Upgrading of a heating plant in central heating system

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Abstract: In the 7-th decade of the previous century it was designed the new power station for Timisoara Romania. It was predicted to work with lignite. As load fuel and sustain of flame fuel it was approved natural gas. The initial profile of the Power Heating Station was: 2×120/150 MW turboalternator groups; for industrial consumers 3×100 t/h steam boilers with 250 ºC and 15 bar; thermal central for start steam boiler comprizing 4×10 t/h steam boiler with 300 °C and 16 bar. The main thermal agent, hot water for district heating of the town had to be prepared in 2×100 Gcal/h (2×116 MW) hot water boiler. During the power station construction, the consumers for 250 ºC and 15 bar steam were no more, or they have changed their production structure. In 1988 began the thermal production of the new Heating Station/Plant, and only for hot water. After 1990 the finances for 2×120/150 MW groups were stopped and their construction also. As the hot water prepared in 2×100 Gcal/h hot water boilers was not enough for district heating of the town, the steam pressure was reduced from 15 to 6 bar, its temperature also and using heat exchangers the Heating Plant could deliver more hot water for district heating of the town. So other 225 Gcal/h (261 MW) were produced. The paper presents the solution for Heating Plant in order to produce enough hot water, electric energy for inner consumption being assured in the same time. Also, the effects on environmental protection and on the heat market in system are analized.

Key-Words: Heat and power cogeneration, Turbine, Steam, Hot water, Heat exchanger, Electric energy, Thermal energy, Energy savings, Environmental protection, Heat market.

1 Introduction

The combined heat and power (CHP) system is not the sole solution for the great cities, but the heat and power cogeneration principle proves the efficiency of fossil fuels use for electric and thermal energy production. The air pollution is greater in the case of separate production of electric and thermal energy because of a greater amount of fossil fuel burning. Comparing the cogeneration with individual production of heat for every house, we must take into account the position of heating and power plants, which are usual placed outside of the town. Even for coal burning, this plant has modern solutions for burned gases exhaust. We must consider the fact that about 31% of houses are supplied by central heating system. In the last 4 years, the old equipments began to be replaced.

In the international energetic policies we can distinguish two main tendencies: thermal retrofit/ rehabilitation of the buildings which, in most of the countries exceeds as volume the buildings of the new houses and the retrofit and modernization of district heating and domestic warm water preparation systems, with purpose of energetic efficiency augmentation. This is necessary because in Romania operate old district heating systems and their modernization could not be made suddenly. The fossil fuel consumption must be reduced in order to save the underground reserves and to reduce the amount of pollutant gases [6].

Taking into account the transboundary character of pollution and the contribution of the combustion gases to the installation of the acid rain phenomenon and of the greenhouse effect, Romania should make efforts to reduce pollutant emissions and to follow the European standards of environmental quality.

In Romania there are about 3 millions of apartments connected to cogeneration/central heat and power stations and distribution of heat. In some of towns or parts of them, this is the sole prepared possibility of heating. In fact it seems that having such a system is the normal trajectory of European and international Energy.

That is why the retrofit of the production, transport and distribution of energy systems, together with the increase of cogeneration efficiency, are some major priorities that must be considered.

The planning of system of development, transport and distribution of energy must cover the consumption, sure enough and, as much as possible more, economical. The optimization criteria must take into account both electrical energy and heat [7].

Timisoara is one of the oldest city from Romania. Its written history is over 700 years old. There are many reasons for people to choose living in this town: it's friendly weather, the fruitful lands of the county, it's neighborhood with advanced countries, it's industrious people. That is why it is no wonder that the industry was fast developed and the number of habitants fast growing. It was here that in 1884 a coal Power Plant produced first kWh electric energy. The source was the Central Power Station, founded in year 1884. In the same year, Timisoara became the first town in Europe whose streets were lighted with electric energy. The Central Power Station Timisoara, the Power Station from Bucharest put in operation in 1885 and the Hidro Power Station from Sinaia on the river Peles 1898, marked the beginning of the use of electric energy in Romania. The first, unlike the others, which were used only for inner lighting, provided electric energy used for street lighting, the lighting network having about 60 km. As the town representatives decided to replace the gas lighting with electric lighting, the Viennese Company Brush Electric has made the offer to built the Power Station. Among others, it included the replacement of 734 gas lamps with incandescent electric lighting. In 1904, began the providing of electric energy by the Power Plant to electric trams, which replaced the horse trams. At the beginning, the Power Station had two steam boilers having each 86 m^2 heating surface. The steam feed an alternative piston machine compound system of 221 kW and 100 rot/min. This machine has driven by belt 5 dynamo DC type Brush of 700 rot/min, which provided a 10 A constant current at voltage of about 2000 V. The need of electric energy increase, the Power Slation deve-loped also, until 1908 being operational six pieces of steam boiler BW type, having total heating surface 1197 m^2.

