BIOGAS TO INTEGRATED SYSTEM

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Background

A trigeneration system uses only one source of primary energy, while providing power, heating and cooling simultaneously. This primary source can be represented by either fossil fuels or some appropriate renewable energy sources (biomass, biogas, solar energy, etc.). This systems therefore have the potential to increase access to the benefits achievable from on-site electrical generation and to reduce emissions and operating costs [1].

Objective

In this research an economical-technical feasibility is carried out for a trigeneration system feed by biogas.

Material and methods

Different sections are present in the trigeneration system: a steam plant to produce electricity; a boiler for the combustion of biogas; a plant for recovery of thermal energy; a mechanical compression heat pump whit R-134a; an absorption heat pump with $LiBr\text{-}H_2O$ as refrigerant fluid.

The biogas is combusted in the boiler of steam plant in order to provide the primary energy to the process; the steam plant produces electricity and steam at low pressure that is send to the absorption chiller and the thermal energy recovery plant.

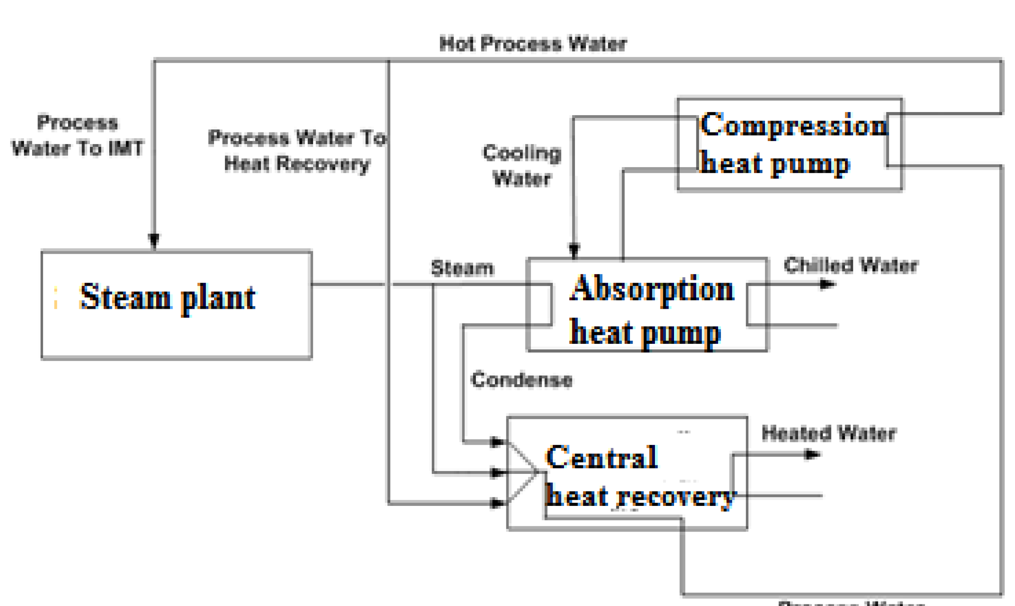

Figure 1. Scheme of the trigeneration system

Components	% vol.
Methane	59,60
Carbon dioxide	39,10
Nitrogen	0,90
Oxygen	0,20
Hydrogen sulfide	0,20

Table 1. Composition of biogas

The innovation of the process is that the heat at low temperature produced by the absorption chiller is used in the vapor compression heat pump which receives the process water at low temperature from the heat recovery plant increasing this value; the hot process water is partially sent to the production system of electrical energy and partially to the plant for heat recovery.

Simulations of the plant are carried out with ChemCad software.

Results

Table 2 shows the results of design for this process obtained with Chemcad software.

Heat of combustion	3280 kW
Power of pumps in steam plant	60 kW
Power of pump in recovery plant	5 kW
Power of pump in HP	0,02 kW
Power of compressor	545 kW
Power of process pumps	194 kW
Total power	4085 kW
Power of electrical energy	925 kW
Power of thermal energy	2523 kW
Cooling energy	473 kW
Total power	3920 kW
PER	1,04 kW

Table 2. Process conditions of trigeneration system

The value of Primary Energy Rate is equal to1.04: the system makes optimal use the introduced feed.

