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MASTER

Optimalisatie van warmtekracht

Hakkert, C.G.

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Abstract

This report describes the effects of several energy demand profiles on operational costs and environmental release of the combined heat and power installation at Bavaria NV. Conclusions and recommendations are made for the best demand pattern in case of Bavaria. Additional recommendations are made regarding the steam system.

m. A. m. Splinter = begeleider.

Hoofdwerk niet ingeleverd: vertrouwelijk.

NIET
UITLEENBAAR

Summary

Bavaria NV

This project has been carried out to obtain a degree in Industrial Engineering at the University of Technology. The project was conducted at Bavaria NV.

Bavaria produces beer, malt and soft drinks. Bavaria has been located in Lieshout since 1719 and is founded by Morees and has been taken over by the Swinkels family.

The internal energy department of Bavaria is responsible for the delivery of the utilities to the different plants at the site of Bavaria; these utilities are steam, electricity, hot water, cooling, compressed air and water.

Assignment and goal of the project

The assignment can be described in the following way:

- Provide insight into the combined heat and power system and its users
- Investigate the demand pattern of the different users of steam and electricity and the effects on the exploitation and environmental performance of the cogeneration plant
- Investigate the effect of change in a decrease of users on the exploitation and environmental performance of the cogeneration plant

The combined heat and power system consists of two gasturbines, two heat recovery boilers and the steam and condensate system.

The goal of this project can be formulated as follows: reduction of costs by reducing the loss in steam and condensate and by means of compatibility of demand and supply. These reductions should also lead into a decrease in the environmental impact of Bavaria.

To reach this goal some steps have to be followed. These steps are:

1. Making an analysis of the present situation regarding steam and electricity at Bavaria
2. Conducting a review of literature related to combined heat and power systems
3. Translating the theories of step 2 to the situation at Bavaria
4. Drafting a model which provides the answers at the research questions
5. Applying the model so that the results for Bavaria can be determined
6. Drawing conclusions based on the results and making recommendations as a result of the project that has been carried out

The combined heat and power system

The combined heat and power system that is used nowadays at Bavaria can be described by figure 1.

