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NATURAL GAS HEATING IN SERBIAN SETTLEMENTS ACCORDING TO URBANITY PARAMETERS *

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Dejan Brkić

University of Belgrade, Faculty of Mining and Geology,
Department of Petroleum Engineering, Belgrade, Serbia
E-mail: dejanrgf@tesla.rcub.bg.ac.rs

Abstract. *Natural gas can be directly used for heating of flats by gas distribution system. Indirectly, heating power plant can disburse natural gas and deliver hot water or steam for heating of flats. Decision of optimal way for gas heating usage is done based on spatial disposal of building, number and size of buildings in settlement, etc. Optimal solution, between gas distribution and district heating system (local or district heating by natural gas), can be done according to methodology (model approach) shown in this paper. According to variety of Serbian settlements (in density, size and layout of buildings) model which has ability to represent their different characteristics is formed. This model could be simple and useful tool for initial decision about energy supply system.*

Key words: *Natural Gas, Urbanism, Gas Distribution, District Heating*

1. INTRODUCTION

When we talk about energy consumption of a city, it is not enough to consider just the quantity and quality of certain raw materials, it is necessary to grade the entire line of other, more or less, directly or indirectly connected components. The first element to be considered is the level of life standard of its citizens. To connect any household to any centralized heating system, certain level of life standard is required. Indirectly, the size of living space per member of household, the quality of the apartment building, the age of the building construction, its position etc. are connected with the standard. People with higher living standard, do not take into consideration only economic parameters when deciding between gas distribution and district heating system. The decision is based on personal affinity (and often, prejudice) [1].

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In city conditions, the most appropriate option for satisfying heating demands is by utilization of the central system. The alternative for district heating system, with the same living standard, is the connection to gas distribution network with additional advantages by substitution of electrical energy for cooking. Today, most heating power plants are primarily disbursing natural gas. If both systems are available near the considered settlement, it is rational to connect flats on a more payable system. General methodology shown in this paper provides an optimal adoption of heating system based on scientific and economic criteria current prices and price ratios of natural gas, pipes, pumps and other elements in Serbia). Model is valid in general conditions for prices anywhere in the world, but with changes to these different inputs. These criteria are average size of buildings, average number of buildings per unit of area, natural gas price, price of system elements, e.g. prices of pipes and valves, prices of pumps or compressors, but without the expense for construction of heating power plants. The evaluation model for options of district heating or gas distribution system is developed on "Conditional Urban Area" of a hypothetical town and confirmed in a real demonstration settlement [1-5].

The present practice for heating systems selection and utilization of existing capacities in systems for centralized energy supply includes separate consideration of every single case or very often selection without clear criteria. However, characteristics of urban areas with the potential for further development of local heating by natural gas or district heating systems are different in habitant density, number of floors (stories) in buildings and their total size, type of building construction and insulation, distance between buildings and settlement layout. Proposed model could be useful to urban planners, municipal officials, public utility companies, etc., as the first step in system selection. Goal of this model is to determinate connections among urbanism and energy characteristics of urban settlements in cities, and to be of benefit for more rational usage of natural gas as non-renewable fossil fuel. Similar analysis was done in but for public buildings (school and office building). Legal and policy aspects of different energy supply systems utilization in households sector can be found also in available literature [6-9].

2. HYPOTHETICAL MODEL OF SETTLEMENT

During structure optimization of energetic supply on urban area, in the first place, it is necessary to determine the borders of observation zone. Such zone, by rule, is not homogeneous in energy demands. Very often, different density number of buildings per unit of area exists here, with different size of buildings and with different type of construction. City blocks with residential and other areas can be called for this purpose "Real Urban Area". For the model research, the term "Conditional Urban Area" can be initiated. "Real Urban Area" can be divided (parceled) into several zones with similar urban characteristics on each particular area and each part can be associated with one of the type of "Conditional Urban Areas". On the "Conditional Urban Area" it is possible to make different sorts of calculations, e.g. variation of gas or district heating pipe diameters, lengths. Changing these and other relevant parameters has an influence on the amount of construction costs and finally on the cost of energy supply. "Conditional Urban Area" can be understood as the model of real settlement that will be used as a basis for further analysis. Conclusions acquired on "Conditional Urban Area" research can be applied on "Real Urban Area". For determining the influence which density of energy demands and building structures (size, number and spatial disposition of building on "Real Urban Area") have on energy supply costs for the energetic model research, "Conditional Urban Area" with rectangular size with dimension approximately 160 m·315m=0,05 km^2 is adopted [2-4], [10-11]. Bigger residential area can be considered as a combination of several different "Conditional Urban Areas" with several different numbers of buildings; (see Fig. 1.). These different types adopted for model consideration are with 4, 8, 16, 32, 64 and 128 buildings per "Conditional Urban Area".

