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RESULTS OF THE COGENERATION EXPERIENCE

FOR THE RTBF-HAINAUT BUILDING IN MONS

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ABSTRACT

For its new building in Mons, the RTBF (Radio and Television organism of the Belgian French Community) decided, with the help of the Walloon Region, to design several equipments with special techniques characterised by a rational and economical use of energy : primary and noble (electricity) energies and reduced use of CFC.

The equipments are : an innovative **humidification** air conditioning system which heats or refrigerates the treated air, the comparison of enthalpie for air mixing, the high-efficiency lighting (first building in the Belgian public sector), a cogeneration installation and a refrigerating absorption group associated with this equipment.

A full DDC centralised management leads, supervises and operates these installations.
This paper explains the choice of the cogeneration type, its exploitation and the results.

The savings are large. A follow-up convention with ELECTRABEL (Belgian company for public production, transmission and distribution of electricity, gas, teledistribution and water energies) must optimise the working in order to increase the installations interest.

A. Presentation of the building and activities of the Mons department

1. The building is made of 6 levels and one technical level on the roof. The essentially technical underground area covers 1200 m2, while each other level covers 1000 m2. The building principally contains :

   - one polyvalent auditorium with 290 seats, a plateau (area : 135 m2), simultaneous traduction boxes (4 languages), an electro-mechanical equipment for the stage,
   - one studio (area : 85 m2) for radio or television purpose**,**
   - five radio studios and their technical rooms .

2. The activities of the Mons department are mainly based on radio but also a television covering for the regional news. The broadcasting from Mons dures over 90 hours per week. The building equipments work 122 hours a week spread over 7 days.

B. <u>The innovative equipments</u> (1)

The innovative character of the equipments proceeds in its brandnew design which dates from the beginning of the eighties. It proceeds also and principally from the complete integration of the cogeneration (cfr. C) at the energy's level.

1. A special air conditioning system based on a humidification by streaming. The humidification water heated or refrigerated as shown in diagram 1. The primary circuit heat exchanger connected to the heat return collector.
   The primary circuit of cold exchanger connected on the iced water production.

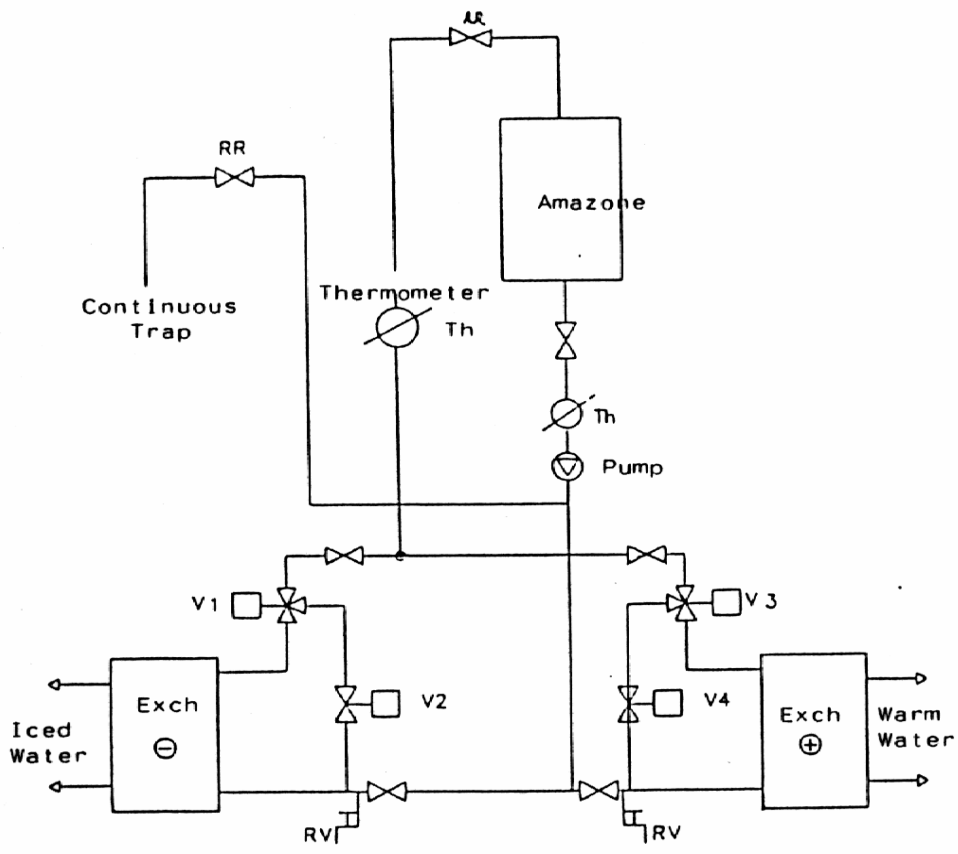


Diagram 1 : Hydraulic draft of the humidification system

The humidification regulation based on the wet bulb temperature. Diagram 2 shows the values evolution with the increase of this wet bulb temperature.