Overall 1914 tep/years of white certificates and 191400 €/years of economical incentives are obtained with a VAN equal to 371.000 €. Considering the all-in tariff, the plant has a VAN equal to 2.181.000 €. Only considering the economical incentives the plant is economical feasibility, as shown in figure 2.

A sensitivity analysis is carried out: as shown in figure 3, 4, 5: electric power and temperature of process water have a positive effect on PER, while cooling capacity has a negative effect on PER.

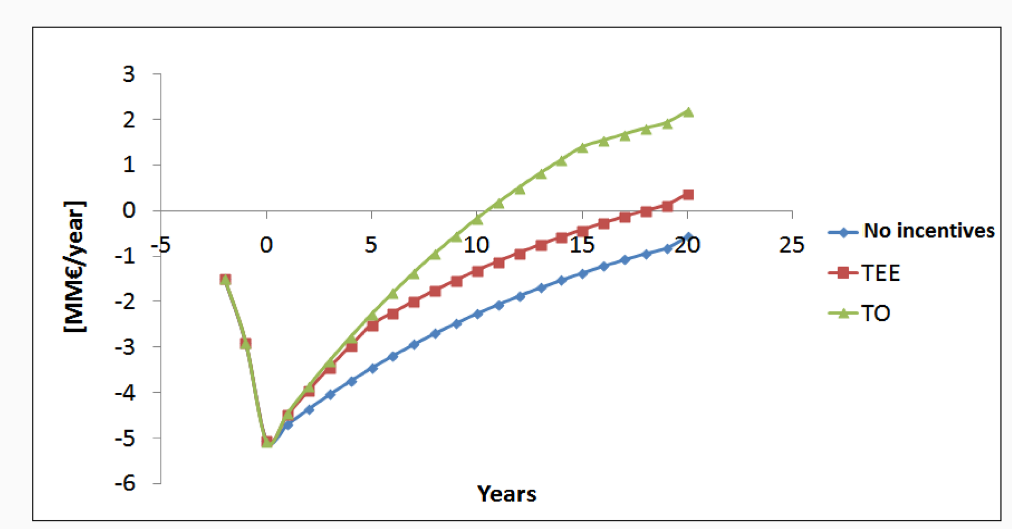

Figure 2. Cash flow for different economic incentives