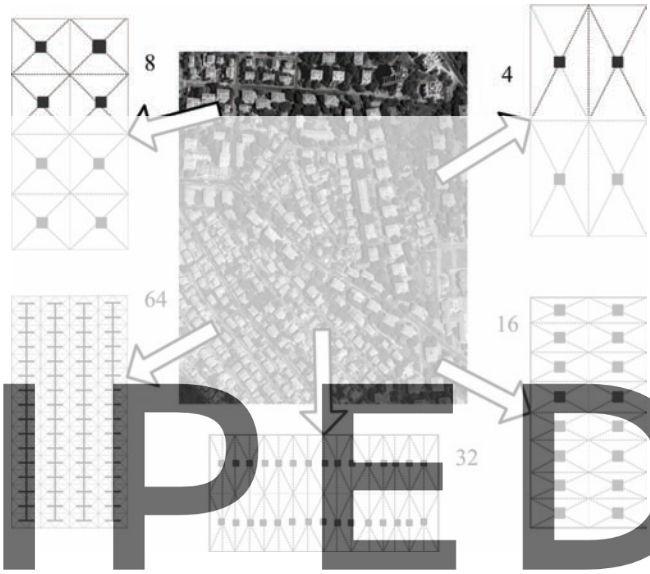

Fig. 1 "Real Urban Area" associates with several types of "Conditional Urban Areas"

Number of buildings at the area of 0,05 km^2 is considered as the first parameter that defines "Conditional Urban Areas". In addition, with each of these six types of "Conditional Urban Areas", it is possible to associate different sizes of buildings which are, in energy sense; equal to energy load, but on each particular "Conditional Urban Area" there has to be a uniform building size (see Fig. 2) [2-4], [10-11].

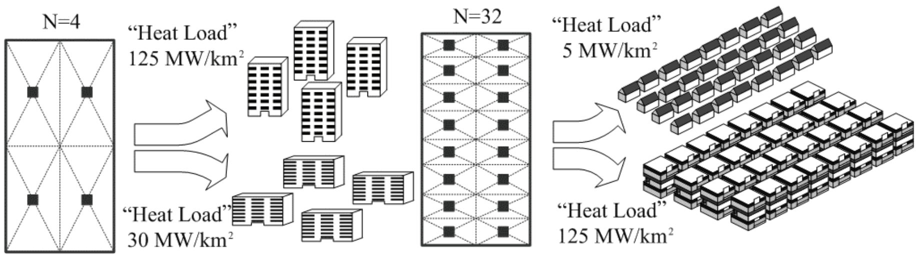

Fig. 2 "Real Urban Area" associates with several types of "Conditional Urban Areas"

Term building is used here also for family houses and similar smaller constructions in the same way of meaning as e.g. for skyscrapers. In all analyses, "Conditional Residential Unit", i.e. "Conditional Flat" with net heating area of 60m^2 is observed.

Similarity between "Conditional Urban Area" and "Real Urban Area" can be determined by two different independent quantities:

1) Heat demand of urban area ("Heat Load" or peak load densities of all heated buildings on a zone divided by size of an area), MW·km^{-2}; (see Fig. 2)

2) Number of buildings on urban area (number of buildings on 0,05km^{2} – 5 hectares); (see Fig. 1)

Different peak load densities or "Heat Load" i.e. size of buildings can correspond to the same number of buildings at structural urban area; Fig. 2. Peak load densities (can be marked as X) of 10 MW·km^{-2}, 20 MW·km^{-2}, 30 MW·km^{-2}, 40 MW·km^{-2}, 50 MW·km^{-2}, 75 MW·km^{-2}, 100 MW·km^{-2} or 125 MW·km^{-2} are chosen for analysis to include wide range of possible real urban situations. "Conditional Flat" has, for the purpose of model approach, heat demand of 142 W·m^{-2} (heat peak load for lower insulated flat) in case of lower (bad) insulation, and in case of better (good) insulation heat demand of 95 W·m^{-2} (heat peak load for better insulated flat). Each combination of defined number of buildings and peak load density corresponds to different number of average dwellings in the building (from minimal number; y=0,509 "Conditional Flat" per building to maximum number; y=180,45 "Conditional Flats" per building) [12-14]. These numbers can be set according to following equations (1-6):

