DISTRICT HEATING IN THE SERVICE OF DEVELOPMENT OF ENERGY EFFICIENCY, COMPETITIVENESS AND SECURITY OF SUPPLY

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Abstract

Since the 70s of last century, precisely in 1973th when the first oil crisis happened due to a sudden increase in the price of oil, and 1979th when the second oil crisis happened, energy has become one of the priority themes of the European Union. In terms of the common electricity and natural gas market through the Directivesof the European Union (2009/72/EC and 2009/73/EC),large progress has been made. Transmission/transportation and distribution networks have become associated entity which provides access to all producers and customers within a single market of the European Union, with the aim of competitive production and supply of energy. Increased number of bidders has forced companies to be more competitive in production and to offer more innovative solutions. Due to the liberalization of the market,it is necessary to protect end users as well as companies that have network (regulated) activity.In this case the national regulator has the essential role to ensure safe and inexpensive transmission and distribution of energy to end users through optimal investment costs, and in the same time to ensure return of investments for energy operators. There is a large number of examples of bad praxiswhich influenced on the lack of competitiveness of individual energy systems, and it is the reason why the national regulator is so important in protection of both participants. The European Union did not deal with the district heating through the Directives, due to the fact that the transfer of thermal energy among Member States is not expected because of the large loss of the thermal energy over a long distances.Therefore, the district heating is left at the legislation of the Member States, so that the intensity of development district heating, especially liberalization, depends on the strategic development and knowledge of the country. Most transition countries did not recognize the importance of district heating in energy development of the country, so they had bad experiences.However, district heating with a well defined legal framework and of course, with a good awareness of the citizens themselves, has great advantages. The most important thing is that one network can receive thermal energy from different energy sources enabling diversification of sourceswhich may have an impact onthe price of primary energy, and consequently the price of thermal energy.

In Croatia, as well as in the most transition countries, there are huge problems related to district heating.Almost all companies dealing with district heating and central supply of thermal energy have had a loss in the amount of over € 200 million in last six years. On the other hand, consumers are dissatisfied with the price of the service. Because of that, most of themhave disconnected from the central production system and switched to use combi boilers that caused significant investment costs.

The aim of this study is to investigate the causes that have led to difficulties in the business of energy operators and to point out the deficiencies of the existing district heating systems. Also, we wantedtomake an overview of new measures needed to be done in order to give encouragement to the development of district heating systems as a competitive, safe and efficient system.

JEL Classification: Q41, Q48

Keywords: district heating, energy efficiency, competitiveness, entrepreneurship, regulation

1. INTRODUCTION

Eropska Union on average imports more than 50% of energy (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Energy_production_and_imports, date of access 03.03.2014.). The same situation is inCroatia whichstands in the average of the Europian Union (http://www.eihp.hr/hrvatski/projekti/EUH_od_45/EUH11web.pdf, date of access 03.03.2014.). Therefore, the European Union has set clear targets to be done by the end of 2020. Theyare known as 20/20/20 - 20% reduction in energy consumption, 20% production from renewable energy and 20% reduction in CO2 emissions. (http://ec.europa.eu/clima/policies/package/index_en.htm, date of access 03.03.2014.). Countries which understand European targets in time and recognize theirs geostrategic advantages and entrepreneurial resources will have the opportunityto take advantages of the funds intended for such projects.Thus, those countries will be able to create their own GDP and to solve the long-term environmental, economic and sociological problems.An example of the best practice is Denmark, which hasused its wind potential to develop wind power plants, so that today Denmark wind power plants are installed worldwide, and this has resulted in the largest direct employment in wind power plants industry in Europe by population (http://www.ewea.org/fileadmin/ewea_documents/documents/publications/factsheets/EWEA_FS-employment.pdf, date of access 03.03.2014.).Croatia should also recognize its potentials in the energy sector which could be drivers of industrial and entrepreneurial development. Also, the energy dependency could be reduced and competitiveness of the energy sector increased. Today, we witness a great use of solar cells for electricity production and also incentive prices for the production of electricity from such sources, although the efficiency of solar collectors for heat production is more efficient solution,but rarely used in Croatia. The explanation lies in the fact that production of such green electricity can be controlled because it ends in distribution network, and there are less ability for manipulation withproduced energy. Produced electricity is then used for heating domestic hot water. This is the sign that the system of incentives in the Republic of Croatia needs to be changed.If entrepreneurshipdevelopment and increased employment are not the result of these incentives, they did not achieve their purpose.Denmark usesits wind power plants potentialsalso in district heating, in a way that they have seasonal tanks for district heating so that in the case of the large amount of produced energy it is used for heating the water for district heating (http://www.folkecenter.net/gb/rd/power-balancing/district-heating/, date of access 03.03.2014.).This is the part of the strategy to produce all of its energy from renewable sourcesby the 2050, for which they need the development of district heating system.In Denmark, the district heating system is regulated, but on the existing network there are different producers who sell their produced energy in the system depending on the price which they offer.