At that time, the river Bega served to 6 mills placed on its arms. The need of river regulation in one channel, led to the idea to use water energy in Hidro Power Station.

In 1910-1912 here, in Timisoara was built a Hydro Power Station with 3×400 kW Francis horizontal type turbines, working with 5.6 average fall and Ganz electric generators. Timisoara was among the firsts town which has built district/central heating system.

The paper presents a practical problem solution in the area of electric and thermal energy production beginning with a heating plant. The solution is based on "Demand Side Management" principle. Even if they are installed, the use of hot water boiler for central heat production will decrease as the production in cogeneration increase.

2 Description of initial situation

In the west side of the country there was produced little quantity of electric energy. Timisoara, a town of about 200,000 habitants was developing. The heat district distribution system for the town began to work in year 1962. The Central Power Station has a turbo alternator group of 4 MW formed by an AKTP turbine coupled with a Vickers electric generator put into operation in year 1926. For this turbine, the Central Power Station has the corresponding steam boilers and also other 5 old steam boilers for industrial consumption having parameters 10 bar and 250 °C. The steam boilers were produced in the third decade of the twenties century. Some of these could produce steam for turbine. This Power Station produces hot water for the central heating of the town and has a capacity of 425 Gcal/h in 5 hot water boilers: 3×100 Gcal/h + 2×50 Gcal/h. The capacity is completed with a heat exchanger at the output/ exhaust of the turbine AKTP. Central combined heating and power plant supplied electric and thermal energy for the town. For an expanding town, there was not enough.

On the other hand in the South West of the town, an industrial platform for food and the biggest pigs farm from Europe could become consumers for an important quantity of industrial or technologic steam. It was approached at 200 tones per hour maximum simultaneous consumption of steam. For that purpose, it was necessary some steam suppliers.

The hot water for district heating, supplied by Central heating and power plant, was hardly enough for the northern and central part of the town. For the rest of the town, it was necessary other source, taking into account also that its transport from the Central heating and power plant to the southern consumers was not economic due to the losses presumed.

The central heating system has 135 heat stations (thermal points), about 80 km pipelines for primary thermal agent transport and 340 km pipelines for secondary thermal agent distribution. Their diameters are between 40 and 325 mm, equivalent diameters (mean diameter) are of 118 mm for heating system and 50 mm for domestic warm water system.

The necessary thermal powers for south heating plant are:

– maximum thermal powers in winter is about 260 Gcal/h (301.6 MW). This power is necessary few hours each year to an external air temperature under calculation temperature $t_e = -15$ °C;

– mean thermal powers in winter 150 Gcal/h (174 MW), about four moths each year, 2880 hours;

– mean thermal powers in spring/autumn 100 Gcal/h (116 MW), about 9 weeks each year, 1512 hours;
– mean thermal powers in summer 30 Gcal/h (34.8 MW), about 4 weeks, 720 hours.

Duration curves (in steps and drown by the middle of the segments) are presented in the figure 1.

All these leaded to the conclusion that another heating and power plant was necessary. It was in the 7-th decade of the twenties Century. The designs for this new Power Station were made in the 8-th decade. Its profile was providing in the same time a backup for an eventual development of the town. It had to take into account the need of thermal energy and a sufficient quantity of electric energy for Timisoara town and its neighborhood.

During the construction of the new Power Station, the main presumed consumers for industrial steam having the parameters 10...16 bar and 250…300 °C changed their mind. Some of them have renounced to the centralized source due to the important heat loses in about 4 km long steam transport pipe, leak of thermal agent, and have built their own boilers for steam or hot water. Others, changing theirs production profile/object, need no more industrial steam. In the same time the steam boilers for industrial consumption, already designed and provided from the producers, were building up. Little by little, the predicted consumers for industrial steam having the parameters 10...16 bar and 250…300 °C, disappeared.

In order to ensure the hot water for district heating of the south-west side of the town, 2×100 Gcal/h (2×116 MW) hot water boilers were not enough. The steam for turbo alternators designed of 120/150 MW electric power had to be produced at higher parameters boilers than 15 bar and 250 °C. In this situation, the 15 bar and 250 °C steam boilers became useless.