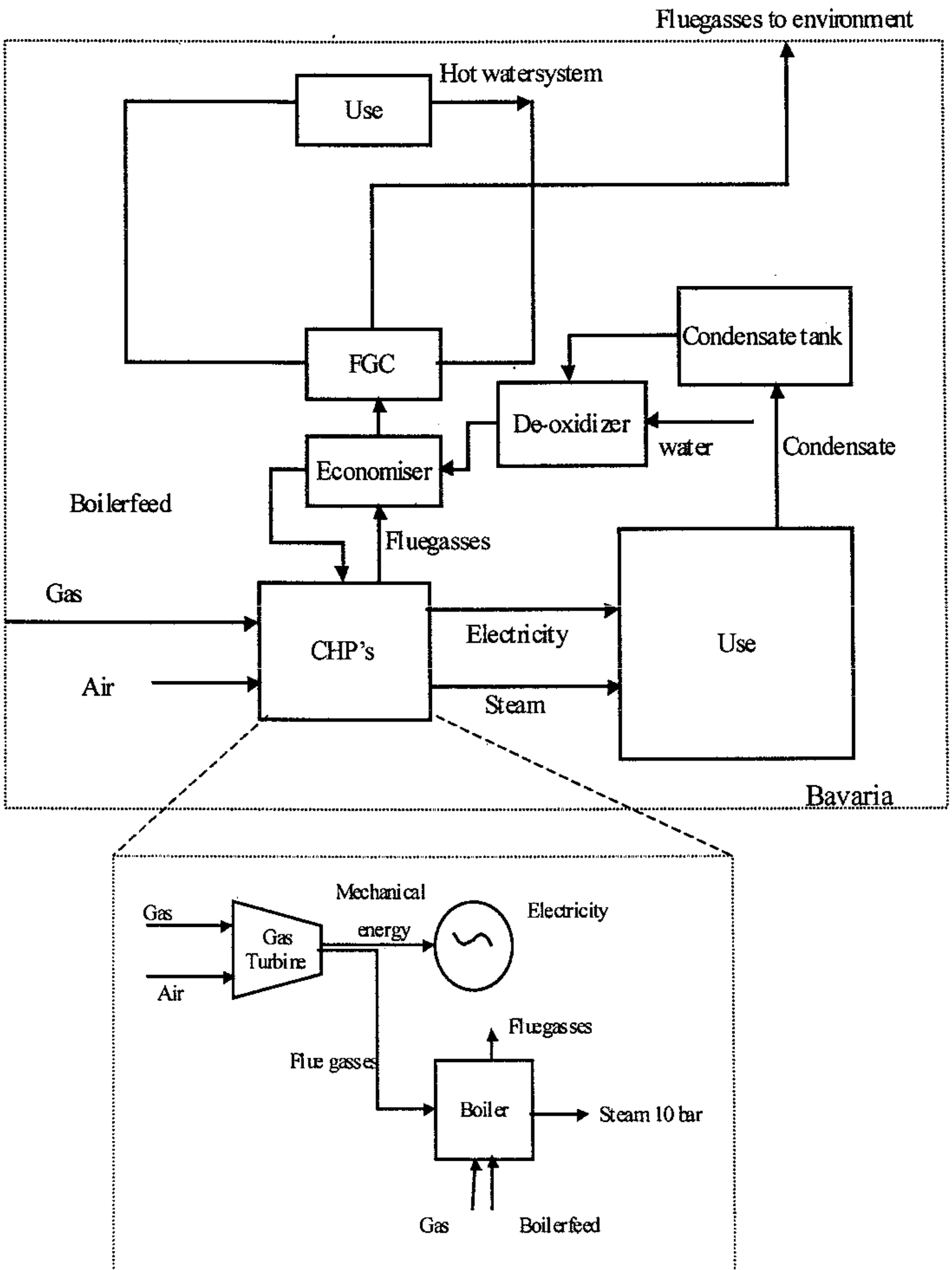

Figure 1 The combined heat and power system

The CHP consists of a turbine, a generator and a heat recovery boiler. Steam is produced at 10 bar and is transported to the users. Condensate returns from the users, is mixed with demineralised water to compensate losses, and goes back in the heat recovery boiler. This boilerfeed is warmed up with the fluegasses from the turbine. A warm watersystem is in use to further cool down the fluegasses.

Review of literature

To gain insight in exploitation in combined heat and power, theory has been reviewed by means of some articles about combined heat and power systems. The theory found can be summarized in three different parts:

i. An article [1] describing the financial considerations when one is considering buying a combined heat and power system. The following factors play a vital role:
  - fuel prices
  - day and night prices of electricity
  - Compensation for returning electricity to the net
  - Investments and aditional costs
  - Added costs maintenance and operations
  - Grants by government or public energycompanies

ii. An article [2] about sensitivity analysis of the factors that are mentioned in 1. The following three conclusions were made:
  - the most important variable is the price of the bought electricity
  - One of the least sensitive factors is the thermodynamic efficiency of the turbine, unless reduced in big steps
  - The repayment period en the percentage borrowed capital are important financial parameters

iii An article [3] about off-design. Off-design is a mismatch between the demand for heat and power and the design of the installation

Translation of literature to Bavaria

In figure 2 the demand for steam and electricity in several hours at Bavaria is given. One point represents the demand in one hour. The productionlines of the turbines are shown by the red and the blue line. A production line shows the production options for a turbine.