$$N = 4 \rightarrow y = 0{,}4436 \cdot X \tag{1}$$

$$N = 8 \rightarrow y = 0{,}72182 \cdot X \tag{2}$$

$$N = 16 \rightarrow y = 0{,}35818 \cdot X \tag{3}$$

$$N = 32 \rightarrow y = 0{,}17818 \cdot X \tag{4}$$

$$N = 64 \rightarrow y = 0{,}1 \cdot X \tag{5}$$

$$N = 128 \rightarrow y = 0{,}05091 \cdot X \tag{6}$$

3. TECHNO-ECONOMICAL MODEL OF RATIONAL NATURAL GAS USAGE

While determining the investment costs, it is necessary to include all possible expenses within borders of the system. Infrastructure, common for both systems (gas distribution and district heating) is not calculated because these costs can abbreviate during comparisons (see Fig. 3). In figure 3, exploitation and transport (including storage) is common for both systems, while distribution of gas or district heating have different costs. Internal heating infrastructure (radiators) in a flat is common for both systems. While developing a model, investments in gas distribution network and investments in district heating pipeline are done separately. Each separate system has different elements, e.g. district heating system is built with iron pipes, pumps and heat exchangers, on the contrary, gas distribution system is built with cheaper polyethylene pipes and has stations for measuring and regulation with internal gas equipment (each flat has domestic gas boiler etc. Investment in a new heat power plant is not calculated for a model, available capacities in existing power plants have to be regarded [15-18].

Relative (per "Conditional Flat") investments (included annual costs as below) in district heating – DH and in local gas heating system –G (each and everyone "Conditional Flat" is equipped with domestic boiler fueled by natural gas) can be calculated after following equations (7-8) [2-5], [19-23]

$$DH = \frac{DHN + HE + DHOC}{y} \tag{7}$$

where:
DHN [€] – costs of District Heating Network, i.e. costs of building/civil works, costs of materials (insulated pipes, pumps, accessories, etc.) and telemetry systems, etc
HE [€] – costs of Heat Exchanger stations located in buildings,
DHOC [€] – annual costs of maintenance calculated as percentage of investment, in network (2,5%); lifetime 25 years, heat exchanger station (1,5%); lifetime 12 years, annual natural gas consumption-10% more than in system with domestic boiler in each "Conditional Flat" (942,7 m^3 per "Conditional Flat" - 0.12 $€\cdot m^{-3}$) and annual electricity consumption for pumps drive (250 kWh – 0,035 $€\cdot kWh^{-2}$)
y – number of "Conditional Flats" per "Conditional Urban Area"

$$G = \frac{MPRS + PRS + DN + DS + B + GOC}{y} \tag{8}$$

where:
MPRS [€] – costs includes costs of Main Pressure Reduction Stations,
PRS [€] – costs Pressure Reduction Stations,
DN [€] – costs of natural gas Distribution Network, i.e. costs of building works, costs of pipes and assembling, costs of control and telemetry systems, etc.
DS [€] – costs of Domestic measurement sets,
B [€] – costs of domestic boilers

GOC [€] – annual costs of maintenance calculated as percentage of investment, in gas distribution network (2,25%); lifetime 25 years, in pressure reduction station (2,25%); lifetime 25 years, in measurement set (2,25%), lifetime 12 years, domestic boiler (2,25%), lifetime 12 years and annual natural gas consumption (857 m^3 per "Conditional Flat" - 0.12 $€\cdot m^{-3}$)

Costs joined to each "Conditional Flat" are costs of Domestic measurement sets DS [€], and costs of domestic boilers B [€]

In the equations above are not shown costs common for both systems. Different investments in these two opposite systems can be compared for the purpose of a model

All previous investments are considered for present conditions in Serbian energy sector. This means that heat sources (district heating plants) and primary natural gas infrastructure (gas transmission pipelines and high/medium-pressure gas stations) have already existed in the greatest number of Serbian towns and have allowed connection of new consumers without further investments. Of course, this model is applicable for conditions and particular cases all over the world, but diagrams (figures in this paper) are generated for prices relation in Serbia.