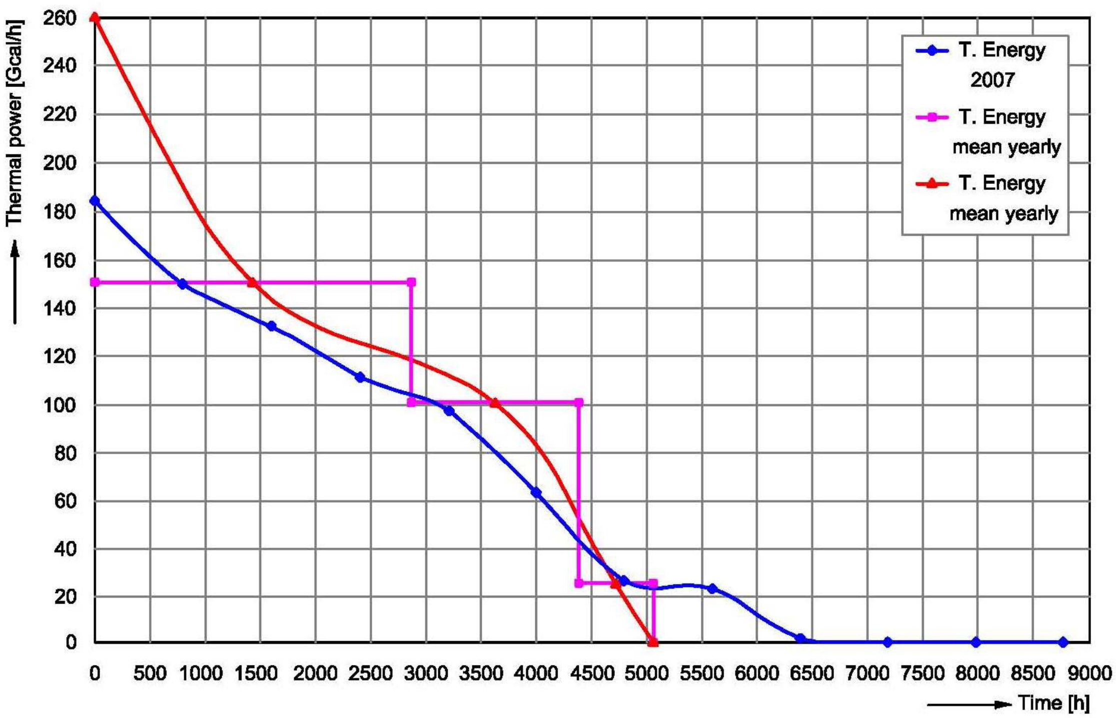

Fig. 1 Duration curve for the thermal power of the southern heating plant

The main characteristics of the 100 t/h steam boiler are presented in the Table 1.

The other technical parameters for steam boilers are: the boiler is natural-circulation one; it has the following heat transfer surfaces: radiation shields; beam convection; steam super heaters; two tube beam economizers; four tube beam air pre heater. The boiler has four pulverized coal burners and eight natural gas burners. The pulverized coal burners are located two on frontal wall and one on each lateral wall, the natural gas burners are two on the rear wall and three on each lateral wall. The basic fuel is lignite, pulverized by four coal mill among them three operating and one in reserve, it ensure a tuning range of 50…100 %.

At the end of the 9-th decade, the industrial steam boilers were near ready to work. But the steam had no consumers.

Then it was found the following solution: the steam was reduced from 15 bar to 6 bar and then sent in several steam-to-water heat exchanges where first the steam was condensed, then, in other heat exchangers, was accomplished the cooling of the condensate.

Table 1. Values of characteristics for the 100 t/h steam boiler

Nr. crt.	Characteristic	Value
1	Boiler capacity nominal/minim G_n/G_{min} [t/h]	100/50
2	Pressure in the drum [bar]	15.5
3	Pressure of superheated steam [bar]	15
4	Temperature of superheated steam [°C]	250
5	Temperature of feed water [°C]	104
6	Temperature of air at furnace input for G_n/G_{min} [°C]	300/260
7	Temperature of flue gas at smoke stack (chimney) for G_n/G_{min} [°C]	140/114
8	Rate of fuel consumption for G_n/G_{min} [kg/h]	43,400/21,250
9	Guaranteed efficiency [%]	84
10	Volume rates of combustion air [m^3N/h]	106,000
11	Volume rates of exhaust flue gas [m^3N/h]	157,000

The steam produced by 100 t/h steam boilers with parameters 15 bar and 250 °C is passed through two modules of tree reduction valves until p = 6 bar and about t = 230 °C.

The pressure reducers are made for 15 to 6 bar pressure and have the following characteristics:

– for providing steam to 75 Gcal/h heat exchangers, three pieces of electrically driven adjustment valves, each of them with two seats of 250 mm diameters, having nominal parameters: D_n = 250 mm, p_n = 40 bar;

– for providing steam to 25 Gcal/h heat exchangers, three pieces of electrically driven adjustment valves, each of them with two seats of 150 mm diameters, having nominal parameters: D_n = 200 mm, p_n = 40 bar.