In Croatia, this system is also regulated, butcompanies that deal with district heating have generated a loss over € 200 million in the last 6 years. On the other hand, consumers are dissatisfied with the cost of heating (not essentially with the unit price of energy), which was often expressed by public protests, burning bills and switching to combi boilers(http://www.tportal.hr/vijesti/hrvatska/239632/Karlovcani-opet-palili-racune-za-grijanje.html, date of access 03.03.2014.), although the central boiler system should be cheaper due to lower investment and maintenance costs.The business results and public protests influence at the overall bad external image of district heating in Croatia. On the other hand, the inner picture is somewhat different and reflect the actual situation and problems of companies dealing with district heating.

Croatia imports 50% of its energy needs, of which the major part is related to fuel oil and natural gas largely used for household heating and heating of domestic hot water.That's why district heating has great potential in creating alternatives to the primary sources of energy.The final product for end users would become heat energy (not gas, wood, or even coal) and conventional energy fuel used to produce heat would obtain a new cost-effective alternative to other sources such as biomass, waste, solar, and other future energy resources, the energy sources can be replaced by other profitable sources such as biomass, waste, solar, and other future energy resources.

2. EXISTING SYSTEMS FOR PRODUCTION OF THERMAL ENERGY

In Croatia, the system of production thermal energy could be classified into two categories. The first one, in which the thermal energy is produced from the "efficient" cogeneration plants (during the production of electricity in the combined process), where the current price is almost twice lower than the price at which energy consumers may purchase natural gas with the aim of production of heat in the convential gas boilers.Delivery of such energy is carried by HEP Toplinarstvo, company owned by HEP d.d.. In econd category, the thermal energy is produced in the town's district heating plants that convert energy source (gas, oil) to heat energy and sell it to the citizens. Beside HEP Toplinarstvo, there are 12 other energy operators which supply citizens with thermal energy.[1]

Production of thermal energy from cogeneration plants takes place in Sisak, Osijek and Zagreb and in all three cities the prices range from 0.16 to 0.18 kn/kWh for households, while the price of thermal energy for legal entities range from 0.31 to 0, 34 kn/kWh (CERA Annual Report, 2013, 126). From the above prices,one can see that there are some illogicalities, because there is no legitimate reason that the price of legal entitiesshould be higher.When this information is added to the price of gas from 0.30 to 0.34 kn/kWh (http://narodne-novine.nn.hr/clanci/sluzbeni/dodatni/429837.pdf, date of access 03.03.2014.)it is clear that the

[1] Croatian Energy Regulatory Agency, Annual Report for the 2012., 2013.

cost of thermal energy forhouseholdsis more than twice lower then its actualvalue. In the case of rising prices for the householdsit would have to be gradual (during two years) because of impact on citizens' standard.It should be doneonlywith previous announcement and explanation to consumers.The cause of the aforementiond prices dates from the past when HEP d.d. delivered electricity throughtout Croatia without competition. On the other hand, HEP Toplinarstvo, although in Croatia holding almost 90% market share of heat energy (CERA Annual Report, 2013, 120),represented less than 5% of the total income of HEP d.d.Hence,it was easier to get increase in electricity prices by 1% rather than 50% increase in the price of heat energy (the increase in revenue for HEP d.d. remaind the same). HEP Toplinarstvo accomplished loss, and loss was covered by HEP d.d.In that way, all Croatian citizens subsidized the price of thermal energy through the price they payd for electricity,although most of them didn't use thermal energy. Today, when the electricity market is liberalized, it is clear that the HEP d.d. can not keep a low cost of thermal energy, because it can't be covered with electricity on the liberalized electricity market.