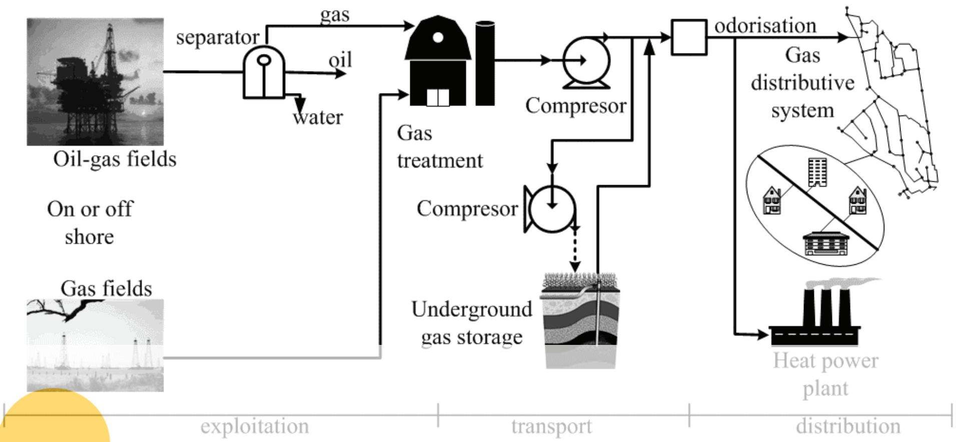

Fig. 3 Flows of natural gas from fields to consumers

District heating and natural gas networks are designed for 48 different combinations, according to previously defined peak load densities and numbers of buildings. Generally, each project task has a time component. Every particular element of the two systems shown here has a lifetime, and has a price on the market (expressed in €). If one of the elements has reached the end of its lifetime (e.g. 26 years), it has to be replaced. Thus, in a project, during the first and the next several years, costs for provision, maintenance and replacement of elements exist (e.g., some elements must be replaced after 14 years and some after 25 years). A sum of costs calculated in each year (t) for gas distribution system here is labeled as G, and for district heating system as DH. "Present Value of Costs" is one of the most useful criterions for project analyses for a whole lifetime of every particular system element. In that way, discount flows reduced on "Present Value of Costs" can be valuated. "Present Value of Costs" is, by default, cumulative cost for all the elements of the system in present and in future expanded for discount rate. "Future Value of Costs" has to be reduced to present value and to be added to real present costs. Thus, generated value is called "Present Value of Costs". For the reduction of "Future Value of Costs", appropriate "Discount Rate" (Dr) has to be adopted. Higher value of "Discount Rate" is calculated when risks for the safety of investments exist. "Discount Rate" could be equalized with "Interest" on the market or for realized credit [2, 24].

In our case, economical evaluation is realized during comparison of two "Present Values of Costs", for gas distribution system (G) and for district heating system (DH). "Net Present Value of Costs" (NPV) (9) is the result of subtraction of "Present Value of Costs" calculated for district heating system (DH) and "Present Value of Costs" calculated for gas distribution system (G).

$$NPV = \sum_{t=1}^{n} \frac{DH - G}{(1 + D_r)^t} \qquad (9)$$

These costs are calculated for all six types; Fig. 1 of "Conditional Urban Area". With every particular type of "Conditional Urban Area" eight different "Heat Loads"; (see Fig.

2) can be associated. All costs are reduced to a flat with net heating size of 60 m^2 ("Conditional Flat"). Value of "Discount Rate" in this case is rated and adopted as Dr=10%. Annual gas consumption calculated for one "Conditional Flat" is 857 m^3 for heating only, and for district heating system, this amount is for 10% higher. Annual costs of electrical energy for running of pumps for district heating system are estimated to 250 kWh per "Conditional Flat". Analyses are done for all 48 cases (six "Conditional Urban Area" multiplied by eight "Heat Loads") for the period of t=26 years (Table 2). Value of "Discount Rate" in this case is rated and adopted as Dr=10%.

Table 1 Costs for gas distribution system and district heating system (example N=32, "Heat Load"=75 MW·km^{-2} - one of 48 cases, 14 "Conditional Flat" per building)

€ per "Conditional Flat"													
	District Heating System						Gas Distribution System						
1	DH	2	3	4	5	6	G	7	8	9	10	11	DH-G
1	947	416	530	0	0	0	954	40,7	13,7	400	500	0	-7,0
2	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
3	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
4	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
5	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
6	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
7	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
8	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
9	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
10	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
11	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
12	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
13	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
14	568	0	530	18,38	10,2	8,75	921	0	0	400	500	22	-353
15	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
16	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
17	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
18	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
19	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
20	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
21	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
22	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
23	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
24	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
25	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
26	37,4	0	0	18,38	10,2	8,75	21,7	0	0	0	0	22	15,7
Σ	2413	417	1062	459	255	219	2397	40,7	13,7	800	1.000	544	16,0
"Discount Rate" = 10,0 %								"Net Present Value of Costs" NPV = 24,88					

Small differences in sum are generated by omission of decimal places

where (in Table 1, third line from top): 1. Year of project, 2. District heating pipeline, 3. Heat exchanger, 4. Maintenance of gas distribution system, 5. Cost for additional gas, 6. Cost for electrical energy, 7. Gas Distribution pipeline, 8. Cost for regulation station, 9. Cost for household connection set, 10. Cost for Gas Boiler, 11. Maintenance of district heating system

Table 2 "Net Present Value of Costs" (NPV) - € per "Conditional Flat"

Number of buildings	"Heat Loads", MW·km^{-2}							
	125	**100**	**75**	**50**	**40**	**30**	**20**	**10**
N=4	-802	-749	-689	-532	-451	-283	-9	467
N=8	-671	-599	-492	-291	-166	42	223	985
N=16	-454	-364	-203	-5	157	398	695	1.959
N=32	-152	-80	25	377	635	1.015	1.652	3.587
N=64	65	163	363	730	1.348	1.415	2.623	5.791
N=128	467	530	1.048	1.504	2.135	3.171	4.820	6.614

Negative values: district heating system has advantage
Positive values: gas distribution system has advantage

Calculations from table 2 are graphically shown in figure 4 and 5. Each individual case, in practice, should be considered in detail using the methodology mentioned in this study.

