THERMAL POWER SYSTEMS DEVELOPMENT IN THE ROMANIAN CITIES ORADEA AND ZALĂU BETWEEN 1918-2018

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Abstract: The energy evolution of Oradea and Zalau cities after 1918 took place in the difficult circumstances of Romania affected by two world wars and by a financial crisis in 1929-1933 interwar period. Thus, in the years following 1918, economic development of Romania was slow, with a peak in 1938. Low-power energy installations, generally smaller than 1 MW_e, have supplied electricity to the towns and local industry.

After 1950, a large number of hydro and thermal power plants were built in Romania, which have been interconnected in the National Energy System, providing electricity and heat to the industrial and dweling expansion.

The paper presents some aspects of the energy field achievements in Oradea and Zalau, registered after 1918 until 1945, especially with regard to the cogeneration thermal power plants built in these cities in the 1960s – 1980s.

Cogeneration thermal plants achieved in Oradea and Zalau have had an installed power capacities of 355 MW_e and 24 MW_e respectively, which have contributed to the economic and social development of these cities, but as we saw, the return to democracy in Romania after 1990 meant stopping and dismantling a great part of the industrial units, these thermal plants needed to be closed, as a result of the heat consumption base sharp decreasing, mainly after 2005-2010.

In Oradea, an up to date 47 MW_e and 51 MW_t gas turbine cogeneration plant was established from non-reimbursable European funds, which supplied the city with thermal energy from winter 2016/2017, but in Zalau the municipality has given up at the district heating system in the favor of the low capacities thermal installations, working on natural gas, placed at the consumers.

Key words: Oradea and Zalău cities, thermal power plants, energy, development.

1. INTRODUCTION

In 1918 the Romanian National Unitary State was founded by uniting the provinces inhabited by Romanians in this part of Europe, this being a reference point in the evolution of the Romanian nation.

The general development of Romania in the years 1918-2018 was decided by the political regimes that led the country in different periods, under the significant influence of theEuropean events, having different overviews on the economic and social future of the country, including the energy strategy.

Between 1918-2018, Romania crossed the economic recovery of the country after the First World War, after which only a quarter of all enterprises have remained in operation, followed by the economic crisis in the years 1929-1933 and by the difficult years of the Second World War, continued with the economy development through an intensive industrial growth of the country in the years 1950-1989.

Then, the years after 1990, when Romania returned to the democracy after 45 years of communism, with few notable achievements in the industrial field, which did not lead, as expected, to a general development of the country, [1]. The economy has been affected in these years by "privatization", then followed frequently by closure and dismantling of the productive units in various branches of the economy, by the alienation of indigenous hydrocarbon resources to foreign companies, thus transforming Romania, from a country producing industrial goods and food, in a sales market for the western products. Was this the price that Romania had to be paid, in order to be integrated into the European Union ?.

After 1918, Romania has been faced with the activities of repairing and putting into operation of the energy facilities, largely destroyed by two world wars. In the interwar period, there was an increase in electricity production of the country, a series of low-capacity energy targets beeing built, supplying both cities and local industry. Thermal industry of Romania was represented in this period by a low number of installations (230 Diesel energy engine units in 1939), with installed power below 1 MW, which mainly operated on liquid and gaseous fuels [1], [2], [3].

The economic and social development of Romania proposed after 1950, could be translated into reality only based on a strong energy system, extended to the whole country. Consequently, through the electrification program of the country, has gradually built up a series of thermal and hydropower plants, integrated into a powerful National Power System, which have ensured the increasing energy consumption, as a result of the massive promotion of the energy-intensive heavy industry (machinery, cement, chemistry industries) imposed as a way of the economic development until 1989. However, putting into service of the first two energy groups at the Cernavoda Nuclear Power Plant in

1996 and 2007 respectively, and the use of wind power at 3,000 MW_e in 2017 represent successes of the Romanian energy field in the last (2-3) decades.

The closure of many industrial and agricultural units, due to the macroeconomic measures taken in Romania after 1990, has contributed to the sharply decrease of the energy consumption of these areas of activity, correspondingly being diminished the production of lignite needed for thermal power plants operation, adversely affecting the coal mining, [5].

The energy field evolution in Oradea and Zalau cities between 1918 and 2018, was in line with the general trend registered at the country level. Energy in the north-west of the country was marked by the 1950s-1960s through a power shortage, that has not allowed a sustainable economic development.

The electricity has been produced in low-capacity thermal installations, generally using Diesel engines or turbo-generation groups at low steam parameters, [1-3]. Energy units, mainly located in the major administrative centers, generally have supplied the cities industry, with isolated operation, delivering electricity to local networks.

The considerable effort to eliminate the effects of the war, carried out after 1945 in the Bihor and Salaj areas, coupled with the proposed industrial and social development trends for the coming period, were conditioned by assuring a strong energy base. In this regard, between 1976-1990 in Oradea, and in 1975 in Zalău, thermal power plants have been put into operation, working in cogeneration regime, based on low-grade coal, partly providing from the local coal-fields Voivozi and Sărmăşag, which have delivered the heat and electricity to the buildings and industrial units, designed to operate in areas adjacent to these energy sources.

The thermal power plants achieved in Oradea and Zalău cities have been connected to the National Power System through high-voltage power lines, enhancing the safety of operation.

2. THERMAL POWER SYSTEM IN ORADEA CITY BETWEEN 1918-2018

The economic and social development in Oradea City after 1918 could only take place on the basis of an energy support, which would supply the electricity and thermal energy required to the industrial units, the social-cultural objectives and the inhabitants.

2.1. A brief history of energy field in Bihor County and Oradea City

The Oradea Electric Plant, built by Ganz Company, has started its activity in 1903, being equipped with 2 horizontal groups of 450 hp and 210 hp, powered by two steam generators of 250 m^2 and two of 100 m^2. Electricity was supplied at this stage on a cable network of 4 km at 3,000 V to the 3,000/150 V transformer stations, delivering the energy to the household consumers and public lighting.

Between 1907-1937, the Power Plant was expanded with 2 groups of 900 hp, 3 groups of 600 hp, then two 2,200 hp turbo-generators. In the year 1938 two other groups of 3,000 hp were put into operation, powered by Steinmuller (300 m^2) and "Astra" steam generators (420 m^2), both at 14 bar, which continued to operate until 1971. The electricity supply system reached 50 km of primary network and 90 km of distribution network, partially placed underground [5].

Starting since 1936, the Oradea Electric Plant was included in the Oradea Communal Enterprise and after 1953 it operated under the name of Oradea Electricity Company, led by the Ministry of Energy.

The power generation capacities of Oradea were increased during the period 1955-1959 by the achievement of the Electric Diesel Power Station, composed of 4 Diesel groups of 2,100 hp, 3,500 hp and 2,800 hp, having together 11,200 hp (8,25 MW_e) and the thermoenergetics groups equipped with 2x2.4 MW_e LANG steam turbines, supplied by Erste-Brunner steam generators of 30 t / h, 375°C and 32 bar, [5].

Among the important energy objectives in Bihor, which contributed to the electricity supply of this county, in the years immediately after 1945, there was the Astileu Hydroelectric Power Plant. Built between 1949 and 1954, this plant was equipped with 4 hydropower groups of 0.7 MW_e, amounting a rated installed 2.8 MW_e electric power, then expanded in 1982 with one unit of 1 MW_e, [7].

Also, in 1951, the Voivozi thermal power plant was started up, running on local coal, which was extended gradually to 3,100 kW_e.

The power units belonging to the Oradea Electricity Company have delivered the electricity to the Crişana zone system, which at the end of 1960 was connected to the National Power System, through the high electricity voltage line of 110 kV Vaşcău-Oradea, [5] [7].

The Oradea Electric Power Plant, known as the "Old Power Plant", placed on Griviţei Street, has supplied thermal energy by the 2x2,4 MW_e thermoenergetic groups, initially in the form of steam, to neighboring industrial units (Communal Enterprise, Food Factory "Avîntul" and Light Industry Factory "Drum Nou"), through the thermal networks achieved by 1957.

The district heating supply area has been extended since 1960 in the urban area near the power plant, at the beginning in the 1st December Square, where steam-supplied heat exchangers were fitted în 2 thermal points, the steam being taken up by the thermal plant, using the stationary steam extractions of the condensing turbines, [5].

After one year, in 1961, through the modifications of the installations, the thermal energy was supplied in the form of hot water, prepared even in the "Old Power Plant." The transition of this plant from the condensing operation regime to the cogeneration led to an enhanced energy efficiency, with a significant reducing of the specific fuel consumption needed for 1 kWh output.

The cogeneration heat supply area was gradually extended to the residential buildings located in 1 Mai Street, then to the center of the city at Crişul Factory, Black Eagle Complex, Municipal Council. The hot water distribution networks have reached the Traian Park area, feeding the police building, the Justice Palace and the Universal Market placed in Republicii Street, including the dwellings in these areas.

