COMPARATIVE ANALYSIS OF HEAT PRICE FOR URBAN CONSUMERS FROM DISTRICT HEATING SYSTEMS TO THOSE WITH APARTMENT BOILER

Carmen COMAN[1], Victor ATHANASOVICI[2]

This article presents a comparative analysis of heat price of urban consumers from district heating systems to those with apartment boiler. Analysis is realized in the context of legislation in force regarding subsidies for heat supplied from district heating systems and regulated prices of natural gas. For this analysis have been selected 12 cities from periodic reports of ANRSC. The selection of those 12 cities took into account different geographic regions from Romania, size of district heating systems and their competition with apartment boiler.

Keyords: heat price, natural gas price, regulated price, subsidy

Nomenclature: ANRE – National Authority for Energy Regulation; ANRSC- National Authority for Public Services Regulation; BNR – National Bank of Romania; DH – District Heating; SR – Romanian Standard; ap. – apartment; ap.cv – conventional apartment; VAT – Value Added Tax.
Name of the cities from the tables are the following: 1- Bucuresti; 2-Constanta; 3-Arad; 4-Timisoara; 5-Iasi; 6-Suceava; 7-Targu Mures; 8-Pitesti; 9-Ramnicu Valcea; 11-Bacau; 15-Piatra Neamt; 29-Alexandria.

1. Introduction

Heat price and natural gas price are constant topics in the last 20 years for Romanian society.

Political mechanisms which have been adopted in this time, either subsidies or regulated prices, led to lack of involvement of decision makers from all links of production, transport and distribution heat chain given that all DH systems are older than 25 years and their efficiency is low, for the most part being almost 50% - see pag. 299 from [10].

Different forms of subsidies for heat price have compensated precarious technical condition and high costs of DH systems but didn't contribute to supply a quality service.

As a result, DH systems have involuted both from technical and economically especially from interest of consumer point of view.

[1] Project Manager, SC ATH Energ SRL, Bucharest, Romania, e-mail: carmen.coman@athenerg.ro
[2] Prof., Depart. of Energy Production and Use, University POLITEHNICA of Bucharest, Romania, e-mail: victorath@gmail.com

In the same time, regulated prices for natural gas have been more attractive for urban consumer which has chosen to disconnect from DH system and install his own natural gas boiler.

Until 2011 year, subsidies for heat from DH systems have been supplied both from state and local budget. From 2011 year, subsidies from state budget have been eliminated. Current legislation provide that heat price from DH systems can be subsidied only by local authorities in the limit of local budget. Natural gas prices are still regulated for population and heat producers for DH systems but these will be eliminated gradually until 2018 year according to a schedule elaborated by Romanian Government.

This paper present a comparative calculation of heat price of urban consumers from district heating systems to those with apartment boiler in context of current legislation. In the same time underlines effects of liberation of energy prices according to the schedule of eliminating regulated prices.

2. Presentation of main charateristics of analized DH systems

In this paper are presented 12 cities with DH systems from different geographic regions of Romania.

2.a Main characteristics of analized DH systems

Table 1 presents main characteristics of DH from analized cities. For the uniformity of comparison has been chosen a conventional apartment composed of 2.5 rooms and 2.5 persons. The items from table 1 are following:

- design air temperature, t_e^c [^{0}C]– according to [1]

- average air temperature during heating period, t_e^{md} [^{0}C]– calculated using monthly average values of temperature from to [2]

- maxim heat necessary for 1 ap.cv, $q_{i.ap.cv.}^M$ – calculated through correction the reference value of maxim heat necessary of 1 ap.cv, $q_{i.ap.cv0}^M$, situated in a region with t_e^c=-15^{0}C [3] and wind speed $w_0^c = 5\,\frac{m}{s}$ - see equation (2).

$$q_{i.ap.cv0}^M = 4.5 \text{ kW} \tag{1}$$

$$q_{i.ap.cv.}^M = q_{i.cv0}^M \cdot \frac{t_i^c - t_e^c}{35} \cdot \frac{E + \left(w^c\right)^{\frac{4}{3}}}{E + \left(w_0^c\right)^{\frac{4}{3}}} \text{ - chapter 2.2.3, page 16 from [4]} \tag{2}$$

where E – eolian characteristic of building. Commonly,

$$E = 20 \div 40 \tag{3}$$

For a building with normal glazing,

$E = 30$ - chapter 2.2.7, page 29 from [4]

w^c - design wind speed [m/s], according to [1]