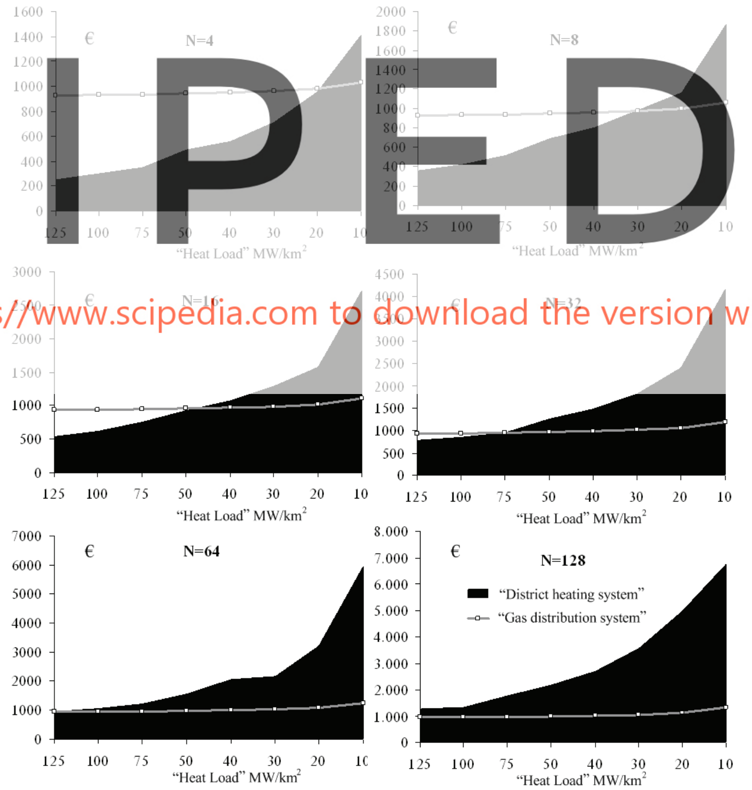

Fig. 4 "Present Value of Costs" (NPV) - € per "Conditional Flat" for district heating system and gas distribution system.

The values in certain cases in table 2 vary more or less from zero. For example, for "Conditional Urban Area" with 16 buildings and with "Heat Loads" 50 MW·km^{-2}, calculated "Net Present Value of Costs" (NPV) is only -5 per "Conditional Flat" for a period of 26 years. Therefore, in this case, realization of gas distribution system for that "Conditional Flat" is only 5€ for 26 years in advantage versus district heating system. This case and other similar are in the "gray zone"; (see Fig. 5). In the "gray zone", both systems are payable, especially for a period of 26 years.

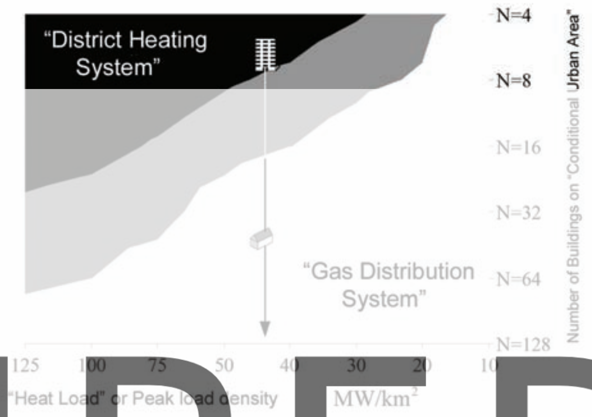

Fig. 5 Identification of cases on characteristic model diagram

If a considered value for a certain housing block exceeds, more or less, the recommended limiting value, the decision to recommend a particular centralized heating system is more reasonable. By changing the structure and the price ratio (i.e. the state political decision to subsidize the price of gas in a system or to issue a price, which would disturb the current price ratio of gas used for district heating system and individual consumers), conception and manner of construction of certain system and its elements, these parameters may vary. Currently, plastic-polyethylene pipes are used for distribution to individual consumers while steel pipes had been used before. It led to considerable cuts in network construction prices, while maintaining the same level of safety and endurance.

For the same "Heat Loads", when there are many smaller family houses located on a "Conditional Urban Area" e.g. N=32, sometimes only with one "Conditional Flat", gas distribution system is more reasonable. On the contrary, when there is a smaller number of skyscrapers located on "Conditional Urban Area" e.g. N=4, it is more reasonable to use district heating system (see Fig. 5).