Between 1966 and 1968 in Oradea, the new system extended to the city center, supplied by the newly built Western Thermal Power Plant and the existing system in the central area, provided by the "Old Power Plant", were simultaneously in operation.

The thermal power units of the "Old Power Plant" were shut down in 1968, at the same time with the operation starting of the first thermal capacities at the new Western Cogeneration Plant and the primary networks have arrived in the central area of the city, being connected in the same year with the primary network M-1, near the Dacia Bridge [5].

During the period 1950-1965 a series of electric power stations and low voltage electricity distribution lines were fitted in Oradea (Oradea Center, Oradea East-Velenţa, CET Oradea Station) and Bihor County (Aştileu, Vascău, Ştei, Băiţa, Avram Iancu, Tileagd, Vadu Crişului, Voivozi, Black Forest, Suplacu de Barcău, Beiuş, Dobreşti, Sărmăşag, Ip). Thus, it was possible to supply with electricity the villages in Bihor areas, which in 1973 has reached a number of 409, compared to 19 villages by 1958 [5].

In the years 1965-1967, two separate companies are established from the Oradea Electricity Company, depending on the activity profile, namely the State Electric Power Company Oradea, who manages the building of the new power plant in the western part of the city and the preparation for starting up the first two 25 MW_e turbo-generating groups, with the future activity in the field of electric and thermal power generation and the Electricity Network of Oradea, with field of operatin in the electricity transport and distribution.

In order to develop Romanian economy after 1945, in the first years after 1960, it was decided to build and expand, in the western part of Oradea city, some industrial units with a diversified activities (alumina, chemical, furniture, sugar, building materials), a poultry complex and a greenhouse, intended to reach an important production area, which will ensure the development of the Oradea community.

The power generation facilities that have been in operation in the first years after the 1960s in the central area of Oradea City, consisting of the Diesel Power Station and the "Old Power Plant", even taking into account the electricity delivered by the Astileu Hydroelectric Power Plant, via high electricity voltage line 110 kV Vaşcău-Oradea, could not cover the energy demand needed by the development of the city.

Under these circumstances, it has become necessary to be achieved, beginning from the years 1963-1964, at the initial stage predominantly in the western part of the city, a new housing district, in order to assure properly social conditions for the inhabitants.

The power supply, especially of thermal nature, to the economic and social objectives to be develop in Oradea during this period, was possible only based on a safe energy source, having an up to date technology, sized in accordance with the energy requirements.

The thermal power plants established in Oradea between 1963-1976 and 1981-1990 in the west side and in the eastern area respectively, have provided the energy support of the industrial and dweling development of the city.

The cogeneration technology of electricity and heat, used by these thermo power plants, has enabled to provide the thermal energy in the City of Oradea in an profitable manner, due to the remarkable energetic and ecological efficiency that offered, [5].

Both power plants built in Oradea City have used low grade coal (lignite), mostly coming from the Oltenia coal-fields and partly from the north-west of the country (Voivozi and Sarmasag), [5].

The hidroelectric management performed on the Crişul Repede river basin, especially in Drăgan-Iad and Criş Aval Aleşd-Fughiu areas, starting by 1973 until 2007, have led to the increasing of the Bihor County energy potential. These hydro facilities were managed by the Crişuri Electric Power Plant Oradea, nowadays called the Hidroelectrica Plant Oradea.

The hydropower plants in Crisul Repede river basin, with the mention of the installed powers and the year of starting up, are: Leşu (3,4 MW_e; 1976), Remeţi (2x50 MW_e 1985), Munteni 1 (2x29 MW_e; 1988) and Munteni 2 MW_e, 1992) from Dragan-Iad, continuing with Lugasu (2x9 MW_e, 1989), Tileagd (2x9 MW_e, 1989), Săcădat (2x5 MW_e, 1994) and Fughiu (2x5 MW_e; 2007) from Aval Criş Alesd-Fughiu. These hydropower plants are equipped with Francis and Kaplan turbines and synchronous generators, summing up an installed capacity of 218 MW_e.

2.2. Main technical parameters of the Cogeneration Thermal Plants of Oradea

In 1963, in the City of Oradea, the achievement of the Western Thermal Plant for electric and thermal energy production in cogeneration mode was started-up, being put into operation gradually by 1976, together with the district heating main pipelines, having the designed stage an installed nominal power of 205 MW_e, (figure 1), [5], [7], [9].

Fig. 1. Overwiew of the Western Cogeneration Power Plant of Oradea.

The main technical characteristics of the energy groups installed, according to the original project, at the Oradea Western Thermal Plant, are presented in table 1, [5], [7], [9].

The overall housing and industrial development of Oradea City from 1970-1980 have contributed to an

important increase of the heating demand, simultaneously with the expansion of the hot water transport system to the Nufărul district, located at about 12 km from the Western Cogeneration Plant, being achieved a high number of distribution stations, especially in the eastern area of the city.

Fig. 2. Overwiew of the Eastern Cogeneration Power Plant of Oradea.

The main technical data of the energy groups belonging to the Oradea Eastern Cogeneration Power Plant, are shown in table 2, [5], [7], [9].

Continuously increasing of the thermal demand, on the background of the city industrial development, especially by identifying of some potential industrial consumers in the eastern area, together with putting into use new dwelings after 1980, have led to the requirement of establishing a new thermal source – the Eastern Thermal Plant – running in 1990 with 3 turbogeneration groups of 50 MW_e in order to contribute, together with the existing power plant in the west side of the city, to the covering of the increased district heating demand, [5], [7].

The main building of the Eastern Cogeneration Power Plant of Oradea, can be seen in figure 2.

Table 1. Main technical data of the power units installed at the Western Cogeneration Plant of Oradea

Thermal equipments	Type of equipments	Rated parameters	Year of starting up	Main manufacturing and operating characteristics
Steam generators	RO-165	165 t/h; 136 bar, 540°C	1966	-natural circulation of the working fluid; -powdered lignit main fuel with fuel-oil support; -coal grinding system with fan type mills; -powdered coal burning system with fuel-oil help; membrane walls boiling system; -two passing ways of flue gases; steam generators delivering on collector pipe system.
	RO-165	165 t/h; 136 bar, 540°C	1966	
	1 BZKG	350 t/h; 136 bar, 540°C	1968	
	1 BZKG	400 t/h; 136 bar, 540°C	1971	
	1 BZKG	400 t/h; 136 bar, 540°C	1976	
Steam turbines	LANG	25 MWe	1966	Condensation operating mode with 2 adjustable steam extractions at $(1,2-2,5)bar$ and at $(10\pm2)bar$.
	LANG	25 MWe	1966	
	PTKO 55/45	55 MWe	1967	
	DSL-50	50 MWe	1973	
	DSL-50	50 MWe	1976	
Hot water boilers	CAF-Vulcan	116,3 MW_t	1969	-pressure system with forced water circulation; -fuel-oil combustion; -membrane walls pressurized system; -one ascending flue gas circuit.
	CAF-Vulcan	116,3 MW_t	1970	
	CAF-Vulcan	116,3 MW_t	1970	
	CAF-Vulcan	116,3 MW_t	1978	
	CAF-Vulcan	116,3 MW_t	1981	

Table 2. Main technical data of the power units installed at the Eastern Cogeneration Thermal Power Plant of Oradea

Thermal equipments	Type of equipments	Rated parameters	Year of starting up	Main manufacturing and operating characteristics
Steam boilers	1 BZKG	420 t/h 136 bar, 540°C	1987	-natural circulation of the working fluid; -powdered lignit main fuel with fuel-oil support; -grinding system of coal with fan type mills; -powdered coal burning system with fuel-oil help; - membrane walls boiling system; two passing ways of flue gases; -steam generators delivering on collector pipe system.
	1 BZKG	420 t/h 136 bar, 540°C	1988	
	1 BZKG	420 t/h 136 bar, 540°C	1990	
Steam turbines	PT 60/40-13	50 MWe	1987	Condensation operating mode with 2 adjustable steam extractions at $(1,2-2,5)bar$ and $(10\pm2)bar$.
	PT 0/40-13	50 MWe	1988	
	PT 60/42-13	50 MWe	1989	Operating on backpressure mode at 1,2 bar and an adjustable steam extraction at $(10\pm2)bar$;
Thermal station for the power plant starting up	ID-30	2x30 t/h	1987	- natural circulation in the boiling system; - fuel-oil combustion.

2.3. Consumed fuels and energy production at the cogeneration thermal plants of Oradea

The thermal power plants built in Oradea were designed to operate based on lignite, using fuel-oil only for the thermal support the powdered coal flame. After the connection of the Western Cogeneration Plant to the national gas pipeline in 2002, an increase share of combustible gas in the power generation of this plant, over coal, was recorded for a period of (3-4) years [5].

Coal used in Oradea came from the Oltenia basin, mainly from Rovinari, Peşteana, Motru and Northwest Romania (Voivozi and Sărmăşag mines), the first source being the main one, sometimes being registered imports from the neighboring countries with the Romanian western border (Hungary, Poland, Ukraine) at lower costs than in the country.