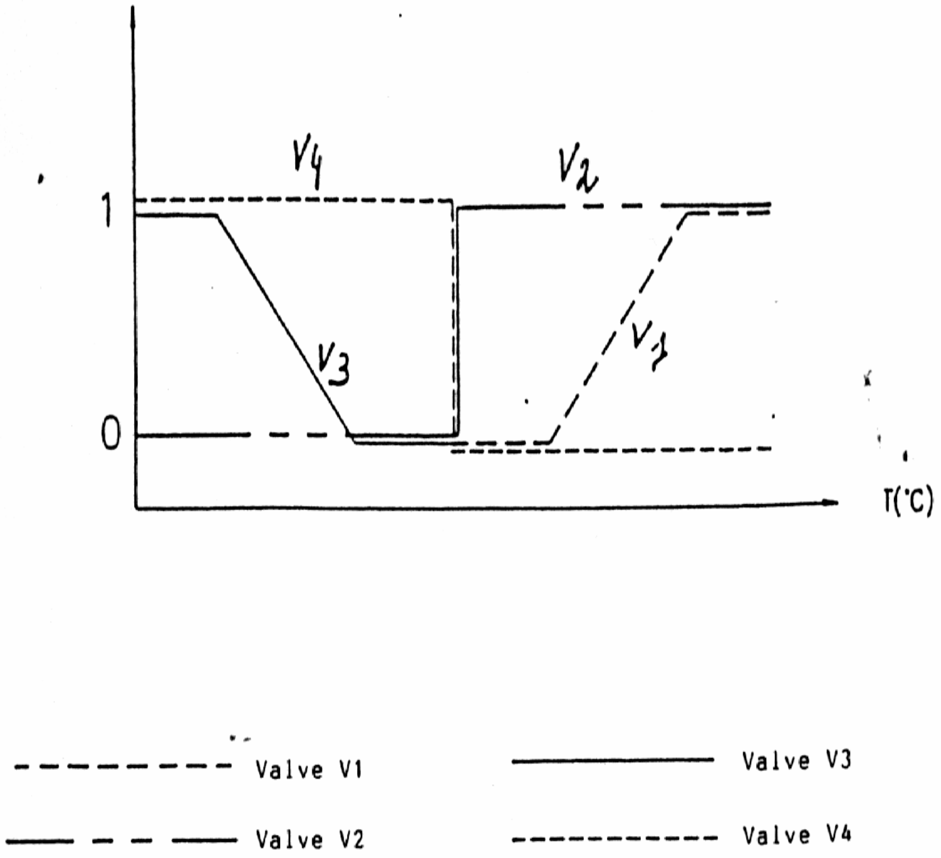


Diagram 2 : Regulation of the humidification system by the wet bulb temperature

This system allows the use of low temperatues in winter (40°C on the primary circuit) and higher temperatures of iced water (9°C on the primary circuit).
This system allows to suppress the pre-heating and cooling batteries in the air treatment groups.

The table 1 hereunder gives the characteristics of the humidification systems and exchangers selection.

GP	WINTER						
	AIR			WATER			Exchanger Power kW
	In °C	Out °C	Flow m3/s	In °C	Out °C	Flow m3/s	
1	8	14,7	5,62	21	17,6	0,01	136,84
3	- 10	14,3	0,83	22	17,4	0,003	49,92
4	-	-	1,31	-	-	-	-
5	11	15,8	5,89	21	17,6	0,008	117,39
6	11	16,8	5,62	21	17,5	0,009	134,85

GP	SUMMER						
	AIR			WATER			Exchanger Power kW
	In °C	Out °C	Flow m3/s	In °C	Out °C	Flow m3/s	
1	27	16	5,62	10	12,7	0,01	109,19
3	30	15,9	0,83	11	13	0,003	22,08
4	23	15,3	1,31	12	13,1	0,003	12,59
5	26,5	16,2	5,89	10	13,3	0,008	116,51
6	26,5	14,7	5,62	10	13,5	0,009	133,33

Table 1 : Characteristics of the humidification systems
and of the connected exchangers.

The advantages of this system are :

- reduction of the humidification pump pressure (80 kPa instead of 250 kPa),

- reduction of the fan pressure on account of the pre-heating and cooling batteries,

- use of low temperatures in winter and higher temperatures of iced water.

2. The mixing of fresh and recycled air is made by comparison of enthalpies. The set point temperature of the mixed air is sliding. This system enables the free-cooling use in spring and autumn (savings on frigories) and the minimum use of the outside air in winter (savings on calories).

   The free-cooling use allows the chilled water production stop at an outside temperature below + 12° C.

3. The high-efficiency lighting equipment of the building was the first ever used in the Belgian public sector. This equipment has involved a planted power reduction of some 40 % or 22 kW. This difference results from the comparison calculation of the previous power with traditional apparatus and the realised installation power.

4. All equipments are led, supervised and operated by a full DDC centralised management. The equipments are also the cogeneration and depending equipments (cfr. C hereunder). This management is necessary because all the concerned techniques are connected and a supervisor contributes to avoid a functioning which doesn't comply with the request.
   In addition, the DDC management leads the security installations : access and anti-intrusion controls, gas and fire detection, fire dampers (200 spread into the entire building), etc.

   Diagram 3 shows the architecture system of the DDC management.