It were designed heat exchangers of thermal power 2×75 Gcal/h (2×87 MW) having 2×550 m^2 heat exchange surface and D_n=1600 mm and 3×25 Gcal/h (3×29 MW) having 3×140 m^2 heat exchange surfaces and D_n=1100 mm.

The 75 Gcal/h heat exchangers are with one crossing on steam side and two crossing on water side. There are 1604 pieces of ϕ 20x2 mm tubes, steel symbol OLT 35 k (laminated tube, maximal temperature 350 °C, cool steel) and are 5606 mm long.

The 25 Gcal/h are with one crossing on steam side and two crossing on water side. There are 476 pieces of ϕ 20x2 mm tubes, steel symbol OLT 35 k and are 4300 mm long.

The steam condensate which raises temperature of the thermal agent in heat exchangers is collected in one tank, because it has not enough pressure in order to reach the thermal gas eliminator of feed water of the steam boilers. That is why the steam condensate is transported to the thermal gas eliminator with special pumps.

These are steam-to-water heat exchangers. Every steam-to-water heat exchanger was followed by condensate cooler water-to-water heat exchanger with 110 m^2 heat transfer surface. For each heat exchanger steam-to-water of 75 Gcal/h and 550 m^2 there are 2 condensate cooler water-to-water and for each heat exchanger of 25 Gcal/h and 140 m^2 steam-to-water there are 4 condensate cooler, proper as heat exchange surfaces. These heat exchangers are tubular types, mounted in steel shells (fig. 2).

On the other side of these heat exchangers surfaces run thermal agent hot water which first is preheated from the return of the town temperature, second heated to the temperature near that which is necessary for district heating, predicted in regulatory diagram for hot water thermal agent. If the obtained temperature after all heat exchangers was not good enough, the thermal agent could enter the hot water boiler supplementary.

In this way we have had fuel heat consumption for increase parameters of water from 10...15 °C and atmospheric pressure to 250 ˚C and 15 bar. Although, steam was not used at these parameters, but the pressure was reduced. In the same time, we had a small temperature reduction.

The energy for rising pressure of the feeding water to over 16 bar is also consumed and lost when pressure steam is reduced to 6 bar. In other words, first we have raised the pressure then reduced the pressure of the steam, the energy consumed both chemical and electrical are in fact "thrown out".

The inner consumption of electric energy for the new central heating station, named South Power Station, because is placed in the south of the town, outside of the town, need a power of about 6 MW, Central heating and power plant needs about 2 MW also.

The electric energy bought by an industrial consumer is more expensive than the energy produced, especially when the electric energy is made by one own electric generator. In other words it is obvious more efficient to consume the energy produced by your own Power Station than to buy energy from the market.

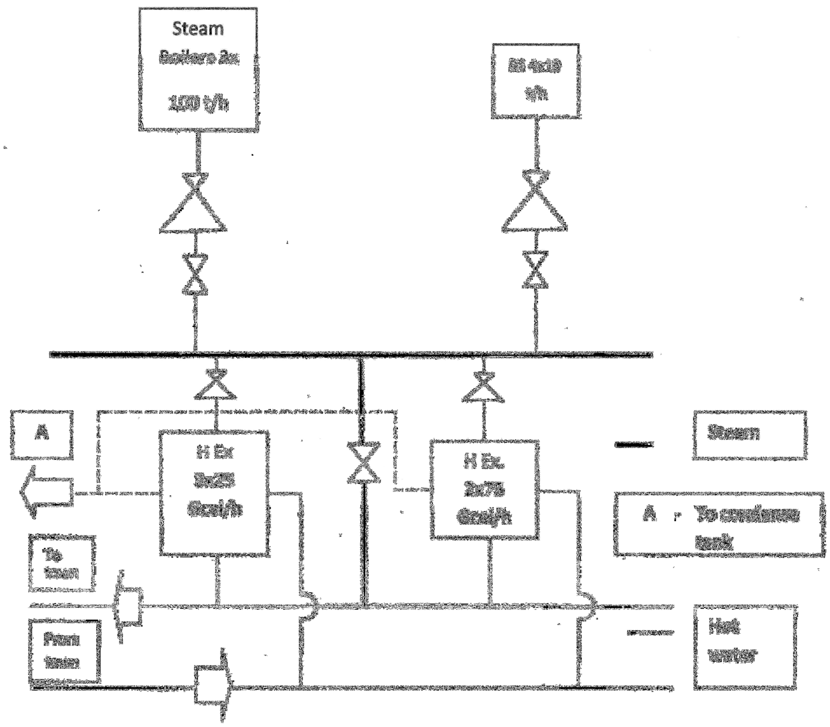

Fig. 2 Steam circuit in pressure reduction case

It was obvious also that the new Power Station named South Power Station must have a proper turbine. It was known also that the groups of 120/150 MW (120 MW in condensing cycle and 150 MW in cogeneration electric and heat power cycle) will not be finished, because of the policy applied after 1989 and the stop of financing them.

