Renewable and Sustainable Energy Reviews 38 (2014) 193–211

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Energetic and economic analysis of a Brazilian compact cogeneration system: Comparison between natural gas and biogas

Federico Brizi [a], Jose Luz Silveira [b,*], Umberto Desideri [a], Joaquim Antonio dos Reis [b,1], Celso Eduardo Tuna [b], Wendell de Queiroz Lamas [c]

[a] Department of Industrial Engineering, Faculty of Engineering, University of Perugia, Perugia, Italy
[b] Laboratory of Energy Systems Optimization, Department of Energy, Faculty of Engineering at Guaratingueta, Sao Paulo State University, Guaratingueta, Sao Paulo, Brazil
[c] Department of Basic and Environmental Sciences, School of Engineering at Lorena, University of Sao Paulo, Lorena, Sao Paulo, Brazil

ARTICLE INFO

Article history:
Received 8 January 2014
Received in revised form
20 May 2014
Accepted 23 May 2014

Keywords:
Absorption chiller
Biogas
Cogeneration
Internal combustion engine
Natural gas

ABSTRACT

Cogeneration may be defined as the simultaneous production of electric power and useful heat from the burning of a single fuel. This technique of combined heat and power production has been applied in both the industrial and tertiary sectors. It has been mainly used because of its overall efficiency, and the guarantee of electricity with a low level of environmental impact. The compact cogeneration systems using internal combustion engine as prime movers are thoroughly applied because of the good relationship among cost and benefit obtained in such devices. The cogeneration system of this study consists of an internal combustion engine using natural gas or biogas as fuel, combined with two heat exchangers and an absorption chiller utilising water–ammonia as working mixture. This work presents an energetic and economic comparison between natural gas and biogas as fuel used for the system proposed. The results are useful to identify the feasible applications for this system, such as residential sector in isolated areas, hotels, universities etc.

Contents

* Correspondence to: Av. Dr. Ariberto Pereira da Cunha, 333-Pedregulho, Guaratingueta, Sao Paulo 12516-410, Brazil. Tel.: +55 12 3123 2836; fax: +55 12 3123 2835.
E-mail address: joseluz@feg.unesp.br (J.L. Silveira).
[1] In memoriam.

http://dx.doi.org/10.1016/j.rser.2014.05.088
1364-0321/

1. Introduction

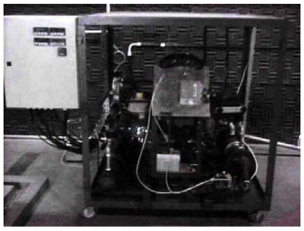
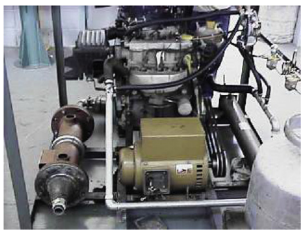
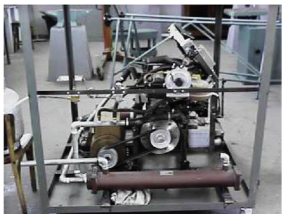
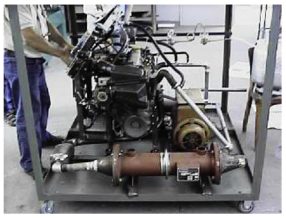
Nowadays, the world economy has experienced a series of crises. In this context and in order to increase their competitiveness, companies are studying a way to reduce their production costs.

It is in this context that cogeneration is presented as an alternative technology very useful. Indeed, cogeneration systems are not characterized only by its energy advantages and environmental preserving, but also for being investments that come with high profitability.

Cogeneration is a technology already used since the last two decades of the XIX century and in the beginning of the XXI century its participation of this technology accounted for 60% of industrial electricity demand in the United States.

Many processes in the chemical, pulp and paper, food and many others, require energy in the form of steam and electricity. When there is simultaneous generation of heat and mechanical or electrical power in industrial plants, it uses the term cogeneration. When is the residential sector, commercial and governmental uses this simultaneous generation, it is customary to use the term integrated energy systems, while for the recovery of residual flows thermoelectric facilities for heating purposes, it is used the term warming district [1].

Table 1
Cogeneration compact system data.

1. Internal combustion engine 	Type: GM Corsa, 1.0 L "98", 4 stroke, injection system: MPFI—Delphi, compression ratio: 9.4:1, maximum power: 44 kW, maximum torque: 81 N m, maximum rotation: 6000 rpm
2. Three-phase alternator 	Frequency: 60 Hz, poles number: 4, rotation: 1800 rpm, $\cos\varphi$: 0.8, power: 12.5 kVA, current at 220 V: 32.8 A
3. Absorption chiller 	Refrigerating capacity: 17.4 kW, (5 TR), current drain: 1275 W, Dimensions:—depth: 850 mm, height: 1190 mm, width: 1230 mm
4. Heat exchangers 	Type: shell and tube (water/water), tubes number: 40, tubes diameter: 9.525 mm, tubes thickness: 0.79 mm, tubes distance: 12.5 mm, baffles number: 7, baffles' cut: 30%
	Type: shell and tube (gas/water), tubes number: 76, tubes diameter: 9.525 mm, tubes thickness: 0.79 mm, tubes distance: 12.5 mm, baffles number: 3, baffles' cut: 27%