The figure 3 presents the coal consumption of the thermal power plants of Oradea during 1966-2006, [5].

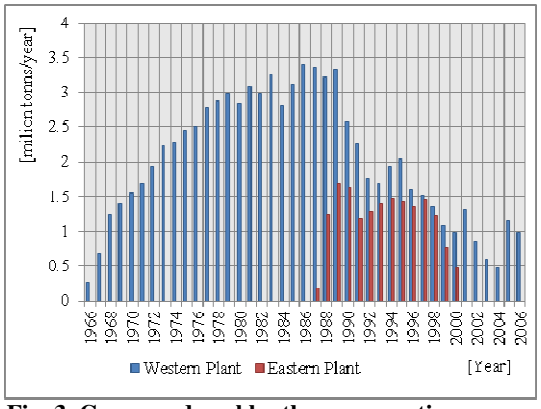

Fig. 3. Consumed coal by the cogeneration power plants of Oradea between 1966-2006.

The Western Cogeneration Plant of Oradea has registered between 1970 and 1990 a coal consumption of (2.0-3.4) million tonns/year, lowered than (1.4-2.5) million tonns/ year used in the period 1990-2000, then after 2000 was stabilized at (1.0-1.2) million tonns/year. At the Eastern Cogeneration Plant were consumed annually (1.2-1.8) million tonns of coal, with a significant decrease in 1999 and 2000, when 750 thousand tonns and 480 thousand tonns were registered respectively.

The fuel-oil was used at the Oradea cogeneration plants for the coal flames support in continuous operation of the steam generators, representing (4-8)%, sometimes reaching up to (9-10)% from the thermal flow introduced into the furnace with the fuel, thus assuring the stability of the ignition and the burning of pulverized coal.

The fuel-oil consumed by the Western Thermal Plant of Oradea until 1989 has reached values in the range of (60-90) thousand tonns/year, after which it gradually decreased, following the general trend of diminishing the power generation of the plant, attaining in the last years about (15-25) thousand tonns/year.

In the case of the Eastern Plant, the consumed fuel-oil ranged from 1987 to 2001, generally between (15-20) thousand tonnes/year, excepting the years 1990 and 1991, when 38 thousand tonns/year were consumed and 23 thousand tonnes/year, respectively.

The graph included in figure 4 highlights the amount of fuel-oil burnt by the cogeneration plants of Oradea during 1966-2006, [5]. After 2006, fuel-oil consumption of the Western Cogeneration Plant was in range of (17-20) thousand tonns/year, according to the energy production delivered, lower values of 11 thousand tonns/year and 8 thousand tonns/year being recorded in the years 2013 and 2014 respectively.

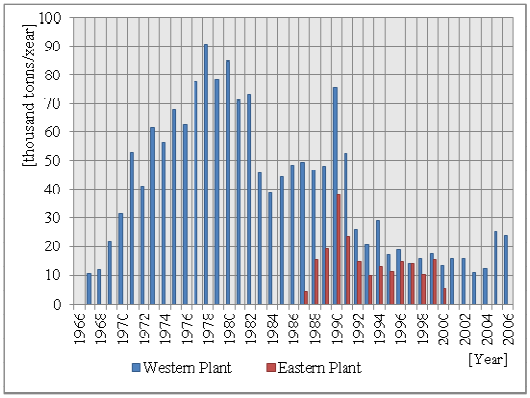

Fig. 4. Fuel-oil consumption registered by the cogeneration thermal plants of Oradea over the years 1967-2006.

The Western Cogeneration Plant starts to use natural gas after the year 2002, when it was connected to the main pipeline that cross in the west part of Romania, between Satu-Mare and Arad cities. This fuel delivers to the plant via Distrigaz West, being available at a flow rate of 30,000 m_N^3 / h and at the pressure of (1-2) bar.

Steam generators no. 1 and no. 2 were the subject of some improvements in 2003, among which the change of burning system from powdered coal to natural gas. Also, at the steam generator no. 3 the burning equipments were modified in 2004, with the aim of using natural gas or fuel-oil, alternatively.

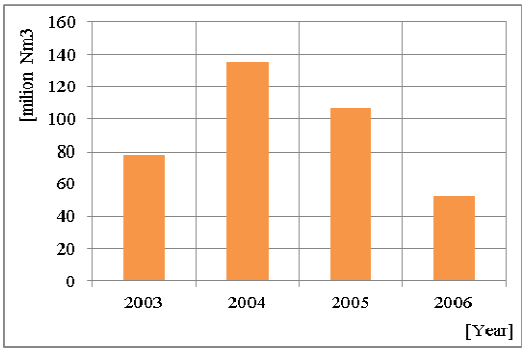

Fig. 5. Consumed natural gas at Western Cogeneration Power Plant of Oradea during 2003-2006.

The natural gas consumption of Oradea Western Thermal Plant has had low values, at 2.3 million m_N^3 in

2011 and 6.3 million m_N^3 in 2012, with an increasing to 17.3 million m_N^3 in 2014. The amount of natural gas consumed in the West Cogeneration Plant in 2003-2006, is shown in figure 5, [5].

The electricity obtained by the cogeneration power plants of Oradea during the years 1966-2000 and 2001-2014, is presented in the graph of figure 6 and figure 7, [5], [7].

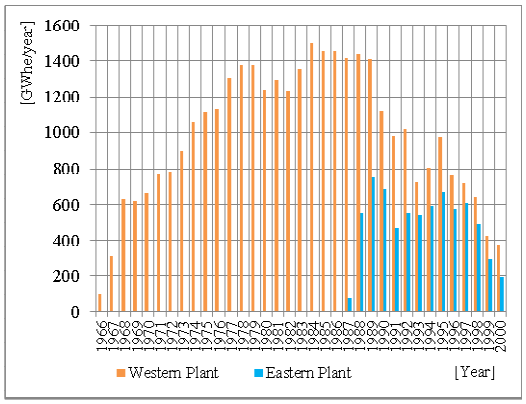

Fig. 6. Electricity generated by the cogeneration power plants of Oradea in the years 1966-2000.

The graphs highlight a general trend of increasing electricity and heat production by 1989. The peak electricity output of the Western Thermal Plant was registered between 1984-1986, at the values in range of $(1{,}455-1{,}500)\ GWh_e\ /\ year$.

The electricity output provided to the National Power System by the cogeneration thermal power plants of Oradea was generally achieved in accordance with the hot water demand required for the ditrict heating (including greenhouse in the case of Western Plant) and process steam, delivered mainly to the industrial units placed in the west side of the city.

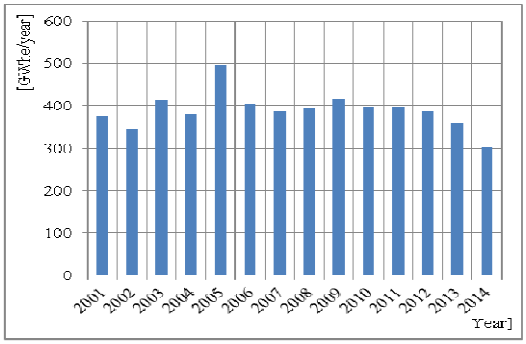

Fig. 7. Electricity production of the Western Cogeneration Power Plant of Oradea over the period 2001-2014.

Overall heat production, in the form of industrial steam and hot water, delivered by the cogeneration plants of Oradea between 1966-2000 and 2001-2014 can be observed in figure 8 and figure 9, [5], [7]. Graphs show the increase of the thermal energy output until 1989, with a peak of $(3{,}120-3{,}180)\ GWh_t\ /\ year$ between 1980-1981.

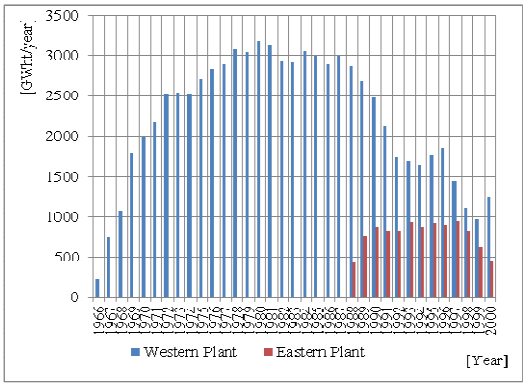

Fig. 8. Thermal energy production in form of steam and hot water provided by the cogeneration power plants of Oradea. between 1966-2000.

The changes on the macroeconomic framework in Romania, starting since 1990, led to the closing of a great number of industrial and agricultural units and complexes operating in the country, some of them being representative at the national level, and therefore a considerable decrease of the thermal demand base has been recorded.

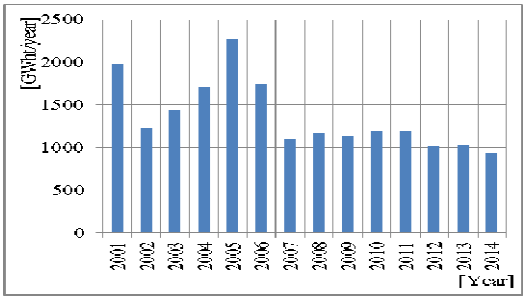

Fig. 9. Thermal energy delivered by the Western Cogeneration Plant of Oradea in form of technological steam and hot water over the years 2001-2014.