- average heat necessary for hot tap water $q^{md}_{acc.ap.cv.}$ [kW] – calculated according to [3]

- average heat necessary for 1 ap. cv., $q^{md}_{i.ap.cv.}$ - calculated through correction of $q^{M}_{i.ap.cv.}$ with value of t^{md}_e - see equation (4)

$$q^{md}_{i.ap.cv.} = q^{M}_{i.cv} \cdot \frac{t^c_i - t^{md}_e}{t^c_i - t^c_e} \qquad \text{[kW]} \tag{4}$$

where t^c_i =20^{0}C - ambient temperature

- heating period [hours/year], τ^{an}_{inc} - calculated according to [2]
- number of apartments connected to DH at 31.dec.2011 - according to [5]
- number of initial connected to DH - according to [5]

Table 1

Main characteristics of DH systems analized

City	t^c_e	t^{md}_e	$q^{M}_{i.ap.cv.}$	$q^{md}_{acc.ap.cv.}$	$q^{md}_{i.ap.cv.}$	τ^{an}_{inc}	Number of ap. connected to DH at 31.dec.2011	Initial number of ap. connected to DH
	^{0}C	^{0}C	kW	kW	kW	hours/ year	nr. ap.	nr. ap.
1	-15	2.30	4.50	0.67	2.28	4560	567657	602000
2	-12	3.50	4.11	0.67	2.12	4320	86614	89000
3	-15	3.20	4.24	0.67	2.04	4584	34727	43660
4	-15	3.20	4.24	0.67	2.04	4560	78078	122160
5	-18	1.50	4.74	0.67	2.31	4872	51062	90700
6	-21	1.20	4.97	0.67	2.28	5496	22800	33160
7	-21	1.60	4.97	0.67	2.23	5064	7024	45000
8	-15	2.70	4.24	0.67	2.10	5064	30512	56598
9	-15	2.70	4.24	0.67	2.10	4632	29902	33000
11	-18	1.00	4.74	0.67	2.37	4992	18590	48000
15	-18	2.10	4.61	0.67	2.17	5088	9000	34900
29	-15	2.00	5.37	0.67	2.76	4680	5049	14700

2.b Yearly values of heat consumption

Table 2 presents yearly values of heat consumption for a conventional apartment.

Items from table 2 are the following:

- yearly heat consumption for heating, Q_{inc}^{an}

$$Q_{inc}^{an} = q_{i.ap.cv.}^{md} \cdot \tau_{inc}^{an} \quad [\text{MWh}] \tag{5}$$

- yearly heat consumption for hot tap water, Q_{acc}^{an}

$$Q_{acc}^{an} = q_{acc.ap.cv.}^{md} \cdot \tau_{acc}^{an} \qquad [\text{MWh}] \tag{6}$$

where τ_{acc}^{an} - yearly period for supply hot tap water

$$\tau_{acc}^{an} = 8000 \quad [\text{hours/year}] \tag{7}$$

Table 2

Yearly heat consumption

City	Q_{inc}^{an}	Q_{acc}^{an}	Q^{an}
	MWh/ year	MWh/ year	MWh/ year
1	10.38	5.36	15.74
2	9.16	5.36	14.52
3	9.34	5.36	14.70
4	9.29	5.36	14.65
5	11.25	5.36	16.61
6	12.53	5.36	17.89
7	11.30	5.36	16.66
8	10.62	5.36	15.98
9	9.71	5.36	15.07
11	11.84	5.36	17.20
15	11.04	5.36	16.40
29	12.92	5.36	18.28

3. Yearly costs of heat from DH

Table 3 presents yearly values of family from a conventional apartment and yearly costs of heat from DH.

Calculations from table 3 are made in the following assumptions:

- source income of a family: one salary;

- yearly income of a family, $V_{an.net}^{md}$: sum of average monthly incomes for a person from respective county. Average income/county has been considered for uniformity of calculation and comparison being in the same time an indicator of economic developing of the county. Values of monthly average incomes are those published in [6].