In this case, South Power Station of the town remained a heating station with the following profile: 2×100 Gcal/h hot water boilers; 3×100 t/h with 15 bar and 250 °C superheated steam (industrial) and 4×10 t/h with 16 bar and 300 °C steam boiler. The heat exchanges had the capacity of 225 Gcal/h and could receive steam from 4×10 t/h steam boilers too.

Most of the time, for hot water preparation, was used only one 100 t/h steam boiler.

In order to maintain a good heat transfer coefficient, the level of the condensed water is maintained between some optimal limits, using electric valves for each heat exchanger. This condensed water level depends on several influences: the flow rates of the district heating which in our case is cooling agent, the demand of this system concerning the thermal agent temperature, the configuration of the running equipments.

The electric valves are between manual actuation valves used for heat exchanger insulation. They have also by-pass circuits for failure cases. This adjustment was proved not reliable.

On water side, the temperature adjustment is made by actuation the electric valves installed on 2 wire by-pass of the heat exchanger. In most of the cases the actuation on these valves is good enough for hot water temperature regulation.

The equipment had to cover heat necessities for winter, transitions periods from spring and autumn, the summer consumption been assumed by Central heating and power plant.

The coal acquisition (lignite) was recommended to be made in summer or at least on warm and dry seasons, due to the difficulties that coal transport in winter appear. There were compared the scenarios of installing 3×6 MW or 2×6 MW or 1×(18...19) MW turbines.

3 Energy efficient solution

3.1 Requirement to install a turbine

In the reasoning previous choosing the type of turbine, it was very important to accomplish in the same time the following conditions: the maximum electric energy in cogeneration produced; the maximum efficiency of the cycle. That is why it has been choose a backpressure turbine and not a condensing turbine and adjustable outlet for cogeneration. In the second case, not the entire amount of steam had to be used for electric energy production and ano-ther circuit of water for cooling the steam condenser had to be mounted with extra expenses.

The technical and financial comparisons between these scenarios leaded to the conclusion that 1×19 MW turbine was the best. Cogeneration of electricity with heating was another condition, due to heat necessity and to higher efficiency that cogeneration has.

So, the turbine ordered and installed was 19.7 MW electric power, heat produced in the bottom of the turbine being the maximum possible for steam of about 2...3 bar and 135 °C that could be obtained at the output of the turbine. So, the steam from the bottom of the turbine must enter the steam-to-water and water-to water heat exchanges that were used for the steam of 6...8 bar and about 230 °C.

The main characteristics for the turbine are presented in the Table 2.

Table 2. Values of characteristics for the 19.7 MW steam turbine

Nr. crt.	Characteristic	Value
1	Speed [rot/min]	3000
2	Power [MW]	19.7
3	Steam flow maximum [t/h]	300
4	Steam flow nominal [t/h]	280
5	Steam flow minimal [t/h]	50
6	Pressure live steam maximum [bar]	16
7	Pressure live steam nominal [bar]	15
8	Temperature live steam maximum [°C]	270
9	Temperature live steam nominal [°C]	240
10	Temperature steam output turbine nominal [°C]	133
11	Pressure steam output turbine maximal [bar]	4

The turbine has two quick closing valve and four adjustment valves.

In parallel with the turbine, the steam could be led through pressure reduction stations to the existing heat exchangers. This allows to obtain the proper parameters for thermal agents and for the start of the turbine.

The main characteristics for electric generator are presented in Table 3.

After putting into function the turbine, it appear another difficulty: the tubular heat exchanges had heat transfer coefficient values and heat transfer surfaces proper for less quantity of steam of 6 at, that were passed through the pressure reduction stations. This means that the old heat exchangers did not allow to undertake so much heat that was contained in about 280 t/h steam from 3 steam boilers, keeping in the same time about 2...3 bar in the bottom of the turbine (at the output of it). This is a condition for obtaining 19.7 MW electric power.

Table 3. Values of characteristics for electric generator

Nr. crt.	Characteristic	Value
1	Apparent power [MVA]	25
2	Active power [MW]	20
3	cos φ	0.8
4	Nominal voltage [V]	6.3±5 %
5	Frequency [Hz]	50
6	Nominal speed [rot/min]	3000
7	Protection degree for terminal box	IP 54
8	Protection degree for generator	IP 44
9	Insulation class	F/B
10	Cooling type	Air

Due to the heat transfer efficiency of the tubular heat exchangers, the maximum level of the output electric power is about 13…14 MW, which means 70…75 % of designed capacity.