The effects of these decisions on the economic life of Oradea have been traslated by stopping of a large number of economic units in the field of food, furniture, chemical and construction industry, including the poultry breeding and the vegetable greenhouse, and as a result the thermal energy demand, in the form of process steam, has been sharply diminished, especially since 1995.

The pricing policy applied at national level after 1989 on the fuels market has contributed to the disconnecting of a significant number of industrial consumers from the district heating system, in favor of its own thermal installations, for space heating and warm water preparation.

As a rezult, this large thermal system supplied by two cogeneration plants has became unprofitable, being taken the decision of closing the Eastern Cogeneration Plant of Oradea in 2000, after a relatively short period of

only 14 years of operation, between 1987-2000. Thus, the coverage of the system thermal load, almost entirely of district heating, has remained in the only responsibility of the Western Cogeneration Plant, [5].

2.4. The maintenance applied to the cogeneration power plants of Oradea

The Cogeneration Power Plant Oradea West, built at the same time with the district heating main and distribution pipelines at the level of the 1960-1970 technology, although without major improvements over 40 years, has been maintained in operation in an appropriate general technical state, the basic equipments and aggregates running at the designed parameters, in safe and continuous conditions, especially before 1990, [5], [7].

The maintenance operations have been focused on the thermal system supplied by the Western Cogeneration Plant, knowing that by the end of the 1980s it was the only plant operating in Oradea City.

A series of improvements have been carried out during the operation years of the power plants, with the view of increasing the safety running and the overall performances of the equipments and installations, [5], [7].

Among these can be mentioned at the Western Plant:

- putting into service of an additional steam generator (no. 6);
- conversion of some condensing steam turbines to backpressure operation;
- combustion change of powdered coal on dust concentrators associated to the steam boilers;
- replacement of existing preheaters with a new version having thermal tubes, including 2 steam generators of 165 tonnes/hour,

and with reference to the Eastern Plant:

- optimisation of the coal dust finennes in addition with improvements of the after-burning grates, in order of thermal losses reducing.

Also, relating to the main district heating network, was doubled the primary pipeline at the Western Plant outlet on a length of 2 km. The old insulation, with a one having high performance, was replaced on a great part of the system and stainless plate heat exchangers, instead of those with tubular fascicles, were mounted on the whole district heating system.

The overhauling and repairing works, carried out systematically over the years on the basic thermal equipment by the engineers of the two cogeneration plants, together with the technological improvements, brought to the equipment and installations, by the scientific contribution of the research institutes in the field, have contributed to an high degree of safety, achieving notable energy performances by both cogeneration plants of Oradea.

Taking into account the special achievements related to the energy production and its performance, to the continuity and safety in service, the Western Cogeneration Plant of Oradea was a remarkable presence in Romanian termoenergy field, taking the second place among the coal power plants belonging to the National Power System during 1981-1983 and the first place between 1984-1988, respectively, [5], [7].

2.5. District heating providing system of Oradea

Cogeneration thermal power plants of Oradea were located in the outside the built city area, at convenient distances of (2-3) km compared to the consumers, but also taking into account the possibilities of access to the water source (the position to the Crişul Repede river-bed).

In 2013, the entire activity of district heat generation and providing in the city of Oradea has been transferred under the control of a newly established unit named S.C. "Termoficare" S.A. Oradea, coming from "Electrocentrale", coordinated by the Local Council of Oradea [5].

The heat generated in the two energy sources was provided, in the case of district consumers, in the form of hot water, via a primary pipeline system, made in a

Table 4. Main technical parameters of the hot water primary pipelines supplied by the Western Cogeneration Power Plant of Oradea

Primary network	Diameter at the start point	Rated flow	Bitubular length	Number of thermal stations	Year of start up
	[mm]	[m^3/h]	[km]		
City Main Pipeline	2x800 tur 2x900 retur	5.000	2 2	--	1966 2002
Main Pipeline M1	2x700	5.000	6	40	1966
Main Pipeline M2	2x800	4.000	8	70	1970
Main Pipeline M3	2x500	500	2,5	17	1972

Table 5. Main technical parameters of the hot water primary pipelines supplied by the Eastern Cogeneration Power Plant of Oradea

Primary network	Diameter at the start point	Rated flow	Bitubular length	Number of thermal stations	Year of start up
	[mm]	[m^3/h]	[km]		
Main Pipeline M4	2x800	4.000	6,5	17	1988
Main Pipeline M5	2x800	4.000	3,5	14	1988
Main Pipeline M6	2x400	600	5,5	6	1988

bitubular closed-loop circuit (were built 3 main pipeline leaving the Westearn Plant and three delivered by the Eastearn Plant, from which two coming inside the city and one to the Sînmartin - Băile Felix area). These main pipelines are interconnected, ensuring on this way a better flexibility of the entire system, in case of unforeseen circumstances, [5].

After the shuting down of the Eastern Plant of Oradea in 2000, the primary heat supply was carried out only by the thermal plant located in the western part of the city, and for the Sânmartin-Băile Felix area, an intermediate repumping station has been foreseen inside the Eastern Plant.

The nominal parameters of hot water leaving the cogeneration power plants of Oradea are for temperature 150° C / 70° C and for pressure 6/3 bar at the Western Plant and 9/3 bar at the Eastern Plant.

The maximum hot water transport distance, when the system was only supplied by the West Plant, ranges between (10-12) kilometers, to the most remote thermal stations being located in the Nufărul district [5].

Taking into account the specific activity of vegetable greenhouse, it was delivered through separate pipelines both with hot water at 9/3 bar for space heating and with steam at the pressure of (3-4) bar, required for soil treatment. The evolution of the hot water generation capacities, installed in the both cogeneration thermal power plants of Oradea, results from the graph shown in figure 10, [5].

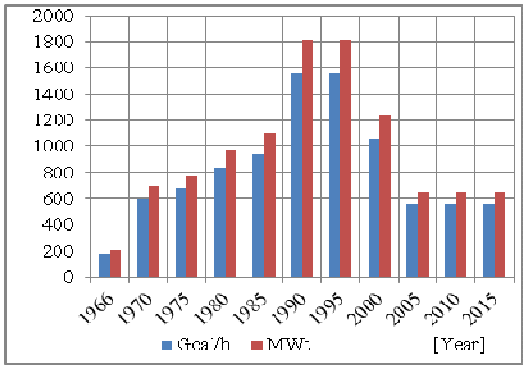

Fig. 10. Hot water preparation capacity installed at the cogeneration power plants Oradea evolving between 1966-2015.

The primary main pipelines hot water supply, connected to the two sources of thermal energy in the city of Oradea, have the configuration, shown in figure 11. The technical parameters of the main pipelines delivered with hot water, prepared in the both cogeneration power plants of Oradea, are presented in the table 4 and table 5, [5], [7].

From the outlet of the Western Cogeneration Plant, the main network delivering hot water to the thermal stations has a common section, over a distance of about 2 km, so called "City Main Pipeline", with a nominal diameter of $D_n = 2x900$ mm.

In order to increase the safety of the whole district system, these 2 km were doubled in 2002 with a portion of $D_n = 2x800$ mm, that has become the tour of the network, while the existing pipe offers the return function.

The primary main pipelines and its connections, have registered in 2015 a total length of 86 km bitubular network, mostly located in underground (about 64%). An important share of the pipelines, about 75%, has register (35-40) years old, 10% between (10-25) years and only 15% is under 10 years old, [8].

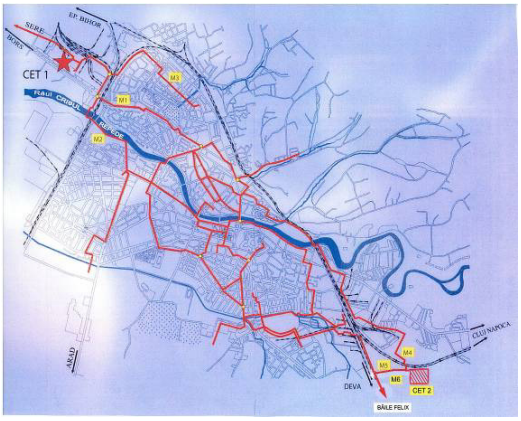

Fig. 11. District heating primary network operating at present in the city of Oradea.

The heating energy delivered to the district consumption is achieved through the thermal stations, connected to the hot water main pilepines network. The thermal stations provide the secondary heating agent needed for space heating and warm water used in the household and in the industrial activities.

These are equipped with heat exchangers, that convert thermal energy coming from the primary circuit at (6-12 bar / 120-130°C) to parameters compatible with those of the secondary heating systems [designed at (3-5) bar / (55-60)°C] and warm water temperature at (50-55°C), thus ensuring the safety operation of the installations fitted at the consumers.