By means of techno – economic analysis for a certain area, it is possible to determine the advantages of one system over the other (district heating and gas). However, considering the situation on the ground, it may turn out that the system is inaccessible in that part of the city (heat power plant does not have enough capacity or, in the first stage, the areas closest to the plant could have a priority in system installation). In that case, if the installation costs of the other available system are not too high, it is rational to install that type of heating system (thus saving the consumption costs of electric energy and reducing the amount of pollution if the object is coal – heated etc.) [25-27].

The biggest disadvantage of choosing the district heating system is that the payment is based on the volume of heated area that is in conflict with energy conservation. On the other hand, compared to gas, this system is safer since the combustion is not conducted inside a flat, which reduces the dangers of explosion and suffocation.

The additional advantage of the gas system is its substitution with the electric energy used for cooking.

If, after the analysis, it turns out that one system has more significant economic advantages than the others do, but it is unavailable, some form of hybrid system should be considered. For instance, if the installation of district heating system has a lot of economic advantages but it is not available, it is possible to build a local boiler room which would be gas operated. This hybrid solution would demand additional economic and ecologic analyses and estimations of which good features of district heating system would be kept and which would be discarded.

4. Applying of the Model in Real Conditions

Characteristics of "Real Urban Area": number of buildings, disposition and size of buildings, construction type, etc. are the factors of influence [2-3], [28-34].

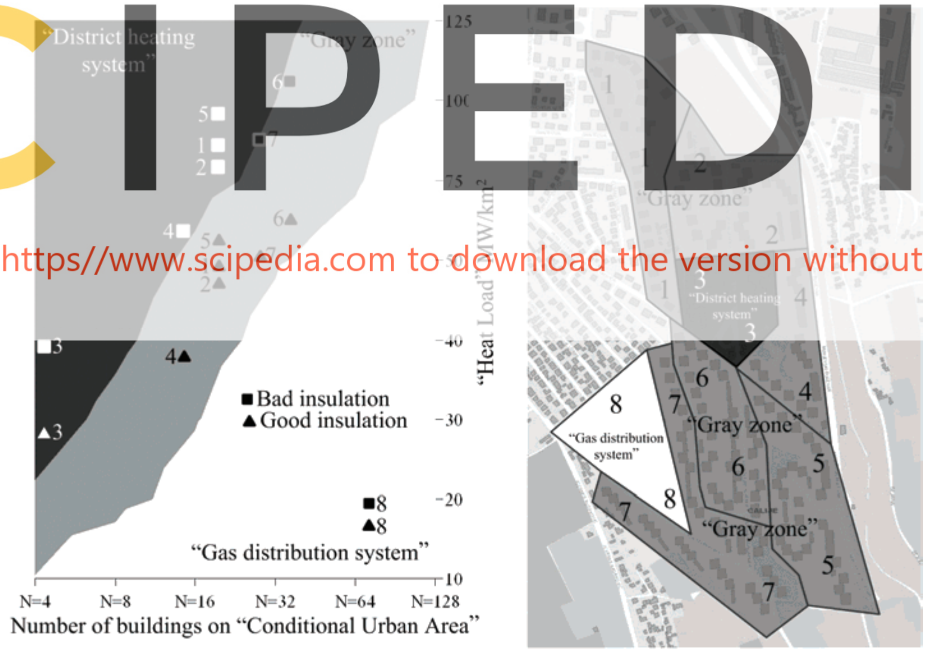

Fig. 6 Diagram for adoption of optimal system

Length and structure of pipeline, heat load, fuel consumption, apropos investments' and maintenance costs and exploitation of centralized systems depend on these specified factors of influence. Adoption of type of centralized heating system can be done according to the conclusion established by the model shown. That is possible only if both systems are available near the settlement. In that case, type of the chosen system depends only on urban characteristic of the settlement. Because of that, the demonstrative settlements are parceled (divided) into eight "Real Urban Areas" with similar buildings on each particular parcel (see Fig. 6). That way, the determined "Real Urban Area" can be associated with "Conditional Urban Area". Characteristic points for each of the eight parcels (intersection of number of buildings and heat load of parcel) can be plotted into the characteristic model diagram; (see Fig. 6). The characteristic model diagram can be like on figure 6 or counterclockwise like on figure 5 because both axes have the same priority. The types of insulation of the buildings in the settlement are mixed; old buildings have bad and new buildings have good insulation. Both old and new buildings have heterogeneous disposal.