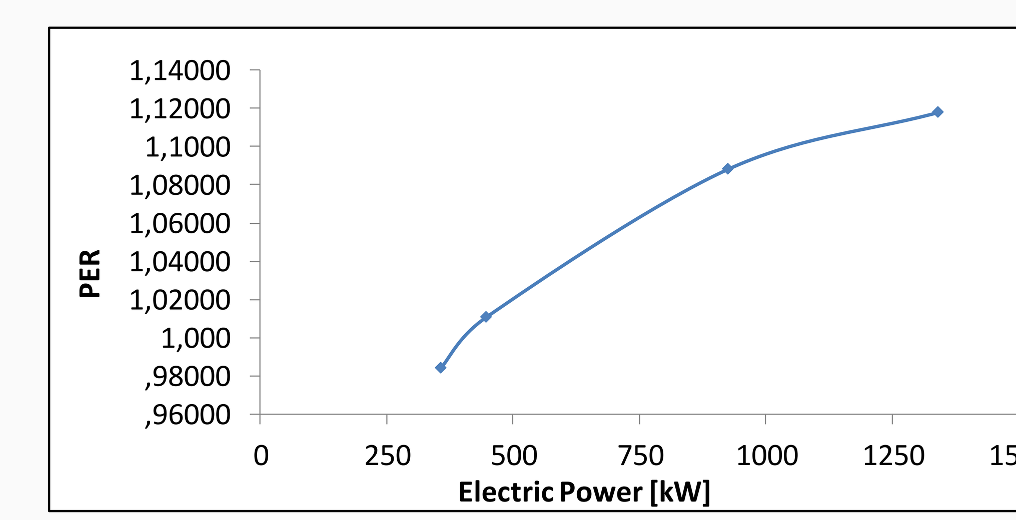

Figure 3. PER versus electric power of the plant

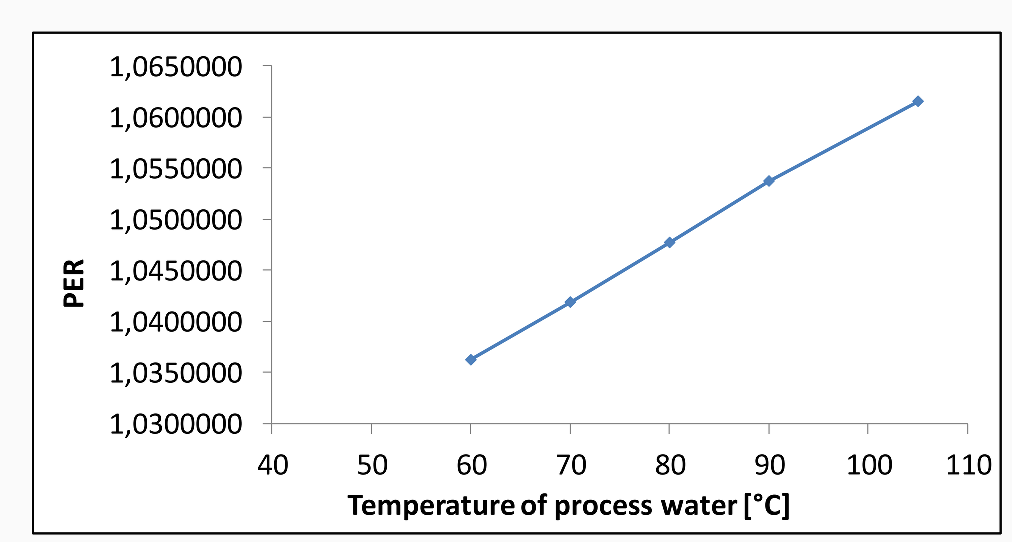

Figure 4. PER versus temperature of process water

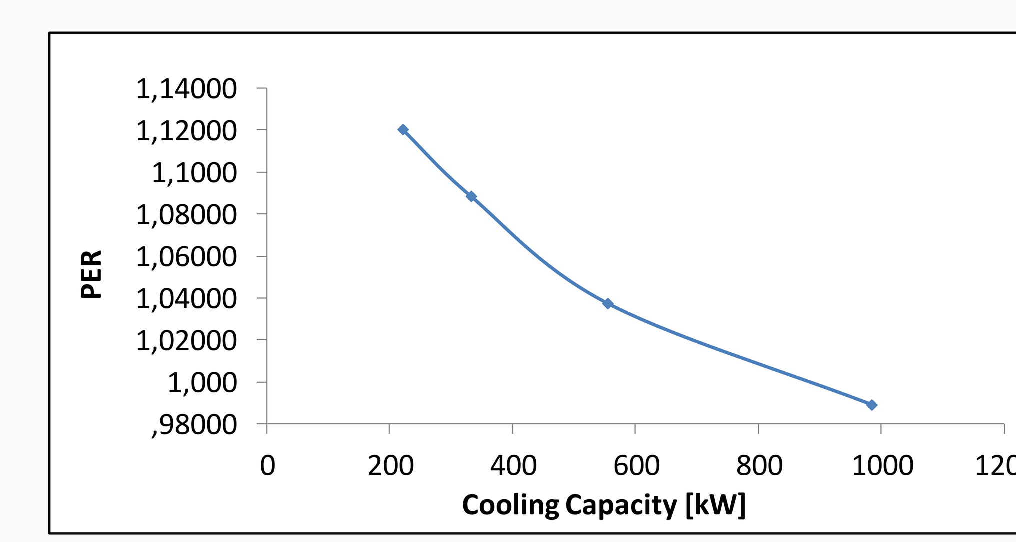

Figure 5. PER versus cooling capacity of the plant

Conclusions

Future researches should address the greater integration of processes in order to have a more energy saving for the construction of pilot plant.

References

[1] Sonar D, Soni SL, Sharma D. Micro-trigeneration for energy sustainability: technologies, tools and trends. Appl Therm Eng 2014;71:790–6.