At the starting up, the thermal stations with tubular fascicles heat exchangers were equipped, in accordance with the technology widespreaded in the 1960s, but at the level of 2016, these have been replaced on the whole district system, with stainless plate heat exchangers, that have an increased thermal efficiency.

The process steam has been sent to the consumers through its own over-pressure, assured at the cogeneration plants outlet.

Industrial units located in the area of the Western Cogeneration Plant were supplied with steam at pressures between (10-16) bar (Alumina, Synthesis, Sugar factory, Building Materials „Simcor", Furniture „Alfa"). The „Alumina" Plant has requested, for a part of its technology, higher pressure steam, at 40 bar.

To the steam pipeline of 10 bar which leaves the Western Cogeneration Plant, delivering the „Simcor" Factory, other consumers were connected, such as the factories „Onix", „Alfa", „Mecord" (IMPS), „UAMT", „West Metalica" and „Premagro".

Steam pipelines at diameters of (2x300 mm) and 10 bar, leaving the Eastern Power Plant, follows a 5 km

length to the "Old" Power Station (CTA), located on Griviţei Street, to which the „Sinteza Color" and „Congips" factories have been connected.

Most of the industrial consumers from in the eastern part of the city, including those supplied in the past with steam at medium pressure by the "Old" Power Station (CTA), consisting of some factories, such as "Avântul", „Drum Nou", „Vinalcool" and „Mic Mobilier" have refused the steam by the Eastern Plant, and have chosen their own thermal stations, so that the steam flows delivered from this plant have low values, reaching sometimes only (20-25) tonns/hour, [5].

A great number of thermal distribution stations have been achieved during the periods of 1970-1980 and 1985-1990, when the Oradea City has met a remarkable dweling construction development.

Thermal consumers connected to the Oradea Western Cogeneration Plant are generally of a districtual type, placed inside the city and in adjacent areas, consisting of housing in multi-flates blocks and individual houses, public administration, trade and tourism buildings, education and health units.

The number of thermal stations starting up during 1966-1995, can be observed in the figure 12, [5].

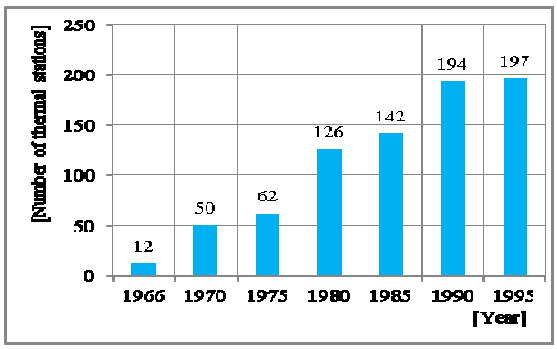

Fig. 12. Number of thermal staţions exploited by the „Apaterm" Oradea involving in the period 1960-1995.

To the thermal stations placed in the city built-up area, exploited by the "Apaterm" Oradea, in number of 197 (of which only 147 thermal plants are in its own management), were added a number of about 35 heating points from the industrial area, of the east and west side of the city, supervised by "Electrocentrale" Oradea, [5].

Table 6. Thermal stations capacities serviced by the „Apaterm" Oradea in the year 1998

Thermal installed capacity [Gcal/h/MW_t]	Number of thermal stations
1-1.5/1.2-1.75	74
1.5-2.5/1.75-2.9	34
2.5-4.0/2.9-4.6	36
4.0-6.0/4.6-7.0	27
6.0-9.0/7.0-10.5	26
Total	197

The size of the heating stations connected to the cogeneration plants of Oradea in 1998, ranges between (1.2-11.0) MWt, (Table 6).

The thermal power capacities installed in the two cogeneration plants of Oradea compared with those of the distributions thermal points during 1966-2005, are shown in the figure 13.

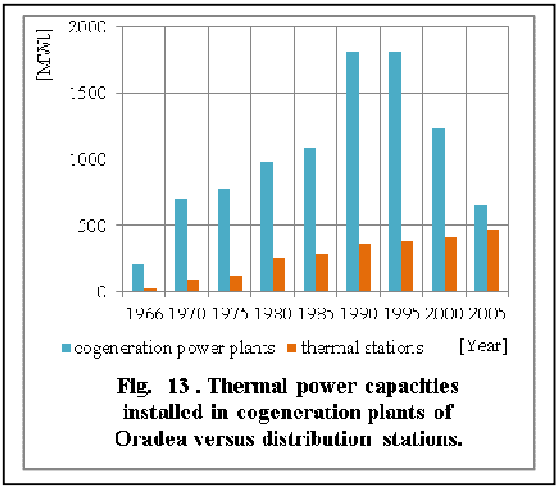

Fig. 13 . Thermal power capacities installed in cogeneration plants of Oradea versus distribution stations.

The thermal power installed capacity of the thermal stations (points), connected to the public district system of Oradea City, evolving in 1966-2005, is presented in figure 14, [5].

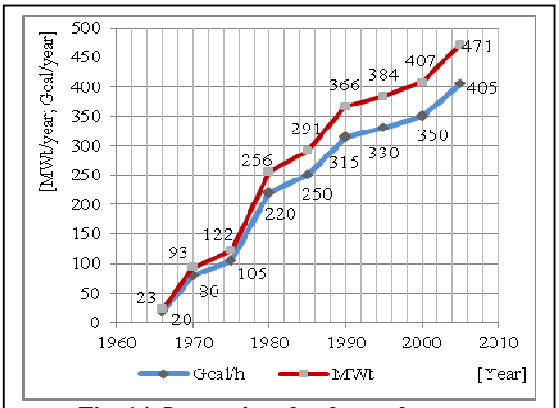

Fig. 14. Increasing the thermal power distribution capacities belonging to the district heating system of Oradea between 1966-2005.

The hot water preparation capacities of the Western Cogeneration Thermal Plant are oversized compared to district heating requirements. Thus, in 2005 this power plant an thermal flow of 650 MW_t was able to deliver, compared to the consumers demand, estimated at 285 MW_t, (figure 15).

At the level of 2016, the thermal energy was distributed to the consumers connected to the municipal heating system of Oradea by a total of 161 main thermal points, to which are added over 780 low-sized thermal modules, fitted at the consumers, directly supplied by the main primary pipelines. This number of 161 main heating points includes 14 geothermal stations, of which

9 stations delivering warm water in the Nufărul and Arad Road districts and 5 stations supply both, space heating and warm water in the Iosia Nord district area, [5], [8].

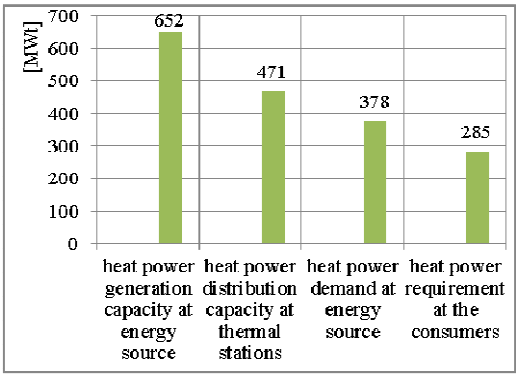

Fig.15. Thermal power production and distribution capacities of the district system of Oradea compared with the heating demand at the level of 2005.

The thermal energy is distributed to consumers through a secondary network system, amounting about 146 km of route, with a nominal diameters of between Dn (40-200) mm, consisting of two tour/return pipes supplying the thermal agent for space heating, a warm water delivered pipe and a warm water reciculating pipe.

A special importance must be given to this recirculating pipe, (that ensures the quality of the hot water service), in order to have at the consumption points temperature of (50-52)°C, shortly after opening the service tap, without exceeding this value, for reasons of the indoor installations safety, [5].

Secondary thermal networks are located almost entirely in closed underground thermal ducts, only about 5% of total being mounted in the buildings basement, [8].

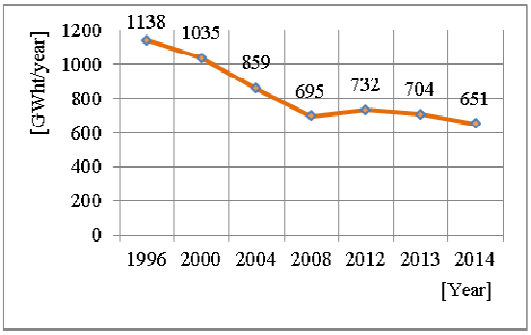

Fig.16. Thermal energy delivered by the Western Cogeneration Plant of Oradea at the consumers inlet in the period 1996-2014.

Analyzing the values of the thermal energy delivered from the Western Cogeneration Plant between 1996-2014, measured at the inlet of the consumers equipments, there is a continuous decrease of the supplied heat during 1996-2008, from 1,130 GWh/year to 690 GWh/year, which then will stabilize by 2014 around the values of (680-700) GWh / year, as results from the figure 16, [5].