The operating parameters of the heat exchangers from the steam obtained in the output of the turbine must ensure simultaneous some of the demands such as:
– the turbo alternator must operate at the maximum power level, taking into account the heat demand of the district heating system;
– the condensed water obtained from the heat exchangers must be cooled to about 80 °C, normal temperature for the water provided to steam boilers;
– the hot water must be at the temperature suitable for adjustment system of the Power Station.

The adjustment system has to be automat, data acquisition and transmission being made to central command point.

As it was expected, the surfaces of the existing heat exchanges were not enough to produce the necessary thermal heat, because of the lower steam parameters and the amount of steam. Or the entire heat capacity of the steam 2 bar and 135 °C from the output of the turbine has to be used. Only so the electric power could be as designed, 19.7 MW.

In order to increase electric energy production, when decreasing the steam pressure at the outlet of the turbine from 6 bar to 2 bar, one must either increase the heat exchanger surface for the existing exchangers, or to replace the existing exchangers by another ones.

It is recommended the second version. The heat exchangers will be replaced as soon as possible with modern plate heat exchanges with corresponding surfaces and capacities.

The main pumps for primary thermal agent transport are not to be changed for the moment.

3.2 Other upgrades

The heat index i.e. the ratio between electric energy produced and the heat provided by power station using cogeneration, is maximum when the turbine is loaded to nominal electric power. The thermal energy necessity decides the load of the turbine and in winter there are conditions to have a great thermal load and implicitly to load to maximum the turbine. In the same time, the maximum detente in the turbine is obtained when all thermal energy could be undertaken from the output of the turbine.

As a result, it is very important that the last condition shall be accomplished.

In the year 2008, for the first stage, it was replaced one 140 m^2 heat exchanger surface with a line comprising 1×50.6 Gcal/h (58.7 MW) steam-to-water and 1×3.1 Gcal/h (3.6 MW) water-to-water plate heat exchanger. The line is preceded upstream the hot water thermal agent with a mechanic self cleaning filter 2000...3600 m^3/h.

The other present heat exchangers will be replaced also with modern plate heat exchangers steam-to-water and also water-to-water (condense coolers).

For better regulation of the temperatures, in parallel with the turbine will operate a pressure reduction and cooling station for the steam. It's parameter are: G_{st} = 100 t/h; p_{st} = 15/2 bar; $t_{i/o}$ = 250/134 °C. The water for cooling the steam will be taken from the output collector of the feed water pumps of the steam boiler, it is then without gases or Oxygen.

In year 2010 will be replaced all existing heat exchangers by other lines 2×50.6 Gcal/h plate heat exchanger steam-to-water followed by 2×3.1 Gcal/h water-to-water plate heat exchanger. Upstream, the hot water the filters line will be completed with another 810...1700 m^3/h mechanic self cleaning filter.

The other parameters for new heat exchanger are: Q_{sw} = 50.6 Gcal/h; G_{st} = 95 t/h; p_{st} = 2 bar; t_{st} = 134 °C. For hot water, the parameters are: G_{hw} = 94 m^3/h; minim t_{hwi} = 55...60 °C; maxim t_{hwo} = 108...130 °C; p_{hw} = 15 bar.

For little heat exchangers, the parameters are: Q_{cd} = 3.1 Gcal/h; G_{cd} = 95 t/h; p_{cd} = 2 bar; t_{cd} = 117 °C; G_{hw} = 60 m^3/h; t_{hw} = 55/108 °C; p_{hw} = 15 bar.

Total capacity for heat exchangers will be: Q = 3×50.6+3×3.1 = 161.1 Gcal/h (186.9 MW).

The heat exchangers will have at the entrance two filters for district heating system water. These filters will eliminate the contaminant particles automatic, using an electro-pneumatic actuation system. This is based on a predicted pressure drop due to contaminant particles presence.

4 Technical and energetical analysis

Considering the process of direct steam production (15 bar, 250 °C) in steam boiler, the thermal power Q_1, in kW, is given by:

$$Q_1 = B_1 \times H_i \times \eta_b = \frac{G_{st} \times 10^3 (i_{st} - i_{fw})}{3600} \qquad (1)$$

in which: B_1 is the fuel consumption rate [10^3Nm^3/s]; H_i – the lower heating value of fuel [kJ/Nm^3]; η_b – efficiency of the boiler unit; G_{st} – capacity of the steam boiler [t/h]; i_{st}, i_{fw} – enthalpies of the superheated steam and feed water, respectively [kJ/kg].

If one take the values for steam and feed water of the boiler (104 °C), for the production of 100 t/h steam of 15 bar and 250 °C, the power consumption Q_1 is given by equation (1).