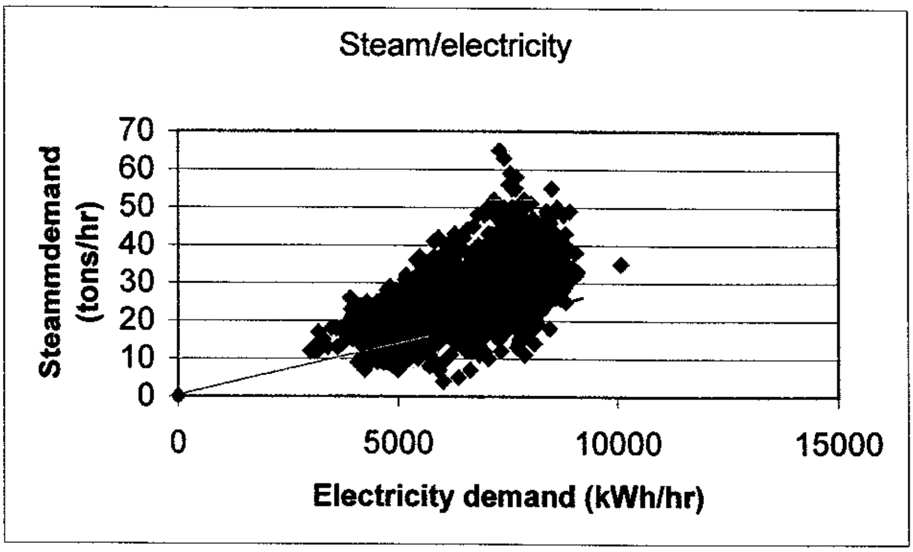

Figure 2: Heat and electricity demand at Bavaria

The demand can be supplied with the following controls

Electricity control: The demand of electricity is produced. Gas is fired in the heat recovery boiler to compensate the shortage in steam; too much steam will be released to the environment.

Steam control: The demand of steam is produced. A shortage in electricity is bought from the net; too much electricity will be sold to the net.

Hand control: The operator can put the machine at a fixed output of electricity, the installation produces also a fixed quantity of steam. When the produced quantity of steam is not enough, extra steam will be produced through extra firing in the boiler. When the produced quantity of steam is too much, the pressure rises and steam will be released to the environment.

Model

To survey what effects are of a changing energy demand pattern, a model is built which can simulate the controls for the turbines at Bavaria.

Filling in a string of hourly demands of steam and electricity, the model gives as output:

- The expenses for exploitation for:
  - Electricity control both gasturbines
  - Steam control both gasturbines
  - Steam control only Tornado gasturbine
  - Situation both turbines turned off

- The output of CO_2 of the steam control for both turbines

Results

The following changes in demand pattern were varied to see if changes occur in carbondioxide release and expenses for exploitation:

- The demand pattern of steam for some weeks is changed into a constant demand (mean of week demand)

Maximum savings possible (in euro's) are given in figure 3.

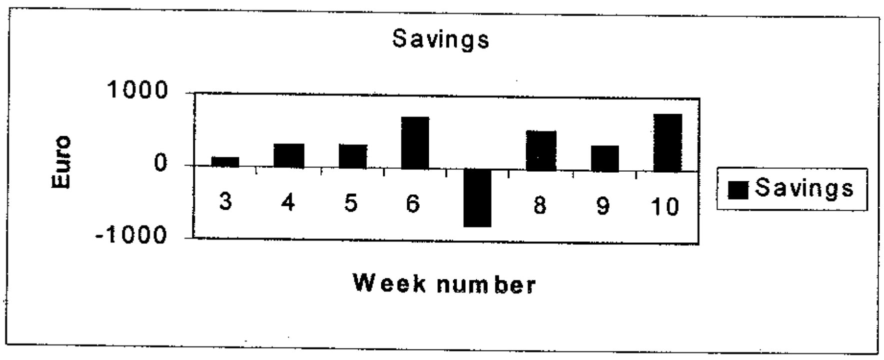

Figure 3· Maximum savings possible a week

Maximum savings possible (in tons CO_2) are given in figure 4.

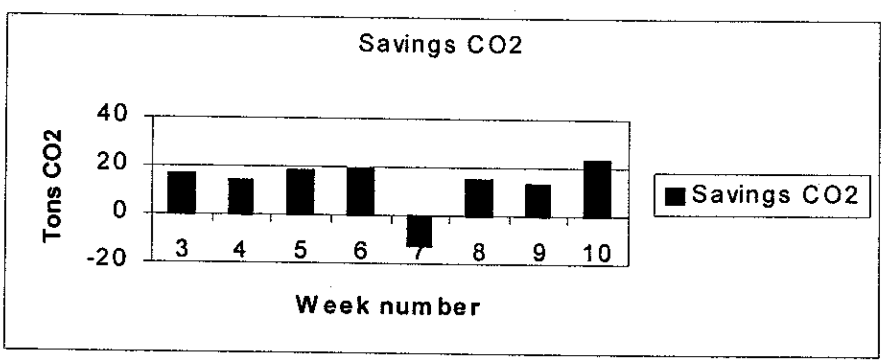

Figure 4 Maximum savings possible a week

- The effect of shifting the breweries demand to the weekend

Maximum savings possible (in euros) are shown in figure 5.