2.6. The performances of the district heating system of Oradea

Although the Western Cogeneration Plant of Oradea operates under the cogeneration regime of electricity and heat, technology that performs in principle, taking into account all the maintenance, overhauling and reparing works carried out during the operation years on the basic equipments concerning the improving of energy efficiency and reducing the atmospheric pollutant emissions, however the overtaken design concept of the 1960s, combined with the wear technical state of the main thermo-mechanical equipments and of the heat transmission and distribution system, accumulated in over 40 years of operation, led to relatively low energy and environmental performance, unacceptable for a modern cogeneration plant.

The Bucharest Institute of Energy Studies and Designs has showed low performances of the entire thermal power system working in the Oradea City, including the Western Cogeneration Plant, mainly consisting of a reduced degree of the fuel usage, significant heat losses on the heat transmission/distribution networks and air pollutant emissions, over the limits allowed by the environmental laws, [5], [9].

In the last period of the Western Cogeneration Plant operation, the fuels valorisation in the energy generation process, as measured by the overall energy efficiency, decreased from 75% through the project, to 66% in 2004, then to 57% in 2008, to reach 52% now, (figure 17), [5], [9].

A significant influence on the energy efficiency of the entirely Western Cogeneration Plant was manifested by the steam generators, which have obtained thermal efficiency in range of (77-82) %, in coal-fired operation (GA-4, GA-5, GA-6), lower than that projected of 86 %, while at running on natural gas (GA-1, GA-2, GA-3) the efficiency was inside values of (85-87)%, versus designed values of de 92 %, [5].

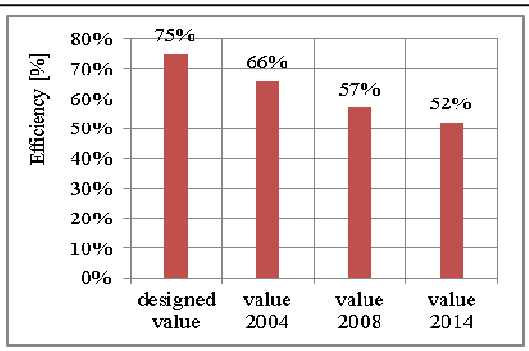

Fig. 17. Decreasing of the fuels overall efficiency usage at the Western Cogeneration Power Plant of Oradea in 2014 compared to the projected value.

The age of the hot water district network, registered after (35-40) years of running, has caused a large number of failures, consisting of pipe corrosion, main valves locking, demage of the thermal insulation, so that the overall thermal losses of the entire district network

reached a share of (40-42) % from the thermal flow delivered by the power plant at its boundary, [5].

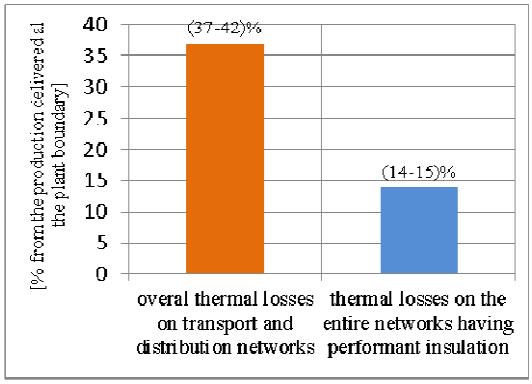

Fig. 18. Thermal losses on the district heating system delivered by the Western Cogeneration Power of Oradea in the year 2014.

The highest share of (20-25)% heat losses is located on the primary network, while on the distribution pipelines it has values of (14-15)%, compared with 15 % registered by the both, primary and secondary upgraded systems, made from pre-insulated pipelines, (figure 18), [5]

2.7. Upgrading the district thermal power system of Oradea

Starting from the significant technical wear state of the district heating system of Oradea, the public administration decided in 2012 the upgrading of the Western Thermal Cogeneration Plant and the renewal of the primary and distribution systems, aiming at higher energy efficiency and lower pollutant emissions, covered by the European environmental laws.

The cogeneration technology promoted by the public administration of Oradea was based on the exclusive use of the natural gas in modern facilities with high efficiency gas turbines, representing the only possible way at that time, from the financial point of view, for which it has had European non-reimbursable funds, [9].

In concrete terms, it was decided to build a new energy source, having the following structure, [8]:

- new built-in cogeneration plant for electric and heat generation, only based on natural gas, composed by:
  - gas turbine installation with a rated production capacity at 47 MW_e of electricity and 51 MW_t of thermal energy, General Electric made;
  - 2 hot water generators, named CAF, each of 116 MW_t.
- power turbo-generation group of 25 MW_e (TG-1), working in cogeneration mode in the old plant, recently renewed on natural gas, consisting of:
  - steam boiler upgraded on gaseous fuel burning, at the rated parameters of 165 tonnes/hour, 540°C and 13,6 MPa;
  - steam turbine having a rated power output of 25 MW_e and a capacity of hot water delivering at 70 MW_t.

A general view of the new gas turbine cogeneration power plant, started up în Oradea city since 2016, near the old western cogeneration plant, can be seen in figure 19, [8].

The overall thermal power installed in the new energy source Oradea is 353 MW_t. The cogeneration plant with gas turbines was sized at 51 MW_t, mainly to cover the thermal demand in the summer, needed for the warm water preparation, but also for the supplying of the district thermal load, until daily average temperatures of (+ 3)° C.

At temperatures below (+3)°C, the thermal capacities of the 25 MW_e steam turbine, located in the old plant, which can deliver 70 MW_t, will be started up. If periods of lower daily outside temperatures occur, the district thermal load covering takes place with the help of the two hot water recovery generators, each sized at 116 MW_t, [8].

Fig. 19. Overview of the performant gas turbine energy source manufactured by General Electric started up in 2016.

Technical measures regarding the thermal efficiency improvements of the primary district system have taken place, especially since 2014, by the replacement of some significant demaged parts of main networks with pre-insulated pipelines, sometimes mounted directly into the ground, by mounting new section valves and by installing devices for the pipe leakage signalization.

Thus, such improvement works were carried out in 2014-2016 for a length of 40 km main pipelines and will continue to another 20 kilometers between 2017 and 2018, thus contributing to the heat losses reducing from about 25% at present, to reasonable (7-8) % of the thermal energy delivered at the boundary of the Western Cogeneration Plant of Oradea, [5], [9], (figure 20).

An extensive upgrading program of the thermal points was started between 1993-1995, being now in different achievement stages, [5]. In 2016, all thermal points were equipped with advanced stainless steel plate heat exchangers for both services, space heating and domestic warm water, having automatic measuring and parameters setting aparatus.

Heat distribution networks are largely improved with pre-insulated polyurethane pipes, placed directly into the

ground. Almost all recirculation pipelines belonging to the warm water distribution, were tested and put into operation.

Fig. 20. The primary main pipeline M1 upgraded in 2015 in the area of CFR Bridge from Borsului Road.

Through the "Cogeneration 2006-2015 Heating and Comfort" program, approved by Romanin Government under no. 462/2006, the upgrading of the thermal points and the distribution networks will be ended, knowing that the program access period was extended until 2020, [8].

In 2016, the thermal energy was delivered through the public system of Oradea to about 70% of the city inhabitants, living in more than 61,500 dwellings in blocks of flats and 3,200 individual houses, along with about 1,900 economic agents and 231 public institutions, [8].

Fig. 21. Overview of the new thermal source operating in the western part of Oradea City from the winter 2016/2017 (new gas turbine installation together with the 25 MWe group upgraded on gaseous fuel).

The thermal energy supply of the consumers in Oradea during the winters 2016/2017 and 2017/2018 was carried out by the new energy source.

The newly built gas turbine installation and the hot water generators (CAF), together with the thermal source of the 25 MW_e turbo-generation group from the old plant, up to dated on natural gas, have covered the district heating requirement, as can be seen from figure 21, [8].

3. THERMAL POWER SYSTEM IN ZALAU CITY

In the years immediately following 1918, the area of Sălaj County and the city of Zalau were faced, like other regions of Romania, to the effort of rebuilding the country after the First World War, significant progress being made in industry, including the energy field.

3.1. A brief history of energy field in Salaj County and Zalau City

The economic and social development of the Sălaj County and Zalău area after 1918 could not be carried out without an energy base, that would assure the electricity supply to the industry and the households.

Electricity production in Sălaj area has began in 1905, when an power plant was installed in Zalău by the company "Electrica Siemens Schuckert" Budapest. This plant was equipped with 2 steam machines, each having 100 hp at 3,000 rpm and 250 V DC voltage, powered by two Warthington steam generators. On this way, the main public buildings, households and street lighting were supplied with electricity.

After the financial crisis of 1929-1933, when investments in the economy decreased, there was an overall development of Romania, which reached a peak in 1938.

During the inter-war period, the electricity production in country has increased, but the energy facilities have had low installed power, generally less than 1,000 kW_e, operating isolated in administrative centers. After 1924, in the Sălaj area, besides the Zalău Power Plant, other plants were in operation at Şimleul Silvaniei, Crasna, also at Sărmăşag, Surduc and Lupoaia coal-fields.