Calculations of heat costs are made in two situations:

- situation of approved heat price by ANRSC, $p_{Q.ap}$
- situation of paid heat price by population, $p_{Q.f}$

where:

$$p_{Q.f} = p_{Q.ap} - s \tag{8}$$

s- subsidy from local budget

Table 3

Yearly costs of heat from DH

City	$V_{an.net}^{md}$ lei/ family/ county	$p_{Q.ap}$	$p_{Q.f}$	Yearly costs of heat from DH :			
				According to $p_{Q.f}$, $C_{Q.f}^{an}$		According to $p_{Q.ap}$, $C_{Q.r}^{an}$	
	lei/ year/ family	lei/MWh with VAT	lei/MWh with VAT	lei/year with VAT	% from $V_{an.net}^{md}$	lei/ year with VAT	% from $V_{an.net}^{md}$
1	25447	273.19	146.07	2299	9.03	4299	16.89
2	16652	290.91	290.91	4225	25.37	4225	25.37
3	14996	264.33	264.33	3885	25.91	3885	25.91
4	18017	280.15	216.83	3176	17.63	4104	22.78
5	15902	249.29	159.07	2642	16.62	4141	26.04
6	12304	254.81	159.48	2853	23.18	4558	37.04
7	15149	336.45	198.62	3308	21.84	5604	36.99
8	17585	349.81	210.66	3367	19.14	5590	31.79
9	14970	169.63	119.29	1798	12.01	2557	17.08
11	14761	241.72	133.14	2290	15.51	4158	28.17
15	12936	267.98	152.34	2499	19.31	4395	33.98
29	13374	288.02	288.02	5266	39.38	5266	39.38

Items from table 3 are the following:

- total costs of heat in case of approved heat price, $C_{Q.r}^{an}$

$$C_{Q.r}^{an} = p_{Q.ap} \cdot Q^{an} \quad \text{[lei/year]} \tag{9}$$

- total costs of heat in case of paid heat price, $C_{Q.f}^{an}$, respective value of heat invoice paid by population:

$$C_{Q.f}^{an} = p_{Q.f} \cdot Q^{an} \quad \text{[lei/year]} \tag{10}$$

From the table 3 can be observed that subsidy for heat from DH, cover until 47% from approved heat price, $p_{Q.ap}$, depending on financial resources of local authorities,

$$\frac{p_{Q.f}}{p_{Q.ap}} = 0 \div 47\% \tag{14}$$

In the same time, table 1, shows that disconnection rate from DH differs from one city to another. This can be explained through low payment capacity of consumers but through existing natural gas distribution network. According to statistic data from [6], in 2011 year, average income at national level was 18048 lei/year/person. Except city 1, for all the others cities, average income/county is lower than average income/national economy – see table 3.

In the cities where local authorities can not provide subsidy, DH supllies heat for 20% from total number of consumers – see cities 15 and 29.

Analysis of share of yearly heat costs in family income – see table 3 –led to the conclusion that eliminating of subsidy will led to a share higher than 20% from anual income of a family.

Statistic data from april 2012 published by ANRSC have shown that eliminating subsidy from central budget, in 2011 year, had the effect of drastic increasing of disconnections – see table 4. The reference is for april month because is considered that in april heating period is ended for almost all cities from Romania.

Table 4

Effect of eliminating subsidy from local budget

City	31 December 2011			30 April 2012			Disconnections at 30 April 2012	
	Number of connected apartments at DH	Heat price, [lei/MWh] with VAT		connected apartments at DH	Heat price, [lei/MWh] with VAT		nr. ap.	% from 31.dec.2011
		$p_{Q.ap}$	$p_{Q.f}$		$p_{Q.ap}$	$p_{Q.f}$		
1	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
29	5049	288.02	288.02	3702	288.02	288.02	1347	27
5	51062	249.29	159.07	49860	249.29	227.86	1202	2
15	9000	267.98	152.34	6500	267.98	256.66	2500	28

It follows that main elements which affect evolution of DH are heat price and payment capacity of consumers.