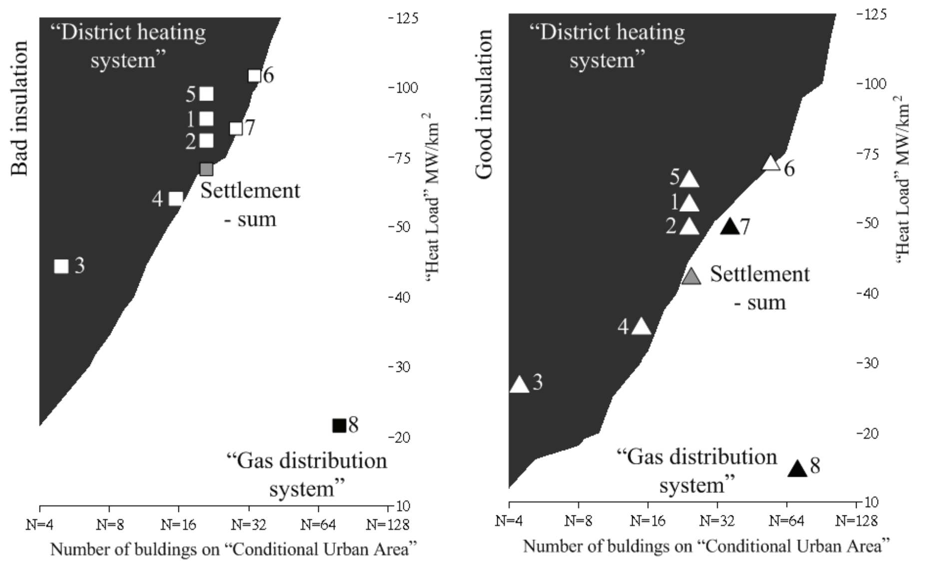

Fig. 7 Displacement of borders and characteristic points calculated for different quality of building insulation

Two border cases have been treated, because of heterogeneity of insulation quality of buildings; (see Fig. 7):

– Maximal "Heat Load", all buildings have bad insulation (144 $W \cdot m^{-2}$),

– Minimal "Heat Load", all buildings have good insulation (95 $W \cdot m^{-2}$),

The value of fuel consumption depends on heating insulation of the building. Therefore, "Heat Load" depends on heating insulation of the building. The number of buildings on each particular parcel is constant. "Gray zone" is the zone where decision on the type of the system depends very much on the type of insulation of the building; (see Fig. 6). In the "Gray zone", the costs for both systems (gas distribution system and district heating system) are very similar. Characteristic points for each of eight particular also depend on the quality of insulation.

"Real Urban Area" No 8 includes types of small buildings or family houses which can contain only one "Conditional Flat". Only for that, "Real Urban Area" the gas distribution system has very payable advantages versus district heating system. "Real Urban Area" No 3 includes school, kindergarten, local office, shops. These kinds of buildings can contain twenty or more "Conditional Flats". Only for that, "Real Urban Area" the district heating system has great advantages. All other zones are in "gray zone". In a "gray zone", one system is more payable in comparison with the other, no more than 200€ per "Conditional Flats". This amount cannot be crucial for decision.

Using one power resource (in this case natural gas) in various systems, the difference for amount of pollution is very little. Big differences cannot occur in the overall effect on the city level, but in certain areas. While heating plant is a concentrated pollutant which disperses harmful combustion products evenly on a wide area depending on the wind, gas lined consumption disperses locally (consumer pollutes his nearest neighborhood). Globally, the biggest gas consumer is the biggest city polluter. Considering the city ecology, it is possible to analyze the use of unconventional gas that solves the deposit problem etc. This problem is far more complicated and exceeds the volume of this study that primarily deals with the use of natural gas. For including environmental impacts of different centralized energy supply systems in model, it is necessary to estimate annual environmental costs for both systems and to include them in related equations.

Comparing all of the fossil fuels, natural gas is a minor pollutant. It burns without a solid residue and has the least coefficient of CO_2 emission of about 56 $kg{\cdot}GJ^{-1}$ (which is significant considering the limitations imposed by The Kyoto Protocol).

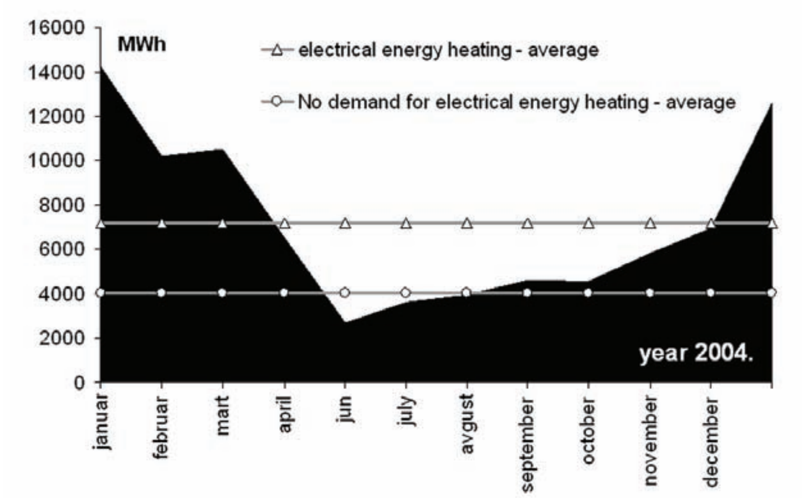

Fig. 8 Consumption of electrical energy in the observed settlement

The key advantage of installing gas or district heating system is not in their mutual differences, but in substitution of the far more expensive (in terms of energy and ecology) and the highest quality form of energy – the electric energy, whose usage for heating is by far less rational (see Fig. 8).