The average energy consumption in buildings in Croatia is about 200 kWh/m2annually and 87% of the building are considered to be a large consumers of the energy. The largest consumers are buildings constructed between 1940 and 1970, with between 200 and 300 kWh/m2annually because of irrational collective consumptionas well as theirpoor insulation (Stirmer et al, 2013, 380-381). The example of comparisons of the heat energy consumption by theoperation areaof distribution (HEP Toplinarstvo, Brod-plin, Tehnostan, 2011) is shown in Table 1.

Table 1 The example of comparisons of the heat energy consumption by the-operation area of distribution (HEP Toplinarstvo, Brod-plin, Tehnostan, 2011)

City	Operator	Number of flats	Price kn/kWh	Consumption kWh	Floor area m^2	Average size of flat m^2	Average annual consumption kWh/m^2
Zagreb	HEP Toplinarstvo	31	0.12	334,000	1,629	53	205
Slavonski Brod	Brod-plin	35	0.23	137,200	1,106	32	124
Vukovar	Tehnostan	30	0.23	198,406	1,870	62	106

Source: Pudic et al, 2013, 149

Although cogeneration power plant is significantly better and more energy efficient than the separate production of electricity and heat because it can achieve greater efficiency, there are cases that such plant does not always work as efficiently as possible. Table 2. shows the usefulness of the cogeneration power plant TE-TO Zagreb.We can see that power plant operates with the usefulness of 54-70% on a monthly basis, and it means that the boiler plant can reach a level of efficiency above 90%on a daily basis. So with better control, we can get a more efficient plant.

Table 2 Efficiency TE-TO Zagreb for 2012

2012.	Delivered electricity	Delivered thermal energy	Delivered process steam		Total energy delivered	Consumption of natural gas		Consumption of fuel oil		Total fuel consumed	Usefulness drive	Share of fuel consumed	
												Electricity	Thermal energy
	[MWh]	[MWh]	[t]	[MWh]	[MWh]	[m3]	[MWh]	[t]	[MWh]	[MWh]	[%]	[%]	[%]
1.	223.843	151.477	34.831	29.026	404.346	47.962.000	455.772	14.044	156.005	611.777	66,1	36,6	29,5
2.	218.215	167.611	39.908	33.257	419.083	43.790.000	413.674	18.187	202.027	615.702	68,1	35,4	32,6
3.	185.626	85.225	20.744	17.287	288.138	45.013.000	423.888	595	6.609	430.497	66,9	43,1	23,8
4.	183.671	68.951	14.920	12.433	265.055	43.124.000	406.266	95	1.055	407.322	65,1	45,1	20,0
5.	156.261	22.420	15.005	12.504	191.185	35.124.000	336.520	0	0	336.520	56,8	46,4	10,4
6.	39.314	3.034	11.650	9.708	52.056	9.557.821	92.038	0	0	92.038	56,6	42,7	13,8
7.	162.446	16.445	14.677	12.231	191.122	36.801.861	354.193	0	0	354.193	54,0	45,9	8,1
8.	185.353	14.417	20.013	16.678	216.448	42.098.199	404.166	0	0	404.166	53,6	45,9	7,7
9.	156.208	15.472	14.814	12.345	184.025	35.615.049	339.904	0	0	339.904	54,1	46,0	8,2
10.	145.415	63.561	17.628	14.690	223.666	36.177.760	339.560	0	0	339.560	65,9	42,8	23,0
11.	113.572	92.225	15.995	13.329	219.127	33.579.120	315.178	194	2.155	317.333	69,1	35,8	33,3
12.	165.935	148.811	35.338	29.448	344.195	49.177.410	464.775	2.446	27.171	491.946	70,0	33,7	36,2
TOTAL:	**1.935.860**	**849.649**	**255.523**	**212.936**	**2.998.445**	**458.020.220**	**4.345.935**	**35.561**	**395.023**	**4.740.959**	**63,2**	**40,8**	**22,4**