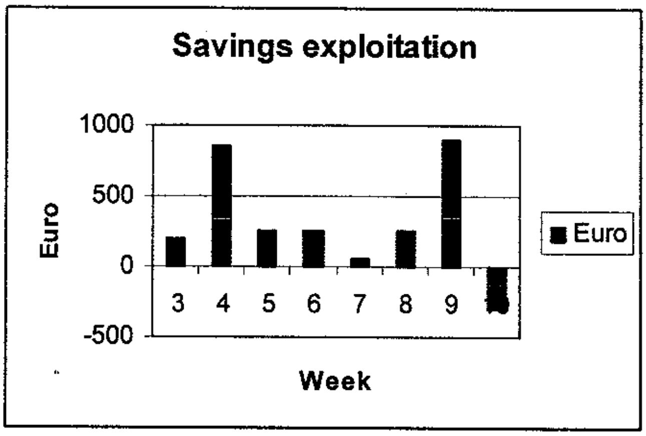

Figure 5 Savings when shifting breweries demand to weekend.

Maximum savings possible (in tonnes CO2) are shown in figure 6.

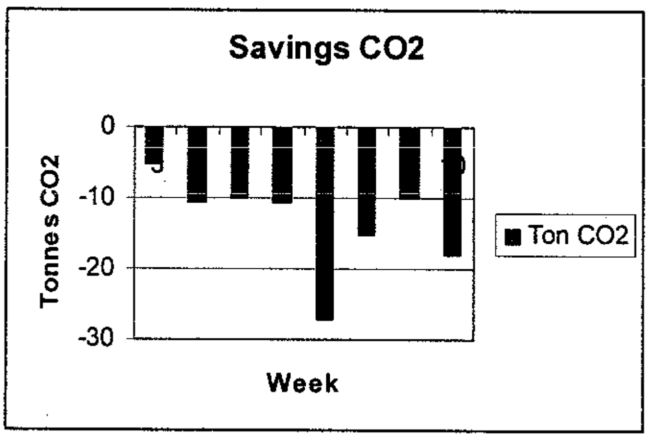

Figure 6: Possible savings tonnes CO2

Conclusions and recommendations

Conclusions

1) A deficit in production and consumption of steam is seen in the mass balance; cause is the measurement of steam and mass losses. These mass losses cost over € 81.000.
   6400 tonnes of steam has been blown into the environment in 2001
2) Moment of turning off TB5000 gasturbine is important
3) Operational costs decrease when steam production is constant at week's mean
   - Savings exploitation 14.950 Euro/year
   - Savings CO_2 715 Tonnes CO_2/year

4) CO_2 to environment decreases when steam production is constant at week's mean

- Savings exploitation 13.000 Euro/year
- Savings CO_2 -650 Tonnes CO_2 /year

Recommendations

I. Check the steam system for leaks every half a year

II. Make an alarm in the procesautomationsystem that warns when the turbines are at hand control

III. Measuring the boilerfeed provides a good insight in production of steam

IV. By measuring the condensate that returns from the users, losses can be quantified to a factory. When letting these factories pay for losses people will make people more carefull for losses

V. Make an alarm in the procesautomation system that warns when steam demand falls under 22 tonnes on Friday. The TB5000 gasturbine can be swiched of.

References:

[1] (1995-2001). Stoom: Theorie en Praktijk. Ten Hagen & Stam Den Haag.

[2] Flint, B.B. en El-Masri, M.A. (1980). Factors affecting the economics of small, free standing cogeneration systems. ASME Paper 84-GT-176.

[3] Lilley, P. (1980). Economic Analysis of industial CHP schemes. GEC Power Engineering Report.