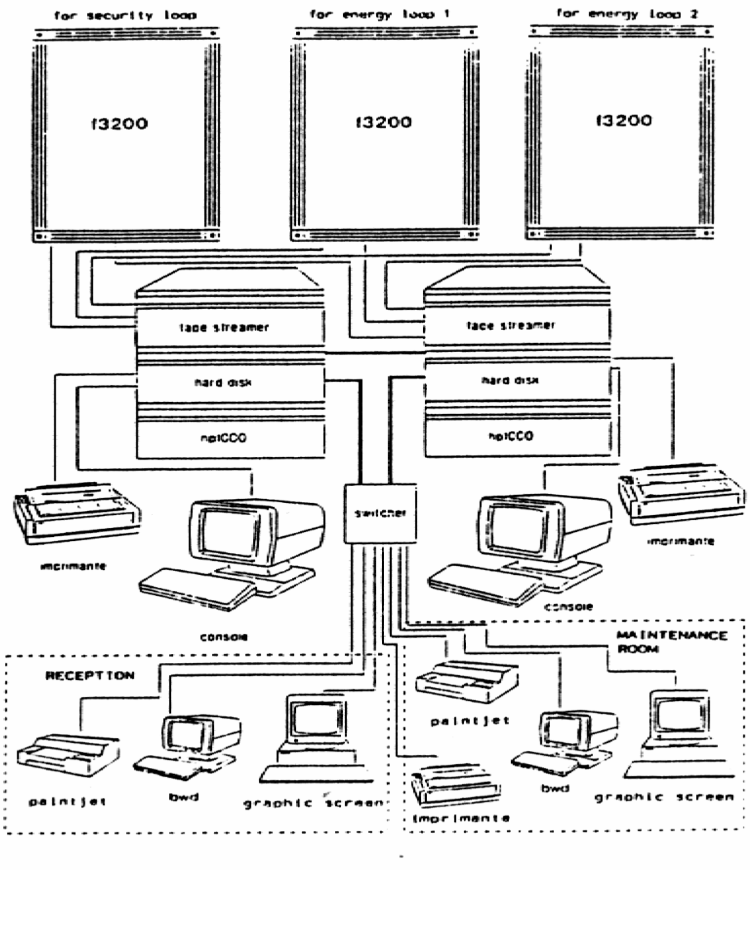


Diagram 3 : Architecture system of the DDC management

C. **<u>The cogeneration installation and attached equipments</u>**

1. The cogeneration is made of 11 units. Each unit produces 15 kW (electricity) and the recovery is 39.3 kW (thermal) into 2 circuits : one at 50-60° C, one at ± 90° C.

Initially, an electrogen group was necessary to stand an electrical supply continuity. This investment can be considered as a non benefit making investment. Therefore, cogeneration was chosen during the study in 1981.

This second function (the production in parallel with the public network) allows an acceptable pay-back.
The functioning permits to command the cogeneration by thermal demand or electrical demand. The RTBF chose the second command because the adequation of both was good (the heat recovery being always used). This adequation is very important and results from an accurate study of the needs for each day, each season and each year.
The regulation based on electrical demand is also a good solution to reduce the power peak.
The cogeneration exploitation allows to produce electricity and heat with a higher energetic efficiency.

Diagram 4 hereunder displays the percentage energy flow diagram of the cogeneration installation.

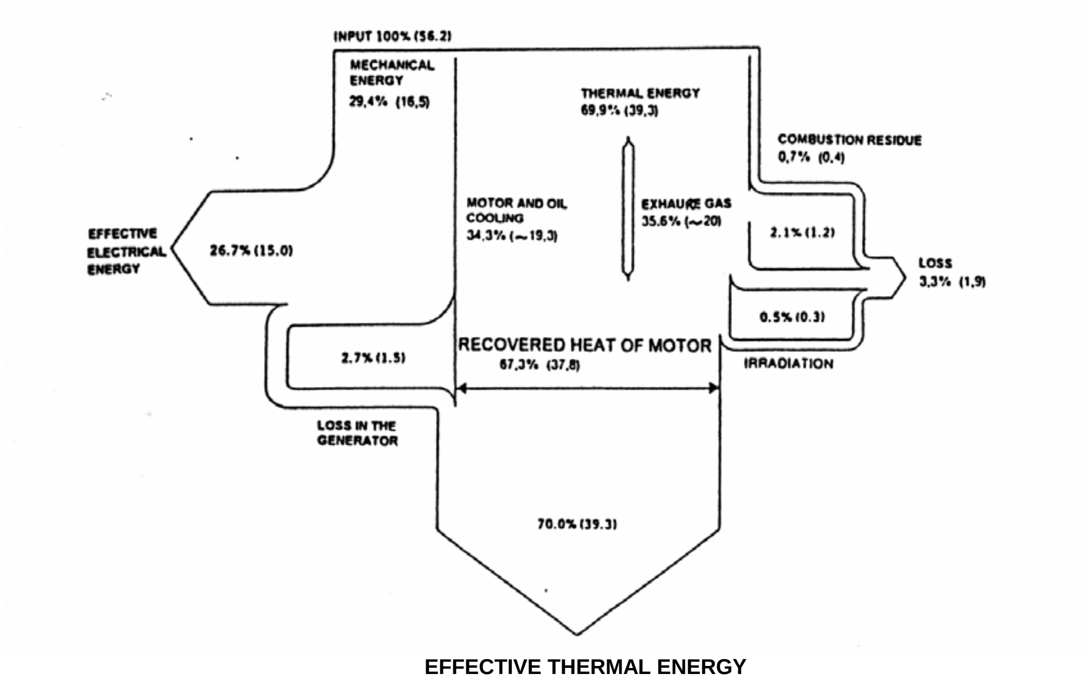


Diagram 4 : Percentage energy flow (kW) diagram
on the cogeneration installation

The modular installation offers following advantages :

- emergency security running : a part of the equipment always remains operational,

- a better efficiency because the module always operates for a total capacity,
- the demand is followed up precisely, step by step.

Moreover, the maintenance charges are higher because of the multiplication of motors and accessories.

2. The heat recovery of the cogeneration is used for the sanitary hot water (low temperature circuit) and for the building heat needs (high temperature circuit). These heat needs are the following :

   - central heating with radiators in the rooms,
   - heat exchangers for humidification (air treatment) (cfr. B.1),
   - air heater batteries (air treatment).

   This process has allowed to reduce the planted heat power at 700 kW (reduction by 40 %).

   Meanwhile, other heat needs are created to allow the running of the cogeneration in summer. Thus, the pay-back can be reduced. Indeed, in Mons, the production of chilled water by a refrigerating absorption group represents 60 % of the planted power (the rest is produced by a compression group). The energy needed for the generator is the heat recovery of the cogeneration group (high temperature circuit).