Source: HEP Proizvodnja

The problem is that with the simultaneous production of electricity and heat the plant does not operate in the most efficient mannerdue to the different needs of energy, and it is not in the proportion of production that would be the most competitive for both types of energy. Therefore, the plant should be optimized with tanks for peak consumption and dimensioned so to works according to the needs of thermal energy.

There are two types of district heating networks: hot water and steam. Both of them are very poorly maintained, with large losses.The heat substation often belong to the distributor of heat.Some of them are new, old, bigger or smaller.Thus, that buildings need to have different prices, but the prices are the same for all of them.

Production of thermal energy in the district heating boilers ismainly produced by fuel oil and natural gas. The prices of heat energy consist of the fixed and variable heat components. Fixed component refers to the investment costs, amortization, maintenance costs and salaries. The variable component refers to the cost of heat energy. The fixed component of the costs is mainly covered, although there is much scope for rationalization and modern technology. The variable component ranges from 0.38 to 0.44 kn/kWh and now can cover costs of fuel, but in the past it was quite difficult to operate because the income of the variable component did not cover operating costs.

The calculation of approved costs of fuel consisted of the real costs of all energy sources (gas, oil, etc.) from which was calculated the average cost of energy. In this way, the building that used cheaper fuel paid a higher price due to higher fuel prices which were used by other buildings (Banovac et al; 2007, 409-420).

Simple calculation shows that the tenants of one building could know whether they pay more than they would pay to managethe heating plantthemselves, and in the case of paying a bigger price they could request separation from the central system or go into public protest. The comparison is simple. For example, we have one company that manages with 50% power plants with one type of fuel, and with 50% power plants with the other type of fuel. In case of increase in the price of one type of fuel for 10% all heating power plants would have increase in the price by 5%.Citizens whose fuel prices rose would not understand why their price rises by 5%, if they use a fuel whose prices were not rised. It is the same as identifying profitable and unprofitable customer. If company has a non-profitable customers,the loss of profits has to be covered with the rise of prices for profitable customers and there is a risk that it will lose profitable customer or its profit.

HEP Toplinarstvo also has such local boilerplants, and which are used for heating of households and legal entities in the areas of the cities of Velika Gorica, Zaprešić, Samobor and Zagreb. The heat energy tariffs in Velika Gorica, Samobor and Zaprešić are 0.30 kn/kWh for households and 0.34 kn/kWh for legal entities and they are the same for all buildings, although as we mentioned above, buildings have different types of fuels (natural gas, extra light fuel oil, light fuel oil) whose purchase energy pricesvary from 0.30 to 0.34 kn/kWh for natural gas and up to 0.55 kn/kWh for extra light fuel oil. It can be seen thatthe income of heat energy tariffs can not coveredthe costs of fuels. Even worse situation with such a local boiler plants is in Zagreb, where the energy prices are 0.17 kn/kWh for households and 0.34 kn/kWh for legal entities, who are also using different types of fuel such as natural gas, extra light fuel oil and light fuel oil.Households which are supplied by HEP Toplinarstvo have much lower costs than they would have, if they would buy their fuel themselves. With this price, HEP Toplinarstvo makes a loss of 22 million kuna (€ 3 million) only on theproduced heat energy for 29 of these boiler plants.This also means that some other consumers and taxpayers subsidize for them. Tables 3, 4 and 5 compare the costs and revenues of the local boiler plants owned by HEP Toplinarstvo.

