CO-GENERATION AT CERN - BENEFICIAL OR NOT ?

M. Wilhelmsson
ST Division – Cooling and Ventilation Group (ST/CV)
CERN, Geneva, Switzerland

Abstract

A co-generation plant for the combined production of electricity and heat has recently been installed on the CERN Meyrin site. This plant consists of: a gas turbine generator set (GT-set), a heat recovery boiler for the connection to the CERN primary heating network, as well as various components for the integration on site. A feasibility study was carried out and based on the argument that the combined use of natural gas –available anyhow for heating purposes– gives an attractively high total efficiency, which will, in a period of time, pay off the investment. This report will explain and update the calculation model, thereby confirming the benefits of the project. The results from the commissioning tests will be taken into account, as well as the benefits to be realized under the condition that the plant can operate undisturbed by technical setbacks which, incidentally, has not been entirely avoided during the first year of test-run and operation.

1. INTRODUCTION

In relation to the project for the renovation of the heating plant at the Meyrin site, a feasibility study was carried out for the extension of the system by installing a gas turbine set for the combined production of heat and electricity. The mentioned renovation project did already contain the conversion from heavy fuel oil to natural gas. Therefore, the fuel supply for the plant would be easily administered by adding an extra supply from the Geneva gas network. The technical and financial feasibility study showed that the investment would be paid off within approximately seven years [Ref. 1]. However, the financial benefit was the dominating argument; also, other important factors, some of which are mentioned below, encouraged us to submit a project request for such a plant.

- There has been a trend in many of our member states requiring a more decentralized customer market in the power industry. This has resulted in an important increase in the installation of private co-generation plants. This trend has since then further accelerated; the European Commission took, in 1996, a policy decision to further promote the development of co-generation [Ref. 2].
- Gas turbine sets are available on the market with a nominal power that matched our need.
- Ailing diesel generation units. These units have, in the past, also been exploited in load shedding purposes. Yet, it should be noted that it is not an objective of the gas turbine unit to produce electricity as safety power supply.

The project for the installation of a co-generation plant was approved by the CERN Management in Spring 1994.

2. TECHNICAL OUTLINE OF THE PLANT

A schematic outline of the co-generation plant is shown in Figure 1.

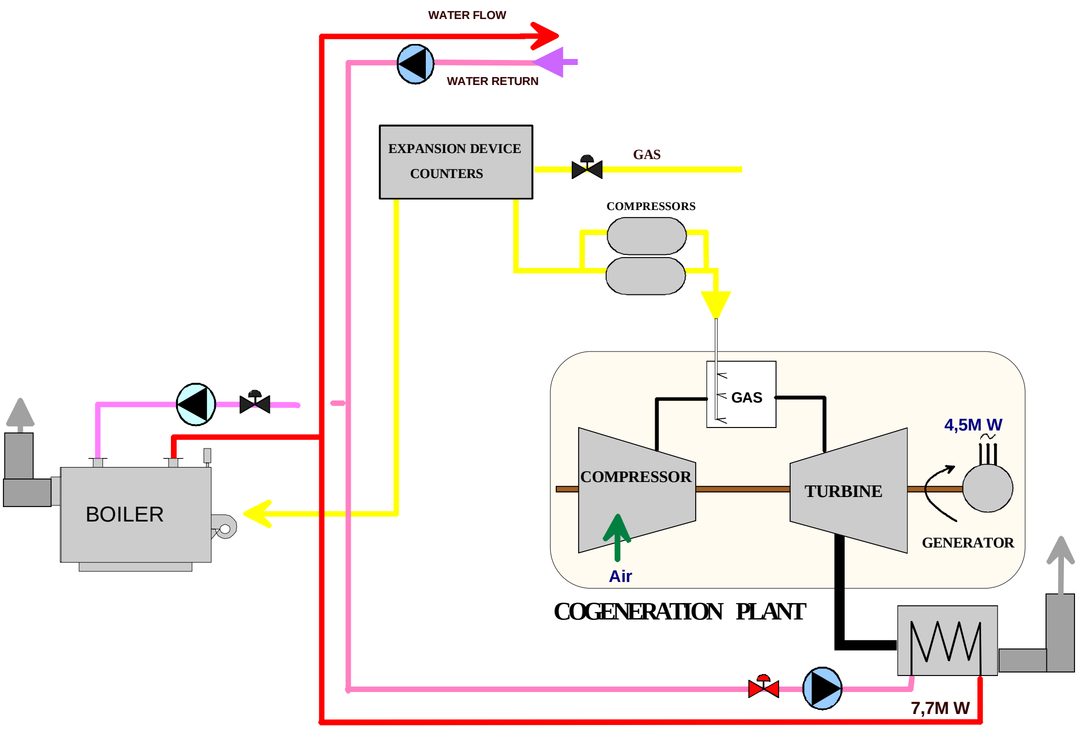

Fig. 1 Technical outline of the plant.

The plant consists of the following main components:

- *A gas turbine generator*; an assembly containing the gas turbine set and the generator, all factory-mounted onto a skid and housed in an acoustic enclosure.
- *A heat recovery boiler* in which the heat from the flue gases is recuperated into the hot water network for the Meyrin site.
- *Gas compressors* which compress the gas from the distribution pressure up to the pressure needed for the gas turbine (15 bar).

Various auxiliary equipment, such as electrical transformer and switch gear, different control and safety systems, are installed for the integration on the site and for the safe operation. A complete new building especially adapted for the plant was also erected as part of the project.