The electric generators were driven by locomotive steam engines using liquid fuel, coal and forest waste, amounting to about 1,000 kW_e. The electricity was provided to the local networks, delivering the mentioned cities and the mining areas.

The Second World War canceled much of the progresses in energy field, achieved in the previous decade, including the Salaj County, which has had to bear the additional difficulties of the years 1940-1945. The war has destroyed all the energy facilities in operation.

The rebuilding and economic development of Romania after 1945 was possible only on the basis of an extended energy infrastructure in the territory. Thus, immediately after 1945, many Diesel power groups were installed in the important cities and villages of Sălaj County.

Between 1950-1960 many thermal and hydroelectric power plants were started up in the country and connected to the high-voltage power lines. Since 1952, the high voltage power grids have been extended in Sălaj County area, so that until 1959 the households heve

received to the National Power System and the local power plants were gradually shut down.

Consequently, in the 1970s it was decided the buildling of a thermal power plant in Zalau City, in order to provide electricity and heat in a cogeneration mode, needed to the industrial objectives and residential buildings development.

In 1978 the Zalau District Heating Plant was

Fig. 22. General view of Cogeneration Thermal Power Plant of Zalau.

established with the initial purpose of supplying thermal energy tothe Tire Enterprise, but according to the industrial and housing development of the city, the cogeneration power plant has delivered technological steam to all industrial units, besides hot water for space heating and warm water preparation of newly built social and cultural objectives.

3.2. General technical data of Zalau Cogeneration Thermal Plant

The Cogeneration Power Plant built in the city of Zalau was equipped with:

- 2 steam turbines, each of 12 MW_e, of IMG Bukarest brand, for running in a cogeneration mode, with back-pressure and adjustable steam extraction;
- 4 steam generators manufactured at Vulcan Bucharest, having 120 tonns/hour, at 100 bar and 540°C, with natural circulation, delivering the steam on a collecting pipe.

This thermal plant was designed to operate on lignite-based fuel, coming from the Sarmasag coal-field, in addition with fuel-oil, used for the thermal support of the powdered coal flame.

An overview of the Cogeneration Power Plant built at Zalau, is shown in the picture of figure 22.

In the first stage, the thermal energy consumed by the of the industrial units, in form of process steam, was satisfied using a generator of 105 tonns/hour, at 17 bar and 205°C, started up in the year 1979, working on fuel-oil.

The steam turbines have began their operation in 1983, powered by the first two steam generators, whose assembly works were ended in the same year 1983 (other two steam generators were put into operation in 1985 and 1995 respectively).

Table 7. Main technical data of the energy units installed at the Cogeneration Thermal Power Plant of Zalau

Thermal equipments	Type of equip.	Rated parameters	Year of starting up	Main manufacturing and operating characteristics
Steam boilers	C-105	105 t/h; 17 bar; 250°C	1979	natural circulation in the boiling system; powdered lignit main fuel with fuel-oil support for C-120 t/h, only fuei-oil for 105 t/h and natural gas/fuel-oil for 4 t/h; coal grinding system with fan type mills; membrane walls boiling system (Vulcan) and flame tubes with boiling pipes (ABA-4 t/h); two passing ways of flue gases and steam collector pipe system (C-120 t/h).
	C-120	120 t/h; 100 bar; 540°C	1983	
	C-120	120 t/h; 100 bar; 540°C	1983	
	C-120	120 t/h; 100 bar; 540°C	1985	
	C-120	120 t/h; 100 bar; 540°C	1995	
	ABA	4 t/h; 15 bar; 200°C	2005	
Steam turbines	IMGB	12 MWe	1983	- backpressure at 7 bar; - one adjustable steam extraction at 17/33 bar
	IMGB	12 MWe	1983	
Hot water boilers	CAF-50	58 MW_t	1982	-pressure system with forced water circulation; -lignit fuel for 2x58 MWt ; 1x116,3 MWt and fuel-oil for 1x58 MWt; -membrane walls pressurized system; -one ascending flue gas circuit.
	CAF-50	58 MW_t	1983	
	CAF-100	116,3 MW_t	1982	
	CAF-100	116,3 MW_t	1980	

Two turbo-generation groups have been able to supply steam via adjustable extractions at the 17/33 bar and through the turbines backpressure at 7 bar.

The district heating demand was provided by means of the four hot water generators (CAF), two units of 58 MWt (50 Gcal/hour) capacity, working on lignit and two 116.6 MWt (100 Gcal/hour) units, one fueled on coal and the other on fuel-oil.

In 2005, an ABA monobloc steam generator of 4 tonns/hour at 15 bar and 200°C was installed in the thermal plant, running on natural gas or light liquid fuel.

The main technical data of the energy groups within the Cogeneration Power Plant of Zalau, can be observed in the table 7, [11-12].

3.3. Consumed fuels and energy production at the Cogeneration Power Plant of Zalau

The Cogeneration Thermal Plant built in Zalau City was designed to operate on low grade coal (lignite) as main fuel, coming from the Sărmăşag coal-field. Fuel-oil was used in order to assure the coal flame stability.

After the year 2000, natural gas consumption at the steam generators CAI-105 tonns/hour and ABA-4 tonns/hour was registered, [11-12]. The coal and fuel-oil consumption of the Zalău Cogeneration Plant, registered between 1989 and 2004, is highlighted in the graph of figures 23-24, [11].

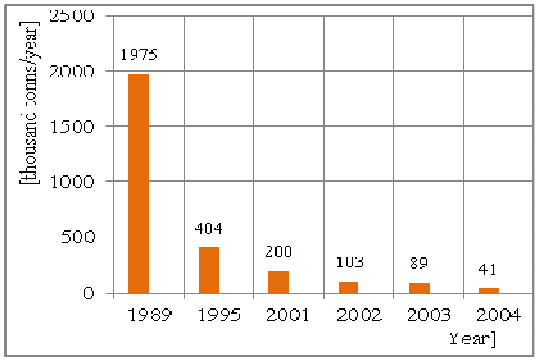

Fig. 23. Coal consumed by the Cogeneration Thermal Plant of Zalau between 1989-2004.

There is a remarkable decrease in the amount of coal consumed, from 1.975 thousand tonns/year in 1989 to 40 thousand tonns/year in 2004. Fuel-oil consumption shows an equally strong downward trend over the period, from 71 thousand tonns/year in 1989 to 10 thousand tonns/year in 2004.

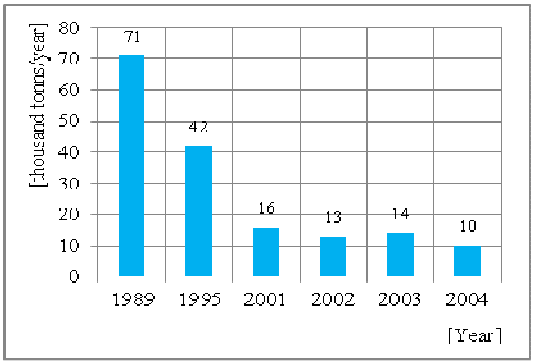

Fig. 24. Fuel-oil consumption of the Cogeneration Thermal Plant of Zalau Over the years 1989-2004.

The electricity and thermal energy provided by the Cogeneration Plant of Zalau between 1989-2004 and 1989-2009 respectively, is in line with the trends highlighted in the graphs of figure 25 and figure 26. During these periods, the thermal plant fueled mainly on coal, but the high share of fuel-oil, at about (35-40) %, in the overall energy production, can be noted, [11-12].

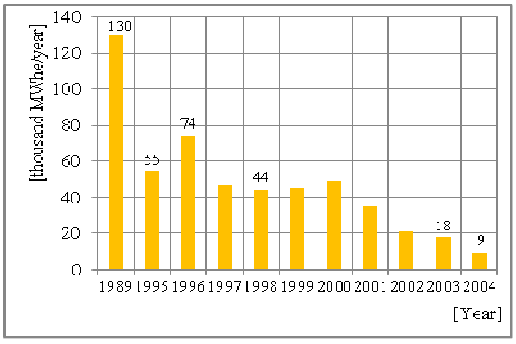

Fig. 25. Electricity production of Cogeneration Thermal Plant of Zalău between the years 1989-2004.

Between 1989-1995, the electricity generated by the power plant decreased sharply, from 130 thousand MWh_e/year to 55 thousand MWh_e/year, followed by an increase to 74 MWh_e/year in 1996, after which in the next 5 years, until 2001, there is stabilization around 45 MWh_e/year.

As the figure 25 shows, in the last 3 years of running in cogeneration mode, electricity produced by the power plant lowers from 20 MWh_e/year to 9 MWh_e/year in 2004, [11-12].

Due to the sharp decrease of the district and industrial thermal demand after 2004, the Thermal Power Plant of Zalau didn't generate electricity in a cogeneration regime, based on powedered coal burning, thus becoming a thermal station, that has operated on gaseous fuel.