   All the equipments described in B and C hereover give the energies draft of the concerned building (diagram 5).

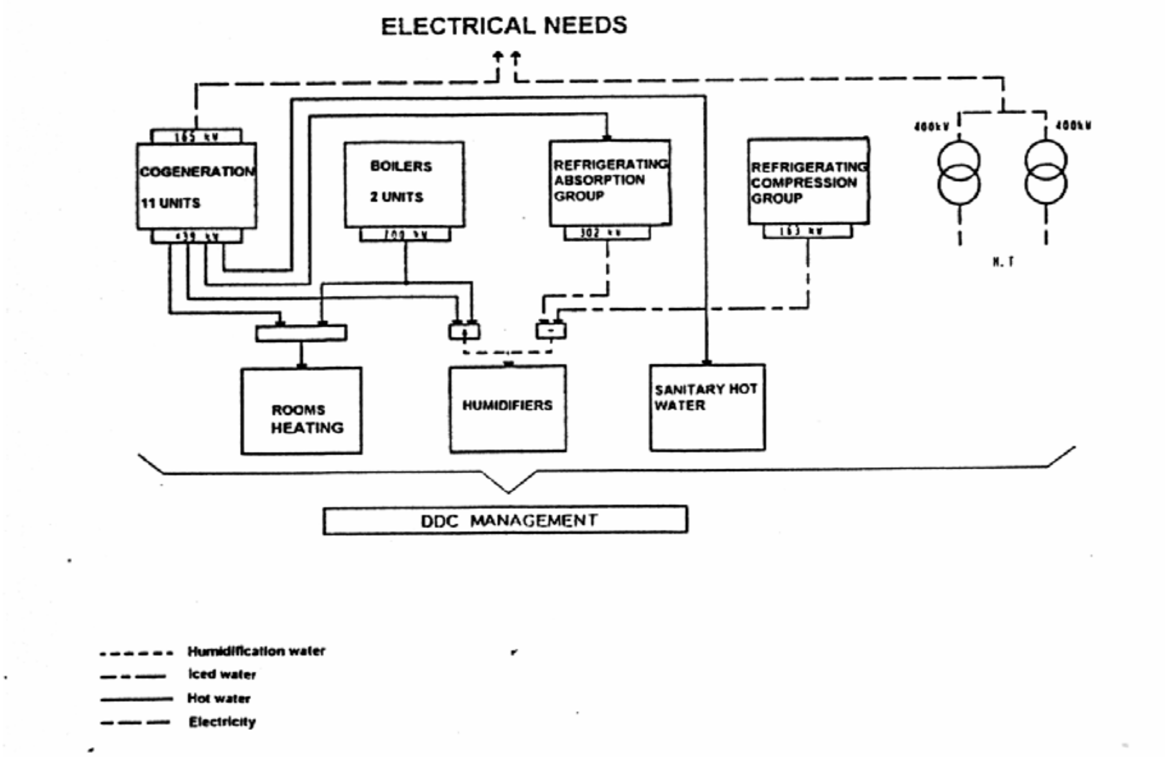


Diagram 5 : Energies draft of the building

D. <u>Exploitation of the installations</u>

As mentioned above (cfr. B.4), all the installations are interdependent.

1. Thus, for an optimal running, the combined production of electricity and heat (cfr. C.1) must be fully exploited. If not, the savings generated by this system can become expenses.

2. Moreover, the heat recovery doesn't have be too large and ever since "counterbalanced" by a refrigerating production.
   To solve these problems, the Mons equipments are designed to simultaneously feed the generator (absorption group) and the heat circuits (radiators, exchangers and batteries).

That is necessary in spring and autumn.

3. A simple formula shows an economical running of the cogeneration :

$$Pue \times 15 + Puth \times 39.3 > Pum + Pug \times 6.3$$

Pue	:	unitary price of electric kWh (BEF/kWh)
15	:	electrical energy produced by one cogeneration unit per hour (kWh)
Puth	:	unitary price of thermic kWh (BEF/kWh)
39.3	:	thermal energy recovered on one cogeneration unit per hour (kWh)
Pum	:	horary charges of the maintenance (BEF)
Pug	:	unitary price of gas (BEF/m3)
6.3	:	gas consumption of one cogeneration unit per hour (m3)

The opposite ratio of the terms and even equality of the terms must be considered as an expensive running.

The Pue and the Pug depend on the public network. A negotiation between RTBF and the energies contractor (ELECTRABEL) permitted to conclude the gas and electricity furniture contracts following the best formula adapted on RTBF's situation.

The Pue variable also depends on the power peak hour, the day and the season :

- the charges of the power peak depend on the season (lower in Summer) and the hour (highly paid during peak hours in Winter),