5. Conclusion

The conducted analyses confirm literature and empirical information.

– With higher number of heating consumers and a small object density, i.e. large number of apartments per object, district heating system is a better solution.

– Gas system is a better option in areas with high object density and, relatively, small number of consumers.

In more detail, if a certain number of objects N exist in a "Conditional Urban Area", it can be concluded that:

N = 4, district heating system has an advantage over gas if an average building has over 29 conditional apartments (i.e. if the overall heating surface is over 1740 m^2)

N = 8, district heating system has an advantage over gas if an average building has over 22 conditional apartments (i.e. if the overall heating surface is over 1320 m^2)

N = 16, district heating system has an advantage over gas if an average building has over 18 conditional apartments (i.e. if the overall heating surface is over 1080 m^2)

N = 32, district heating system has an advantage over gas if an average building has over 15 conditional apartments (i.e. if the overall heating surface is over 900 m^2)

N = 64, district heating system has an advantage over gas if an average building has over 12 conditional apartments (i.e. if the overall heating surface is over 702 m^2)

N = 128, gas system is practically always advantageous.

Based on the heat load, limiting parameters can be summed in regards to the number of objects per conditional construction area for:

N=4, district heating system has an advantage over gas if the heat load exceeds 20 $MW•km^{-2}$ (1.000 kW per 0,05 km^2 i.e. 5 ha)

N=8, district heating system has an advantage over gas if the heat load exceeds 30 $MW•km^{-2}$ (1.500 kW per 0,05 km^2 i.e. 5 ha)

N=16, district heating system has an advantage over gas if the heat load exceeds 50 $MW·km^{-2}$ (2.500 kW per 0,05 km^2 i.e. 5 ha)

N=32, district heating system has an advantage over gas if the heat load exceeds 75 $MW·km^{-2}$ (3.750 kW per 0,05 km^2 i.e. 5 ha)

N=64, district heating system has an advantage over gas if the heat load exceeds 150 $MW·km^{-2}$ (7.500 kW per 0,05 km^2 i.e. 5 ha)

N=128, gas system is practically always advantageous.

If large areas are covered by agricultural terrain, by excluding it, the above-mentioned parameters obtain unrealistic values. In this case, it is better to consider the length of routes. For:

N=4, district heating system is an advantage if the length of route is about 8 m

N=8, district heating system is an advantage if the length of route is about 7,6 m

N=16, district heating system is an advantage if the length of route is about 7 m

N=32, district heating system is an advantage if the length of route is about 6,4 m

N=64, district heating system is an advantage if the length of route is about 5,8 m

The above-mentioned limiting values for use of gas are consistent in case of an average heat-isolated apartment of 60 m^2. In other cases, additional corrections should be made, or different input values must be entered in the model.

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GREJANJE NA PRIRODNI GAS U NASELJIMA SRBIJE U SKLADU SA URBANISTIČKIM PARAMETRIMA

Dejan Brkić

Prirodni gas može biti korišćen direktno za grejanje preko gasne distributivne mreže. Posredno, prirodni gas može da se koristi kao gorivo za toplanu i da se putem daljinskog sistema grejanja isporučuje toplotna energija za grejanje stanova. Odluka o optimalnom korišćenju gasa između dva ponuđena rešenja može biti doneta na osnovu prostornog rasporeda zgrada, njihovebrojnosti i veličine u okviru pojedinog naselja, itd. Stoga, optimalan izbor između ponuđene upotrebe gasa u širokoj distribuciji domaćinstvima i sistema daljinskog grejanja koji kao primarno gorivo koristi gas (lokalno ili centralizovano sagorevanje gasa) može biti donet primenom metodologije (modelskim pristupom) prikazanim u ovom radu. Model je napravljen tako da obuhvati raznovrsne tipove naselja (u skladu sa veličinom i prostornim rasporedom zgrada) kakva se mogu sresti u Srbiji. Ovaj model predstavlja jednostavan i koristan alat za donošenje inicijalne odluke načinu grejanja

Ključne reči: *Prirodni gas, Urbanizam, Distribucija gasa, Centralno grejanje.*