The thermal energy flow delivered to consumers, in form of hot water and technological steam by the Cogeneration Power Plant, halved between 1989-1995 from 1,100 GWh_t/year to about 560 GWh_t / year.

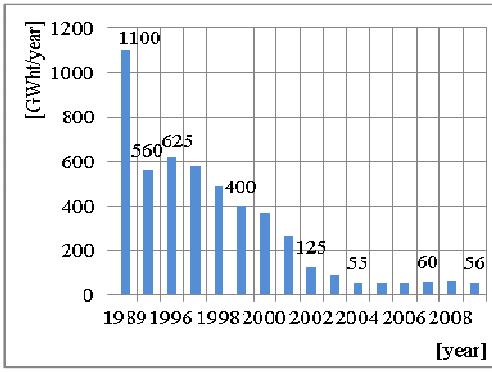

Fig. 26. Heat delivered to the consumers by Cogeneration Power Plant of Zalau in 1989-2009.

After a slight increase of around 600 GWh_t/year in the years 1995-1996 there was a continuous reduction of the heat output to 125 GWh_t/year in 2002 and a relative constancy at low values of (55-60) GWh_t/year by 2009, as a result of the massive passage of the district consumers to their own mini-thermal stations, working on natural gas, (figure 24), [11-12].

3.4. District heat providing system in Zalau City

In the Cogeneration Thermal Plant of Zalau, the hot water preparation for the heat consumers connected to the district system was asssured by the two heat exchangers (boilers), each having a capacity of 58 MW_t, attached to the steam turbines. The steam coming out at the turbine backpressure with a flow rate of 80 tonns/hour at (6-7) bar and (200-250)° C raises the water temperature in the primary network system from 50° C to (110-120)°C, [11].

The thermal points of the district system were delivered by means of two main pipelines, having diameters of D_n = 800 mm and D_n = 500 mm respectively. The pumping station that circulates the hot

water in the overall district network was equipped with 3 units for winter operation at 680 m^3/hour and 120 mCA, while other 3 pumps units at 2,500 m^3/hour and 120 mCA, have assured the system operation in the summer time, [11].

The placement of the Thermal Cogeneration Plant in the built area of Zalau City, can be seen in figure 27.

Fig. 27. Cogeneration Thermal Plant of Zalău located in the city area.

The consumers of the district heating system of Zalau were represented, at the starting up, mainly by dwellings, social, administrativ and comercial buildings, almost 20,000 households and 64 public institutions, as well as buildings in the industrial area.

Industrial consumers consisting of 42 manufacturing units in range of pipes, rubber tires, iron and steel fittings, furniture, ceramic products, enameled electric conductors and many others, were supplied with technological steam provided by the 105 tonns/hour generator and ABA-4 tonns hour at (15-17) bar and (200-250)°C, [11].

Over the last decade, before the cogeneration plant shuting down, have been reported interruptions in heating supply and temperatures below of comfort limit, that have led to the dissatisfaction of the inhabitants and of the other consumers connected to the district system, [12].

These findings related to the quality of the heat supply, in addition to the avalability of connection to the natural gas pipelines existing in Zalau City and the relatively low price of this fuel around the year 2000, have led to the increasing of consumers disconnection from the public system in favor of the gas fired mini-thermal stations, fitted at the level of dwellings and of the other buildings from the city area [12].

The measures taken in Romania in the macroeconomic field after 1990 were also reflected in Zalau City having the effect of clossing, especially since 1995-1996, most of the units on the industrial area and those who continued the activity were focused on the installing their own heating systems, to the disadvantage of the centralized district system and to the steam delivered from the generators of the cogeneration plant [12].

Under these circumstances, there was a considerable decrease, in just a few years, during 1996-2002, of the district heating and technological steam demand, which was reflected in the significant lowering of the thermal energy production of the cogeneration power plant, as can be observed in figure 26.

In the year 2000, the Cogeneration Thermal Plant of Zalau has supplied only 27 thermal stations and 22 industrial consumers. Thermal energy was delivered from the plant, mostly in the form of hot water for district consumption, of about two-thirds of the overall demand, while the technological steam has had a lower share of about one-third of the total.

The number of household heat consumers, public institutions and industrial units connected to the public heating networks in Zalău City during 2005-2013, evolving in a decreased trend, are shown in the graph of figure 28.

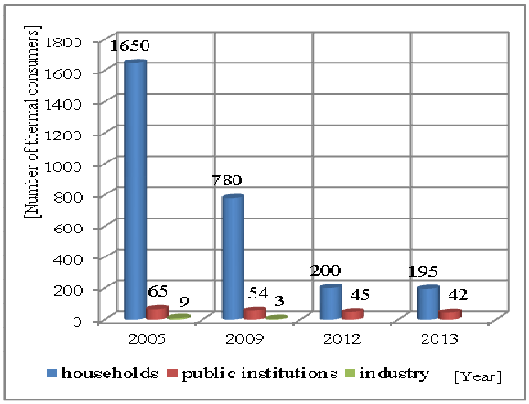

Fig. 28. The number of thermal consumers in Zalau City between 2005-2013.

There is a halving of households in just four years, from 1,650 in 2005 to 780 in 2009, [12].

The inefficient technical and economic conditions found in the operation of the entire district heating system of Zalău City (including the cogeneration power plant), underlined in a specialty study in 2013, has led to the decision of Local Council of the Municipality to give up in 2014, at this thermal energy supply way in the city area, [12].

The thermal comfort will be provided by mounting low capacity thermal stations on natural gas in the buildings belonging to the Municipality of Zalău, as well as in all houses located in the city area, considered by the local administration being as the most appropiate way to solve the city heating, at this moment.

The timely access of the European non-reimbursable funds through the insistence of the municipality, before the rised disconnection of consumers, followed by the establishing of a modern cogeneration gas turbine power plant, would be keep in operation of the district heating system, to the satisfaction of the inhabitants.

The Thermal Cogeneration Power Plant of Zalau, until recently an important industrial objective of the city, has been converted since 2014 into an energy equipment repairing unit, also managing the public lighting activity in the city.

The municipality of Zalău is paying attention to the decentralized production of thermal energy from renewable sources (thermal solar and biomass), for which European non-reimbursable funds have been obtained. Thus, starting with 2010 a number of 48 thermal stations operating on forestry waste have been achieved, [12].

4. CONCLUSIONS

Between 1918 and 1950, electricity was provided to economic units and to the population of Romania using small-scale Diesel engines, generally less than 1 MW_e, which operated on the local power networks.

In order to ensure the development of Romania after 1945, a large number of hydro and thermal power plants were built, over a period of ten years and the national power system was implemented, by which the electricity was supplied on the entire territory of the country and the thermal energy was delivered to the cities and industry.

In this respect, in 1960s-1970s, in the cities of Oradea and Zalau, thermal power plants with cogeneration function, on local lignite were built, having installed power capacity of 355 MW_e in Oradea and 24 MW_e in Zalau, together with other thermal capacities in peak demand (CAF), which were represented the base of economic and social development.

The cogeneration thermal power plants started up in Oradea and Zalău were the main industrial objectives in the economy of the respective cities.

Although the events that have been taken place in Romania after 1990 were contrary to the continued operation of these power plants, was demonstrated the capacity of the specialists to exploit with a notable efficiency a complex energy facilities on the basis of a high performance technology for the years 1960-1970.

The thermal energy generated has reached high levels, so that in 1995 the Oradea cogeneration plants registered 2,320 Tcal and in the year 2000, together with the Zalău plant, there were delivered 1,850 Tcal, each time being ranked first among the coal-fired plants operating in Romania.

The district heating system of Oradea is one of the most extensive in Romania, including a 98 km length primary bitubular pipeline network in 1990, 90 km in 1995 and 80 km in 2000, so that in 2016 reaches 86 km.

The operation of these thermal power plants after 1990 has become unprofitable, as a result of the sharp diminishing in heat consumption. Thus, the Eastern Cogeneration Plant of Oradea was shut down in the year 2000, although it had relatively new equipments after a short time of operation, while the Oradea Western Thermal Plant has adapted its production to the new energy market for a further 15 years.

The technical state and the outdated technology of the equipment and installations of the Western Cogeneration Plant of Oradea, as well as of the district heating system, have required the upgrading of the entire municipal thermo energy system.

In 2016 an up to date cogeneration power plant equiped with a new gas turbine installation was started up, that together with the first turbo generating unit belonging to the old plant, but up to dated on natural gas, represents at present the new energy source of Oradea, assuring in an efficient mode the thermal energy in the districtual heating system of the city

The fuel chosen for the thermal energy delivering was the natural gas taken from the national network, although from a thermodynamic point of view, the use of this higher fuel is, in principle, unprofitable for low temperature heating processes.

In contrast, in Zalău City, due to the closing of most industrial units and significant disconnections of the household consumers, the municipality has given up at the centralized district heating system in the year 2014, in the favor of installing low capacity thermal stations on natural gas, placed at the consumers.

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