4. Yearly costs of heat from an apartment boiler

Table 5 presents yearly values of heat costs of family which has own boiler in apartment (conventional apartment).

Yearly costs of heat supplied from an apartment boiler are calculated, taking into account the following hypothesis:

- calculations are made in euro due to different date of approval of prices by ANRE or ANRSC;
- natural gas price, p_{GN} [lei/MWh] without VAT– regulated price approved by ANRE for supplier from respective city, according to [7] .
- natural gas price, p_{GN} [euro/MWh] – according to exchange rate of BNR at approval date.
- natural gas consumption, B_{GN} is calculated considering an average yearly efficiency of boiler =95%

$$B_{GN} = \frac{Q^{an}}{0.95} \text{ [MWh/year]} \tag{11}$$

- yearly cost of natural gas, C_{GN}^{an} :

$$C_{GN}^{an} = B_{GN} \cdot p_{GN} \text{ [euro/year]} \tag{12}$$

- electricity price, $p_{.E}$ [lei/MWh] without VAT - regulated price of electricity for population, according to [8];
- electricity price, $p_{.E}$ [euro/MWh] – according to exchange rate of BNR at approval date.
- invoice for electricity includes, C_E^{an} :
  - Cost of electricity consumption for pumping hot water for heat and hot tap water, considering a specific consumption of 15 kWh/ MWh .
  - Cogeneration tax, paid according to electricity consumption for pumping, considering 0,0212 lei/MWh – according to [9] .
  - Excise for electricity, respective 1 euro/1 MWh, for noncommercial consumption.
- periodic inspection of boiler, $C_{insp.boiler}$ - every two years, estimated to 200 lei/inspection, respective 100 lei/year.

- periodic inspection of natural gas circuit, comprised between individual branching and site of consumption, $C_{insp.GN}$ - every two years, estimated at 250 lei/inspection, respective 125 lei/year.
- yearly cost of heat, $C^{an}_{boiler.ap.cv}$:

$$C^{an}_{boiler.ap.cv} = C^{an}_{GN} + C^{an}_{E} + C_{insp.boiler} + C_{insp.GN} \text{ [euro/year]} \quad (13)$$

- heat price, $p_{Q.ap.cv}$:

$$p_{Q.ap.cv} = \frac{C^{an}_{boiler.ap.cv}}{Q^{an}} \quad \text{[euro/MWh]} \quad (14)$$

Table 5

Yearly costs of heat supplied from an apartment boiler

City	p_{GN}		$p_{.E}$		$C^{an}_{boiler.ap.cv}$ without VAT	$p_{Q.ap.cv}$		% from $p_{Q.ap}$	% from $p_{Q.f}$
	lei/ MWh	euro/ MWh	lei/ kWh	euro/ kWh	euro/ year	without VAT lei/ MWh	with VAT lei/ MWh	%	%
1	96.48	22.33	0.4547	0.105	468.84	128.69	159.58	58.41	109.25
2	89.51	20.72	0.4547	0.105	410.69	122.14	151.45	52.06	52.06
3	96.20	22.27	0.4547	0.105	440.22	129.39	160.45	60.70	60.70
4	96.20	22.27	0.4547	0.105	438.92	129.44	160.51	57.29	74.03
5	96.20	22.27	0.4547	0.105	490.80	127.63	158.26	63.48	99.49
6	96.20	22.27	0.4547	0.105	524.46	126.66	157.06	61.64	98.48
7	96.20	22.27	0.4547	0.102	491.21	127.39	157.97	46.95	79.53
8	96.48	22.33	0.4547	0.102	474.56	128.27	159.06	45.47	75.51
9	96.48	22.33	0.4547	0.102	450.60	129.12	160.11	94.39	134.22
11	96.20	22.27	0.4547	0.102	505.55	126.97	157.44	65.13	118.25
15	96.20	22.27	0.4547	0.102	484.49	127.60	158.23	59.04	103.87
29	104.02	24.08	0.4547	0.102	570.90	134.88	167.25	58.07	58.07

Comparing heat price from an apartment boiler, $p_{Q.ap.cv}$ from table 5 with approved heat price from DH, $p_{Q.ap}$ from table 3 result that $p_{Q.ap.cv}$ represents until 80% from $p_{Q.ap}$ leading to a false conclusion that heat production in apartment boiler is more profitable than DH system.