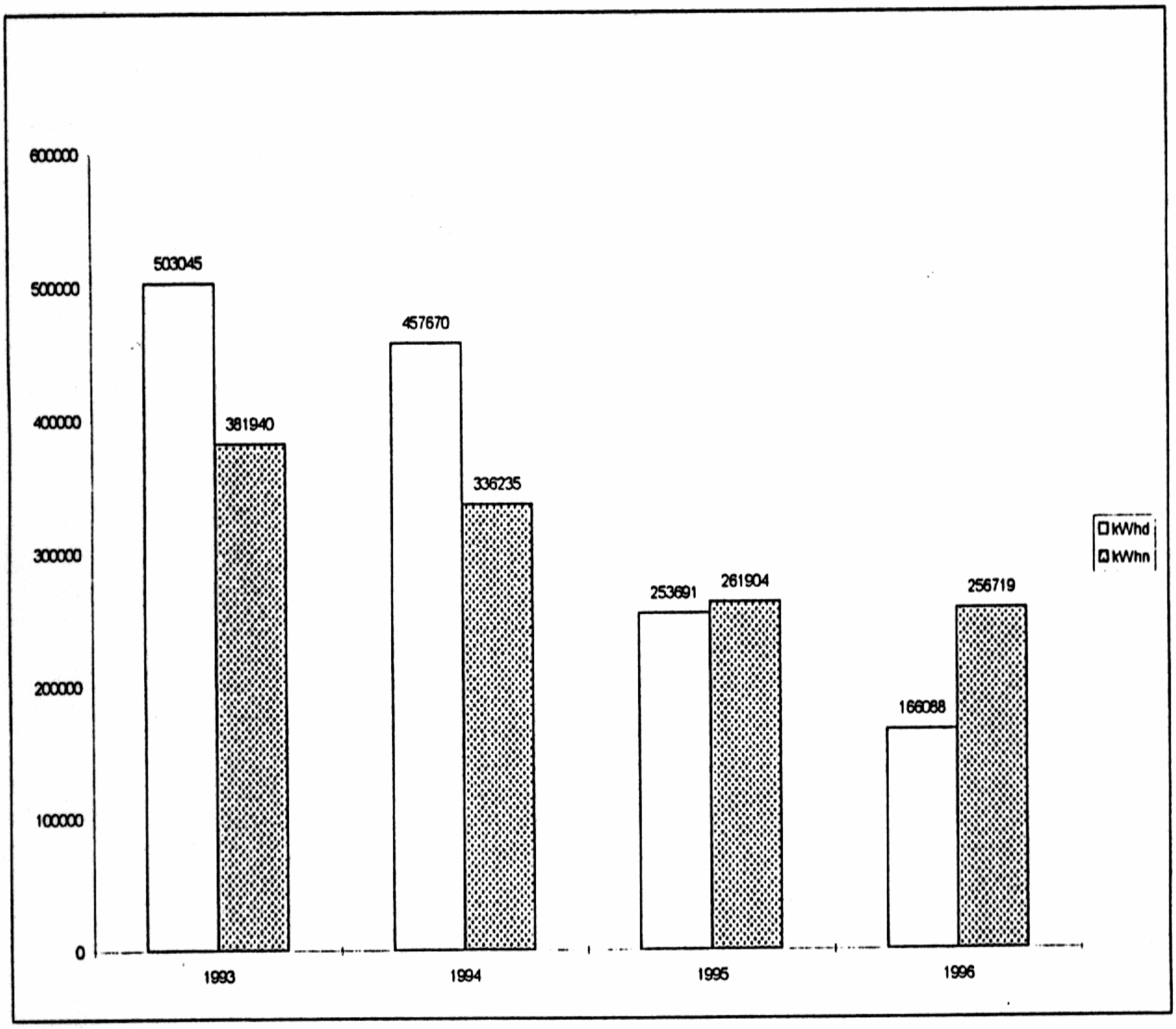
- the cost of the kWh depends on the hour (lower during night) and the day (lower during the week-end).

4. As conclusion, the generated savings result from the combinated production of electricity and heat but also from the time of this production.

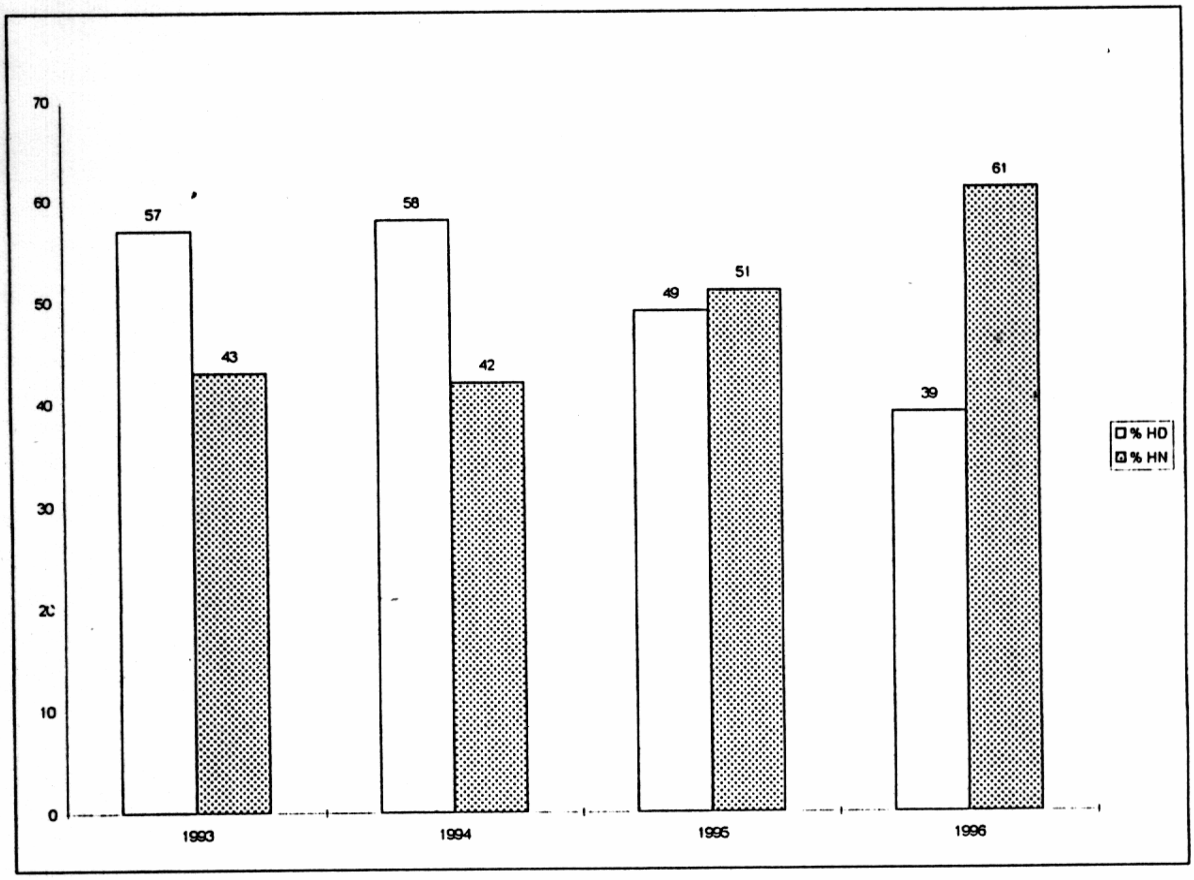
E. <u>Results of the concentration exploitation</u>