After the adiabatic steam expansion from 15 bar to about 6 bar, its enthalpies becomes i'.

From this expanded steam in amount of 100 t/h, by passing it through tubular heat exchangers, we can obtain a thermal power Q_{exp}, in kW, calculated with the following equation:

$$Q_{\exp} = G_{st} \times (i' - i_{hw}) \times \eta_{ex} \qquad (2)$$

in which: i_{hw} is the enthalpies of the district heating system hot water, of about 90 °C; η_{ex} – heat exchanger efficiency with the value of 0.95.

The efficiency η_{exp} of the heat utilization is for the case of expanding steam calculated with the following correlation:

$$\eta_{\exp} = \frac{Q_{\exp}}{Q_1} \qquad (3)$$

If we use the same 100 t/h steam of 15 bar and 250 °C in combined heat and power cycle, using the turbine also, the thermal power Q_t possible to use becomes:

$$Q_t = G_{st} \left[(i_{st} - i'_{st}) \times \eta_t + (i'_{st} - i_{hw}) \times \eta_{pex} \right] \qquad (4)$$

in which: i'_{st} is the enthalpies of turbine exhaust steam; η_t – turbine efficiency, considered at the value of 0.88; η_{pex} – plate heat exchanger efficiency having the value of 0.98.

The efficiency η_{tur} of the heat utilization contained in the same 100 t/h steam of 15 bar and 250 °C if we use the steam in combined heat and power cycle, using the turbine also, will be:

$$\eta_{tur} = \frac{Q_t}{Q_1} \qquad (5)$$

The power saving ΔQ for 100 t/h steam, results from the following equation:

$$\Delta Q = Q_t - Q_{exp} \qquad (6)$$

The corresponding values of thermodynamic parameters and calculation results are presented in Table 4.

Table 4. Thermodynamic parameters and calculation results

p=15 bar t=250 °C	p=16 bar t=104 °C	p=6 bar t=230 °C	p=7 bar t=90 °C	p=2 bar t=135 °C	G_{st} kg/s	η_{exp}	η_{tur}	ΔQ kW
i_{st} kJ/kg	i_{fw} kJ/kg	i' kJ/kg	i_{hw} kJ/kg	i'_{st} kJ/kg				
2920	435.24	2750	377.6	2670	27.77	0.907	0.99	5909

We can consider that from 100 t/h steam of 15 bar and 250 °C, in the case of using it in combined heat and power cycle, using the turbine also, the economy of power is 5908.68 kW compared with the other case when steam was expanding from 15 to 6 bar.

For a yearly time operation of the turbine of about 2000 h, the energy saving becomes 11,817 MWh for one steam boiler. Usually the turbine shall operate with 3 boilers, so the energy saving will be 35,451 MWh/year.

Considering that the CO_2 emissions are c_{CO2}=0.35 kg/kWh, the amount of this gas less emitted every year will be C_{CO2} = c_{CO2}×35,450,000 = 12,407,500 kg/year. The coal consumption for the energy produced would be b=0.2 kg/kWh. The coal saved every year becomes B = b×35,450,000 = 7,090,000 kg/year.

This quantity of coal saved every year is about 6% of actual yearly coal consumption.

The calculation is not based on measurements, but on predicted values. It is possible that on reality, after the improving will be applied, the economy be even greater.

In order to obtain a good management of the production by a precise surveillance, the thermal energy from the heat exchangers must be measured and stored. The system must measure thermal energy from the steam boiler and the amount of this produced in CHP cycle.

5 Environmental protection

Concerning the environmental protection, we must mention that all the measure have been and will be taken in order to comply with legislation in field. We consider that the solution taken by turbine mounting is friendly to environment because:

– the power station uses the same burning installation used until now, without any modify;

– it is produced also electric energy, in cogeneration with thermal energy, the amount of produced energy being provided in National Energetic System, thus decreasing the amount of electric energy produced in other power plants, reducing the pollutant factors for air: CO_2, SO_2, NO_x, dust;

– it is so reduced the fossil fuel consumption because of the mean specific consumption of 190 g c.f./kWh in CHE such as ours, instead of mean specific consumption for other Thermal Power Plant from National Energetic System which is 350 g c.f./kWh;

– the equipments mounted along with turbine guarantees the noise level according to the field legislation: the turbo alternator is provided with sound proof enclosures; the foundation of new constructions reduces the negatif effect on sorrounding constructions and for operators too;

– there are not sourses of radiation;

– concerning the soil protection: all the waste technological or domestic waters are collected and directed to the severage network;

– the terrestrial and aquatic ecosystem will not be affected by the turbine operation

– the sorrounding human settlements are not affected;

– waste circuit will be connected with the specialized company of the town;

– the lubrication oil used is only about 3 m^3, that is why it was not built a new oil household. Nevertheless the oil circuit is supervised and acoording to general rules;

– there are not toxic substances.