Table 3. Natural gas boiler plants 2012 (25 boiler plants and approximately 7,000 households)

MWh gas	Quantity of gas m3	Price of gas kn/m3	Fuel costs kn	Price of heat energy kn/kWh	Heat energy costs kn	Increase % (4/6-1)*100
0	2	3	4	5	6	7
13,822	1,865,719	3	5,597,157	0.17	2,349,740	138.20
5,373	725,250	3	2,175,750	0.17	913,410	138.20
2,767	373,536	3	1,120,608	0.17	470,390	138.23
2,297	310,053	3	930,159	0.17	390,490	138.20
2,485	335,458	3	1,006,374	0.17	422,450	138.22
1,683	227,151	3	681,453	0.17	286,110	138.18
2,130	287,513	3	862,539	0.17	362,100	138.20
3,011	406,380	3	1,219,140	0.17	511,870	138.17
1,046	141,130	3	423,390	0.17	177,820	138.10
1,140	153,893	3	461,679	0.17	193,800	138.22
1,013	136,783	3	410,349	0.17	172,210	138.28
4,812	649,479	3	1,948,437	0.17	818,040	138.18
3,850	519,605	3	1,558,815	0.17	654,500	138.17
3,764	508,027	3	1,524,081	0.17	639,880	138.18
4,497	606,602	3	1,819,806	0.17	764,490	138.04

2,763	372,944	3	1,118,832	0.17	469,710	138.20
1,984	267,849	3	803,547	0.17	337,280	138.24
1,806	243,760	3	731,280	0.17	307,020	138.19
4,538	612,476	3	1,837,428	0.17	771,460	138.18
1,722	232,461	3	697,383	0.17	292,740	138.23
326	43,992	3	131,976	0.17	55,420	138.14
2,541	342,960	3	1,028,880	0.17	431,970	138.18
4,164	562,010	3	1,686,030	0.17	707,880	138.18
1,632	220,267	3	660,801	0.17	277,440	138.18
1,655	223,404	3	670,212	0.17	281,350	138.21
76,821	10,368,702	3	31,106,106	0.17	13,059,570	138.19

Source: Done by the author

Table 4. Extra light fuel oil boiler plants 2012 (3boiler plants and approximately 500 households)

MWh ELFO	Quantity of ELFO l	Price of ELFO kn/l	Fuel costs kn	Price of heat energy kn/kWh	Heat energy costs kn	Increase % (4/6-1)*100
0	2	3	4	5	6	7
1,115	158,851	5.5	873,681	0.17	189,550	360.92
1,967	280,316	5.5	1,541,738	0.17	334,390	361.06
2,532	360,866	5.5	1,984,763	0.17	430,440	361.10
5,614	**800,033**	**5.5**	**4,400,182**	**0.17**	**954,380**	**361.05**

Source: Done by the author

Table 5. Light fuel oil boiler plants 2012 (1 boiler plant and approximately 150 households)

MWh LFO	Quantity of LFO l	Price of LFO kn/l	Fuel costs kn	Price of heat energy kn/kWh	Heat energy costs kn	Increase % (4/6-1)*100
1	2	3	4	5	6	7
1,622	193,580	5	967,900	0.17	275,740	251.02

Source: Done by the author

Tables 3, 4 and 5 show that buildings in Zagreb, 29 of them managed by HEP Toplinarstvo, pay 14.5 million kuna (€ 2 million) for heatenergy, while thefuel costs of HEP Toplinarstvo for the same building are 36.5 million kuna (€ 5 million). Therefore, the loss is, as stated above, 22 million kuna (€ 3 million).

In Zagreb, there are still hundreds of boiler plantswhich are independently managed and maintained by their owners and their real costs are higher. We can see that there differences between boiler plants, but the question is why?

The main problem in both cogeneration and local boilerplantsis collective consumption and it is one of the reasons why people disconnect from the system of district heating.In collective consumption system, consumers can not manage their own consumption, andit depends on theirs neighbors in the same building.Consumption in buildings in which heat cost allocatorsare not installed to the radiators is 50-70% higher and it's distributed according to the square area.This means that all tenants, regardless of theirreal consumption, will pay the same price per one square. It was a problem, primarily because when someone wasabsent from home and did not heat his apartment (by closing the valve), he would have to pay the same account as if he heated it. There were cases of buildings where 50-80% of all apartments installed the heat cost allocators and then tenants who did not install them got less accounts.This provoked them to removethe heat cost allocators and return to the calculation without the heat cost allocators.