These elements (cfr. D. above) are the consequence of the actual cogeneration exploitation : during the day (from 6 a.m. to 8 p.m.) excepted on Saturday and Sunday. This exploitation has begun at December 1, 1994.

Graphes 1 and 2 hereunder show the evolution of the electricity consumption for 1993, 1994, 1995 and 1996. The proportion of the kWhn (kWh used during the night and the week-end) increases in 1995, as consequence of the cogeneration exploitation during the above said hours. The ratio kWhn/kWhd reverses completely in 1996 with whole cogeneration exploitation.

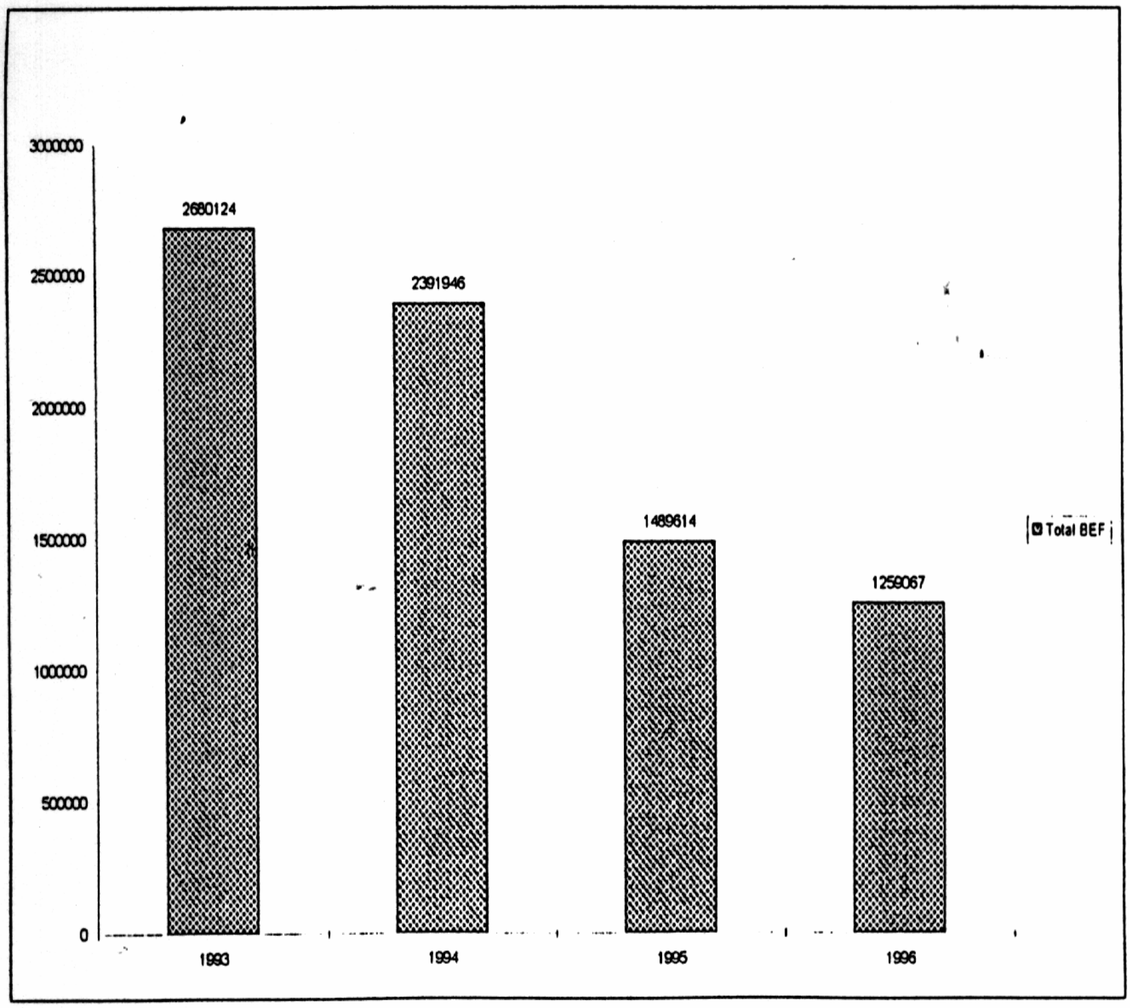


Graphe 1 : Electrical consumption evolution for 1993, 1994, 1995 an 1996
kWhd : kWh used during the day (from Monday to Friday)
kWhn : kWh used during the night and the week-end