There are ensured also hygienic conditions for operators: proper light, phone installation, heating and air conditioning, water-sewerage.

Introducing turbines, it is not harmful for environment: the only supplementary fluid that is involved in its operation is the lubrication oil. The oil works in a closed lubrication circuit, it is provided a collection vessel for incidental leaks; the oil is replaced by a specialized company that takes it for recycling; the operation of lubrication circuit is supervised by measuring, command and control system.

6 Heat market

Because of high prices of thermal energy for inhabitants, the invoices payments were delayed. By decreasing the production price for thermal energy, the market for it can be maintained. In the last time, some heat consumers have renounced to the central heating and use individual or condominium warm water boilers.

The decrease of heat consumption in the last four years due to the high price for it was felt in decrease of heated building surface: almost 3%. Yet the decrease was less in the last two years.

The heat intensity i.e. heat quantity provided for heated building surface decreased also. Their values are presented in the Table 5.

Anyway, the heat intensity is much higher than the mean heat intensity from older European Union (EU) members having similar climatic conditions. It is obvious that there is a potential for future energy savings for buildings.

The new Energy Policy of the EU provides among others, the following rules: reduction with 20% of pollutant gas emissions; reduction with 20% of the total primary energy consumption until year 2020. The solution mentioned in the paper is in agreement with this policy.

Table 5. Annual values of heat intensity

Nr. crt.	Characteristic	Year			
		2005	2006	2007	2008
1	Total sold heat [TJ]	4,106	3,829	3,442	3,270
2	Total heated building surfaces [mil. m^2]	6.56	6.37	6.28	6.18
3	Heat intensity [GJ/100 m^2]	62.6	60.1	54.8	52.9

The new Energy Policy of the EU provides among others, the following rules: reduction with 20% of pollutant gas emissions; reduction with 20% of the total primary energy consumption until year 2020.

Romania, member of European Union since January 2007, could be considered a country rich in poor and expensive resources. The dependence on imports of hydrocarbon fuels is about 42% for natural gases and 54% for oil and is growing as Romanian resources are depleting. In the same time, the energy loses are important in different kind of consumers. For example, the multistorey residential blocks have energy consumption about tree time greater that those of si-milar building from advanced countries of EU [6]. That is why the Government adopted National Programme that provides measures in this spirit.

The Heat and Power Cogeneration National Programme 2006-2009, Quality and Efficiency, updated with Heat and Power Cogeneration National Programme 2006-2015, Heat and Comfort, has as general objectif the improvement of efficiency for local Heat and Power Cogeneration Systems and the improvement of heating services quality, in order to decrease the annual fuel consumption with at least 100,000 tones/year (corresponding to about 1 mil. Gcal/h or 1,160,000 MW) compared with national consumption of year 2004.

The solution mentioned in the paper is in agreement with this policy.

7 Conclusions

It was necessary to install in the city a turbogenerator group. The steam boilers prepared for technological consumption, is possible to be used in cogeneration of heat and power production, with maximum efficiency. In the same time, the inner consumption of electric energy for both Central Heat and Power Plants of the city is covered from self production, with the economic and financial positive results.

The exceed amount of electricity could be sold. In the same time, the superheated steam produced by steam boilers for industrial consumers is used proper, in the most efficient way. The technological parameters of the turbine are up-to-date, according to modern technology.

The overall efficiency of the plant was enhanced by: using superheated steam to produce power instead of expanding it; using system to improve efficiency and allow the electricity produced to be sold; replacing old heat exchangers with new, more efficient ones; introducing plate heat exchangers to improve heat transfer and reduce fossil fuel consumption.

Applying this solution for central heating system is better for environmental protection because the steam boiler units have very efficient gases electric filters, allowing very small quantity of pollutant gases.

Reducing the amount of fossil fuels consumption, greenhouse gases (GHG) is reduced also, in accord with international treaties and conventions in the field of environmental protection, including the Kyoto Protocol.

Romanian energy sector‘s operation with a high efficiency parameters imposed by modern world will be mainly realized through the following policies: establishment and improvement of the equipments and the way to operate with it.

Recalling a well known assertion: “not energy is expensive, but lack of energy”, one can say that especially in this domain, future is not a world to go, but a world to built.

The advantage of this solution is that for the same thermal energy produced, i.e. by transforming the thermal station into power station, it can be obtained electric energy less expensive that electric energy bought before. The price for thermal energy produced is lower. As a consequence, the subsidy of the local authorities decreases.

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