This false conclusion is the resultant of the following aspects:

-Subsidy from central budget for heat from DH has been eliminated at the begining of heating season 2011-2012 but really it has been transfered as a task of local authorities.

- State, through ANRE, maintain regulated prices for natural gas both for population and heat producers from DH. These will be eliminated gradually until 2018 year, according to a schedule of Romanian Government with approval of International Monetary Fund.

- In conditions of eliminating subsidies heat from DH must confront unfair competition of apartment boilers at least until 2018 year.

5. Conclusions

DH systems from Romania fronts today with two main problems:

- precarious technical condition due the life time of 25-30 years, oversizing in relation to actually heat demand, high losses, all these leading to high costs;
- regulations regarding heat price from DH and natural gas prices.

Unfortunately, these regulations had and still have an uneconomic effect for DH systems.

In these conditions, local authorities face two major problems:

- finding financial resources to maintain and rehabilitate DH systems because DH is a public service which must be available for all citizens even for those which today has apartment boilers –see pag. 296 from [10] ;
- rehabilitation DH in actually conditions of heat demand but also in terms of legislation regarding energy efficiency and environment.

The EU Council has adopted the energy strategy for the period until 2020 “Europe 2020 for an intelligent, sustainable and favourable for inclusion growth” having the targets of reducing green house gas emissions, increasing of share of energy production from renewables and increasing of energy efficiency – see remarks from pag. 297 and 298 from [11].

In 2012, EU approved Directive no. 27/2012 regarding energy efficiency which promote district heating as a solution to meet the targets for 2020 year to growth energy efficiency and decreasing consumption of primary resources. Implemention in national legislation of EU Directive no. 27/2012 seems to be an aid for future of DH.

R E F E R E N C E S

[1] SR 1907-1/1997, Instalaţii de încălzire, necesarul de căldură de calcul, prescripţii de calcul (Heating installations, design heat necessary, design prescriptions)

[2] SR 4839/1997, Instalaţii de încălzire, necesarul de căldură de calcul, Numărul anual de grade-zile (Heating installations, design heat necessary, yearly number of degree-days)

[3] SR 1478/1990, Alimentarea cu apă la construcţiile civile şi industriale (Water supply for civil and industrial buildings)

[4] *V. Athanasovici – coordonator, I. S. Dumitrescu, Roxana Pătraşcu, I. Bitir, E. Minciuc, F. Alexe, V. Cenuşe, C. Răducanu, Carmen Coman, C. Constantin*, Tratat de inginerie termică. Alimentări cu căldură. Cogenerare, Editura AGIR (Thermal engineering treaty. Heat supply. Cogeneration, AGIR Publishing), Bucureşti, 2010.
[5] http://www.anrsc.ro
[6] Institutul Național de Statistică, Buletine statistice lunare județene din anul 2011 (National Institute of Statistics, Monthly statistic bulletins for counties from 2011 year) http://www.insse.ro
[7] *** Ordinul ANRE nr. 48/06.12.2011 (ANRE Order no. 48/06.12.2011), http://www.anre.ro
[8] *** Ordinul ANRE nr. 25/28.06.2012 (ANRE Order no. 25/28.06.2012), http://www.anre.ro
[9] *** Ordinul ANRE nr. 27/28.06.2012 (ANRE Order no. 27/28.06.2012), http://www.anre.ro
[10] *Cristina Cremenescu, A. Leca,* Le prix de la chaleur produite en cogeneration, Scientific Bulletin, Series C, Volume 74, Issue 3 from 2012, pag. 293-305, Universitatea Politehnica Bucureşti, 2012.
[11] *Roxana Pătraşcu, E. Minciuc, G. Darie,* Case study regarding the energy efficiency of cogeneration compared to separate heat and power supply of a residential area, Scientific Bulletin, Series C, Volume 75, Issue 1 from 2013, pag. 297-308, Universitatea Politehnica Bucureşti, 2013.