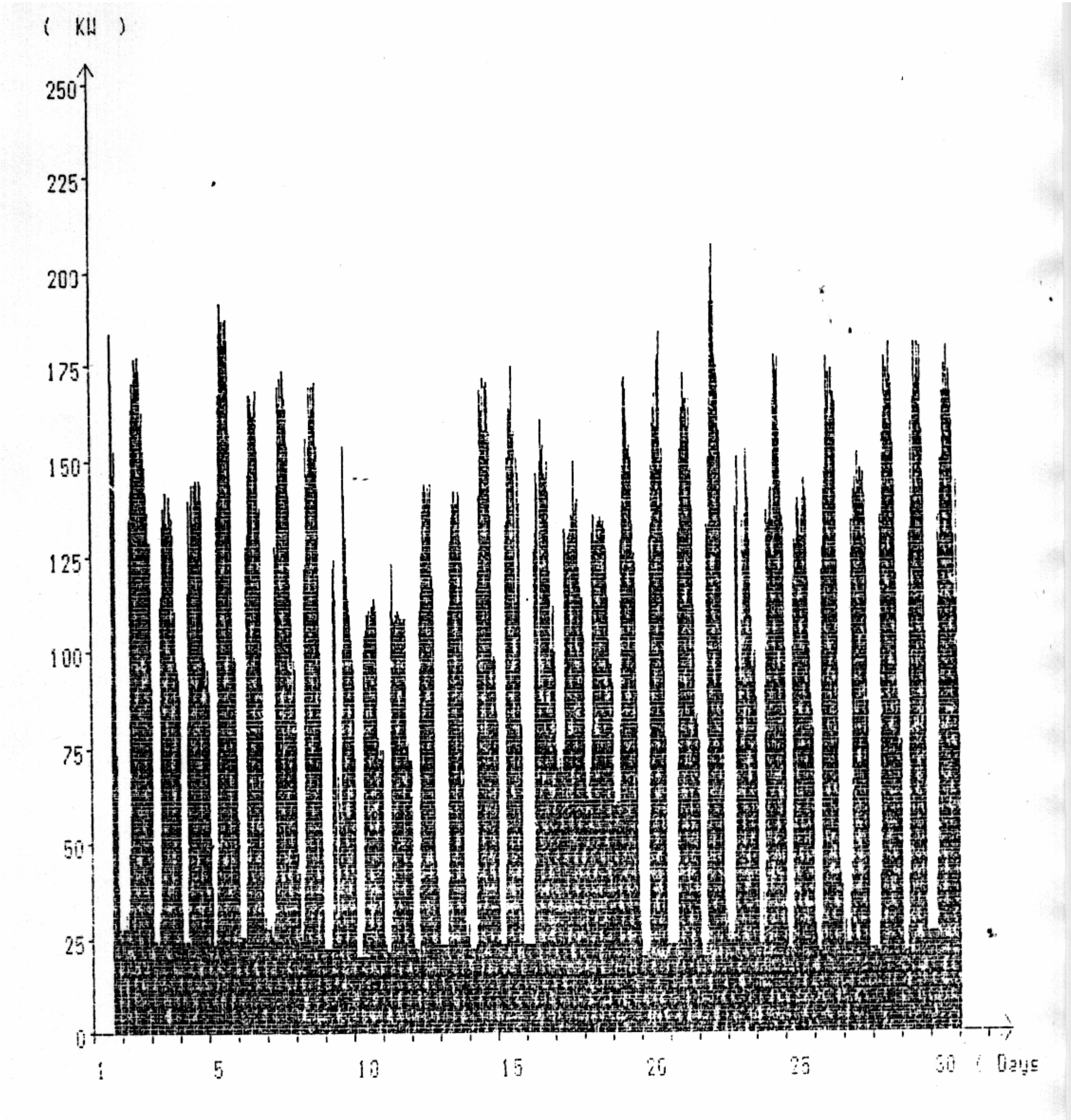
Graphe 2 : Percentage evolution
of the electrical consumption repartition Hd-Hn
Hd : from 6 a.m. to 21 p.m., from Monday to Friday
Hn : other hours

Graphe 3 shows the electrical consumption charges evolution for 1993, 1994, 1995 and 1996.