The nominal power of the plant was chosen, optimizing the heat power output, so that the load profile of the Meyrin site always contains the produced thermal power of the co-generation plant.

3. ENERGY PERFORMANCE AND PAY-OFF CALCULATION

The essential performance parameters for the plant are presented in Table 1, with comparison to the contract data:

Table 1
Performance parameters [1]

Item	Measured data	Contract data
Electric power turbine	4 854 kW	4 831 kW
Power consumption for auxiliaries	95.6 kW	
Net electric power	4 758.4 kW	
Heat power	7 612 kW	7 970 kW
Gas fuel consumption	1 556 Nm^3/h	
Power content in	15 836 kW	
COP electric	30.65 %	30.5 %
COP thermal	48.1 %	51.2 %
COP total	78.75 %	
Average ambient temperature	5 °C	
Gas price	0.033 CHF/kWh	

The performance tests of the plant were carried out by ASIT (Association Suisse d'Inspection Technique) on 24-25 March 1997. For the complete results, see Ref. [3]. The performance of the gas turbine slightly exceeds contract data, whereas the heat recovery boiler lacks a few percent in thermal output. For a better overview of the energy flow in the plant, a so-called Sankey's diagram is presented below (Figure 2).

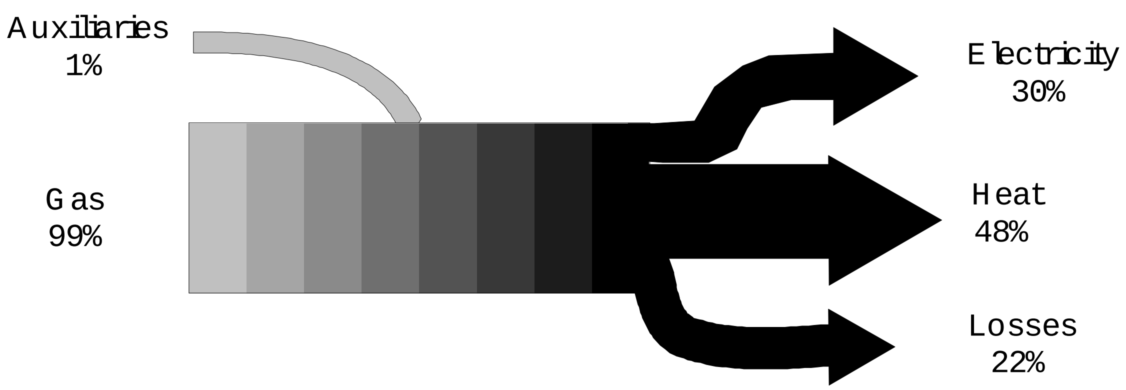

Fig. 2 Sankey's diagram

The pay-off calculation presented here follows the same calculation model described in Ref. [2]however, with up-dated measured performance data. The production data is shown in Table 2 below. The running hours of the plant is the most optimized case from Ref. [2]. It should be noted that the model year does not correspond to the first year of operation, 1996-97, which was incidentally disturbed by several mechanical and electrical running-in problems.

---

[1] The table is adjusted to represent the average seasonal ambient temperature (5°C).

Table 2
Results from the model year

Period	Price of electricity *(CHF/kWh)*	Production time *(h)*	Electricity produced *(kWh)*	Value of the electricity *(CHF)*	Heat *(kWh)*
EJP	0.322	400	1 903 360	612 881.9	3 044 800
Mar. & Nov.	0.059	1936	9 212 262	543 523.5	14 736 832
Dec.-Jan.-Feb.	0.083	1288	6 128 819	508 692	9 804 256
Total		3624	17 244 442	1 665 097	27 585 888

In addition to the given data, the value for a heat unit, for the purpose of comparison, is 0.03587 CHF/kWh.

The results of the calculation is presented in Table 3 below .

Table 3
Results from the pay-off calculation

Electricity value (net)	1 665 097	CHF
Heat value	989 494	CHF
Gas consumption	1 893 859	CHF
Energy net gain	760 732	CHF
Maintenance	50 000	CHF
Net gain	710 732	CHF
Investment	6 200 000	CHF
Pay-off time	8.72	years

4. CONCLUSIONS

A pay-off time of 8.7 years might not be considered as a success in industrial terms. However, the project is an important step for a higher awareness in the use of energy. It is one of the very rare projects at CERN which, in a long term, will be beneficial to the CERN budget. It should be mentioned in this context that the investment cost increased a little, mainly due to the general contractors bankruptcy. Consequently, one year of operation was also lost. The effect of avoiding peaks in power consumption can have some very favorable consequences, although difficult to calculate. Finally, the investment during the year 1996-1997 is being recuperated during a period in which every available centime, will be greatly needed during the whole construction period of the LHC.

REFERENCES

[1] P. Chevret, M. Wilhelmsson, Note Technique ST-IE-ER/94-19 (1994), Co-Génération, Turbines à gaz: Intégration dans le projet "Chaudières" de ST/CV.

[2] Michel Browns (Director of COGEN-EUROPE), «European Co-generation Policy Trends 1997», Paper presented at the Conference Co-generation in Europe, held on 12-13 June 1997, at Milan, Italy.

[3] ASIT - Inspection des chaudières/Economie thermique, Rapport No 9789608, Mai 1997, Essais de performance contractuelle, Turbine à gaz - MAN avec chaudière de récupération - BONO Energia S.p.A.