addition to the production of heat and electricity. Trigeneration systems are implemented when there is a need for cooling equipment such as absorption chillers to produce cold (Baghernejad 2016, Feidt, Dupont et al. 2017). Figure 1 (Feidt, Dupont et al. 2017) presents a diagram referring to the connection of Trigeneration systems with Cogeneration systems.

Figure 1. Working of trigeneration



In Figure 1, the area enclosed by the acronym CHP (Combined Heat and Power) represents the constitution of Cogeneration systems, while the area enclosed by the acronym CCHP (Combined Cooling, Heat and Power) represents the composition of Trigeneration systems. The implementation of Trigeneration systems has several advantages, one of these is based on more efficient, economical and reliable use of primary energy compared to the cogeneration system. This advantage is guaranteed because the heat lost in the prime mover, is recovered through a heat exchanger and used in heating and cooling systems (Baghernejad 2016, Feidt, Dupont et al. 2017). By taking use of this energy, lower energy production is needed, thereby lower social and environmental impacts are present. The technologies used for the Trigeneration Systems are based on Absorption Chillers, Adsorption Chillers, Desiccant Cooling Systems and Ejector Cooling Systems.

The present work has the main objective of implementing a Trigeneration System in an isolated out of grid system (case study - island) and studying its technical-economic feasibility. This study makes sense to be carried out, since sometimes, in isolated remote areas, the connection to the power grid is either not possible to be made, or it is very expensive, so it is necessary to find an alternative. If the use of this system is feasible, it is possible to present a good alternative to conventional systems to produce energy on large scale consumption islands and remote areas.