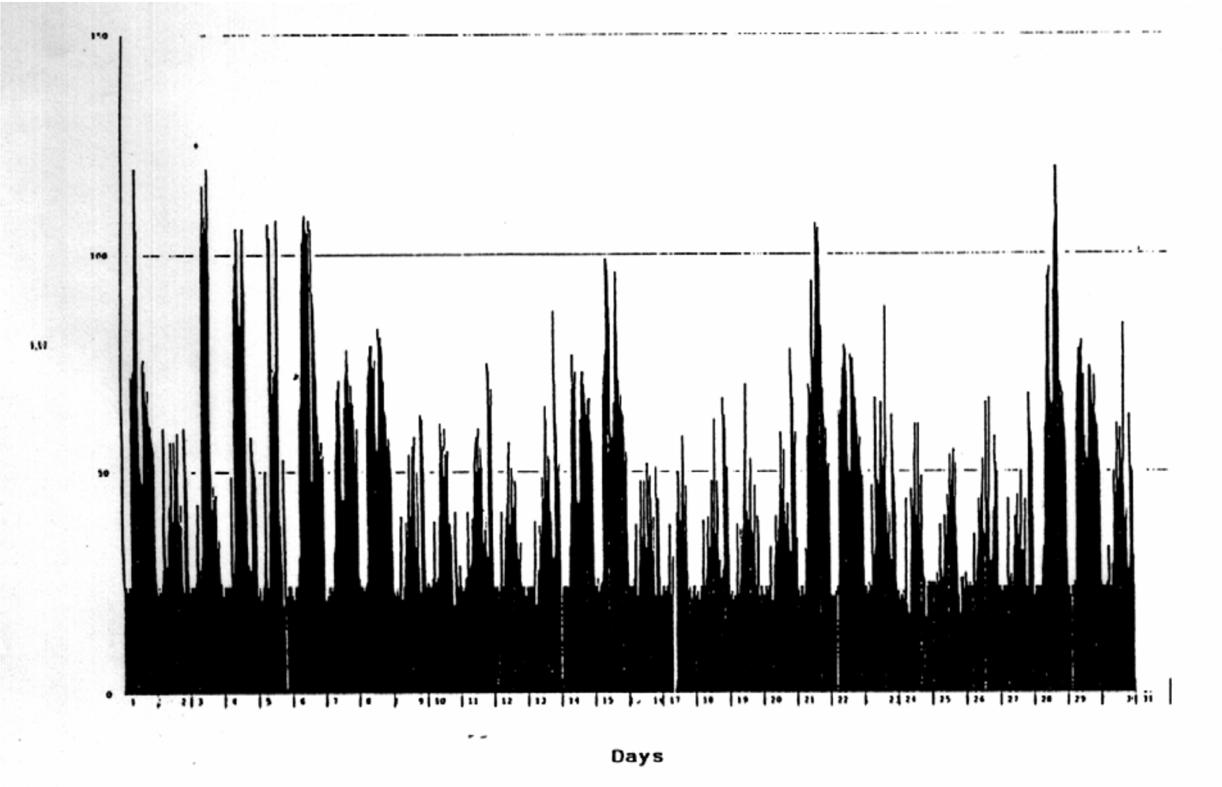


Graphe 3 : Electrical consumption charges evolution (BEF, free taxes)

Graphes 4 and 5 compare the peak power during September 1994 and 1996. The reduction of this power is realised by the cogeneration installation.



Graphe 4 : Peak power evolution in September 1994



Graphe 5 : Peak power evolution in September 1996

Table 2 shows the evolution of the total (cogeneration and boilers) gas consumption (GJ) for every month in 1994 and 1996. The consumption was more constant in 1996 because of the cogeneration installation exploitation.
The table also contains the degrees-days 15/15 and the ratio consumption/degrees-days for every month in 1994 and 1996.

Month	1 9 9 4			1 9 9 6		
	Gas consumption GJ	Degrees-days 15/15	Consumption/ degrees-days	Gas consumption GJ	Degrees-days 15/15	Consumption/ degrees-days
01	685.633	312.8	2.192	697.421	394.1	1.769
02	411.773	338.5	1.216	607.285	395.2	1.537
03	424.328	233.0	1.821	482.027	342.3	1.408
04	360.146	188.3	1.913	436.406	170.4	2.561
05	208.106	72.0	2.89	389.097	144.2	2.698
06	236.566	27.2	8.697	326.062	24.7	1.320
07	135.146	0.2	675.73	320.792	5.0	64.158
08	131.026	4.5	29.117	430.474	7.1	60.630
09	207.757	45.6	4.556	384.331	78.7	54.131
10	277.418	163.7	1.695	353.261	133.1	2.654
11	274.529	136.5	2.011	401.847	286.4	1.403
12	262.174	298.9	0.877	448.396	429.0	1.045
Total	3 614.601	1821.2	1.985	5 277.399	1981.2	2.664

Table 2 : Evolution of the total (cogeneration and boilers)

gas consumption in 1994 and 1996

The monthly gas consumption values depend on the gas-meter reading date. The ratio consumption/degrees-days is only relevant for the heating period (November-March). In this period, the ratio is generally better in 1996. That shows an increase of installations efficiency.

The total balance 1994-1996 is (BEF, including taxes) :

	1994	1996
Electricity	2 882 349	1 523 471
Gas	851 042	980 152
Cogeneration maintenance	0	460 868
Total	3 733 391	2 964 491
Savings		**768 900**

The savings value doesn't include the degrees-days increase in 1996 (1981.2 instead of 1821.2 : 8.78 %). Without the cogeneration installation and on account of the climatological conditions. the gas consumption would have increased from 3 614.601 GJ to

$$\frac{3\ 614.601 \times 1\ 981.2}{1\ 821.2} = 3\ 932.158 \text{ GJ}$$

The gas consumption cost would have advanced : 317.557 x 169 = 53 667 BEF, including taxes (169 BEF, mean cost of gas in 1996).

That represents thus a **real benefit** ot : 768 900 + 53 667 = **822 567 BEF**.

These savings permit a pay-back of 5 years for the cost difference between the electrogen group and the cogeneration installations.

A follow-up convention is made between RTBF and ELECTRABEL in order to optimise the functioning of the cogeneration. This convention is beginning since January 1, 1996 and continues for 3 years. Perhaps, this work will modify the running periods of the cogeneration (hours and/or moments).

F. <u>Conclusions</u>

1. The generated savings prove the interest of the cogeneration. Office buildings and the hospitals could for example apply techniques.

   It could of course also be applied to manufactories where it could represent a real solution beacause of the heat needs for the process.

   In our case, the pay-back time is 5 years.

   The sizing of the equipments is the most important : the adequation between the electrical needs and the heat needs must be perfect.

2. Finally, these equipments contribute to the rational and economical use of energy and also to the environment protection in 3 fields

   primary energy : principally, reduction of the planted heat power, the savings in the installations (cfr. B.1, B.2 and B.4 above), the superior energetic efficiency of the cogeneration installation,

   noble energy (electricity) : essentially, high-efficincy lighting equipment, the superior energetic efficiency of the cogeneration installation, the electrical consumption of the refrigerating absorption group (5 kW instead of 70 kW for the equivalent chilled water production),

   CFC use : the absorption principle is a safe solution which replies to the CFC reduction problem.

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(1) Clima 2000 - London 1993 -

An original conception to cover the energy requirements of the RTBF-Hainaut
DAUGE Jean, RUTTER Luciano