Another problem was the case where tenantsof the buildings heatedby energy operators (legal entities) had to pay up to 40% more expensive gas for heating of their households, because the price of gas for the legal entitiesin Croatia was more expensive than for households, and the reason of that lays in the fact that the Croatian Government had a social prices-policy. This was the cause of big losses for companies which are dealt with district heating, because they had to buy expensive gas which are then couldn't calculate to the households,because households would pay 100% higher prices than households which usecombi boilers due to the irrational collective consumption and higher gas prices.

3. DISTRICT HEATING AND HEATING WITH COMBI BOILERS

In each product, including the central heating plants costs per power unit decrease with the size of the plant, so combi boilers are significantly more expensive per flat than the large heating plant. In addition, simultaneity factor for heating domestic hot water used for only one flat is 1.15, while simultaneity factor for heating domestic hot water decreases when number of flatsincrease. So the power of the heating plant for heating a building is significantly lower than the overall power of the all combi boilers in the building.Same goes for the use of renewable energy sources in the application of solar collectors. The number of solar collectors significantly reduces per flat unit with increasing number of flats because of the simultaneity of using domestic hot water. Simultaneity factors for calculating power are 1.15 for 1 flat, 0.47 for 10 flats, 0.32 for 50 flats and 0.28 for 100 flats (Andrassy et al, 2010, 346).[2]Additionally, individual flats within a building can not use solar panels, while common facility is not a problem. Share of energy for domestic hot water in the total energy consumption ranges from 25% to 50% depending on how the building is energy efficient in heating.[3]Therefore in buildings which spend less energy for heating the share energy used for domestic hot water ranges up to 50%, with the inefficient consumption of hot water, because there is no measurement of consumption per flat unit. Ifmeters for domestic hot water would be installed, consumption of hot water would decrease up to 40%.[4]In the future, the measures that will be used in energy efficiency of buildings, primarily insulation, will increase the share of energy for domestic hot water in relation to the total energy consumption, and solar energy will have a significant impact on overall energy consumption. Approximately 30% of the total heat energy consumption in households is energy for domestic hot water.In continental part of Croatia, use of solar panels can satisfy 60% of needs for hot water, while in the coastal region it can satisfy about 85% of total needs. Data clearly show that we can significantly reduce energy consumption by using solar collectors (Domac et al; 2012.,13).[5]

4. CONCLUSION

The price of heatenergy shouldas soon as possible be put to the market prices. Also, energy poverty has to be defined as soon as possible, in order to make the system of subsidies and help those citizens who need it, but not all.Citizens have the wrong impression that energy is cheap so they waste it, and the government subsidizes it from other revenue, which is again paid by citizens.Looking at all the facts that are mentioned in the text, from the regulatory point of viewit is evident-

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2 UNDP, Handbook for energy certification of buildings, 2010.

3 Source of data: Brod-plin d.o.o., Heat consumption 2011.

4 Source of data: Brunata d.o.o., Consumption in buildings in Zagreb, 1-9/2013. to 10/2013-1/2014.

5 Regional Energy Agency of Northwest Croatian, Brochure to promote renewable energy sources, 2012.

that the district heating system has toreduce losses and operating costs. On the other hand, it is necessary that all households install heat cost allocators as soon as possible, in order to pay for only what they have consumed.

Solar power plants in low-temperature heating will have a great role in reducing consumption of fossil fuels, reducing CO2 emissions, developing entrepreneurship and the competitiveness. The same goes with biomass plants. These renewable energy sources significantly impact on reduction in imports and an increase in GDP.On the other hand, large facilities that can be connected to the district heating distribution network will certainly replace all small gas and oil boiler plants, so an efficient energy mix that will be used for heat production (wind, solar, biomass, waste) will increasethe purchaser's negotiation positionregarding the fossil fuelsprice.All this, together with the seasonal tanks the tanks of peak load, and with cheap surplus of heat energy from the market and the industrial facilities are a prerequisite for a secure, competitive and environmentally friendly heat energy supply.

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