REASONS FOR HEAT DEMAND CHANGES AND EFFECTS ON PLANNING AND DEVELOPMENT OF HEATING SYSTEMS

by

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Planning the development of heating systems in circumstances of dynamic changes in the energy field is becoming very demanding from the aspect of consideration and involvement all impacts on the future development.
The paper deals with a methodological approach towards the change of normatives which includes future conditions for the development and changes of heat energy consumption and possible scenario for the change of consumption in Novi Sad within the boundaries of capacities for future construction. The possible dynamics is determined and the projection of the existing consumption growth in the conditions of increasingly stringent energy circumstances for the further growth and strict energy requirements of contemporary moment.

Key words: *heat demand, specific indicators*

Introduction

Heat energy consumption implies heat for heating and air conditioning of buildings and heat for the preparation of sanitary hot water. The size of the heat energy consumption is determined by the built up area, purpose, structure and manner of building construction, as well as the local climatic conditions.

The built up area, purpose, type and structure of buildings are urban categories and the manner of building construction is determined by standards for building construction and climatic conditions. This is why defining the size of heat energy consumption in a particular area is a complex task with a large number of independent influences.

Additional difficulties in determining heat demand and heat energy consumption are caused by different periods of construction. This is manifested through different conditions which existed in the periods in which they occurred (application of different standards, design conditions, materials, common practice and the like). Cumulatively stated consumption of particular city zones or blocks makes one unit which includes all these differences. This means that it is possible to determine heat energy consumption accurately only as a simple sum of or individual buildings. On the other hand, it is difficult to check whether design documentation for every object is available and accessible. However, such a level of accuracy in planning

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documents is not necessary. At the same time, this will be an exceptionally complex work and a question can be raised whether it is justified under given circumstances.

Because of this, for the requirements of planning analyses, useful information concern average values of heat loads for certain categories of buildings from different periods of construction in the analyzed area. These values are calculated over heating and air conditioning normative for a building and net built up area in a given district.

Thus, heat energy consumption for heating and air conditioning at the level of cities is usually calculated as a product of net built up area of buildings and an average normative for a certain type of building. The first factor, datum about built up area, is an urban category and the other is energy characteristic of a building. It depends on the purpose, climatic conditions, applied standards in design and construction, type, dimensions, forms and other characteristics of a building.

Layout plans for determining heat demand

With reference to the aspect of the city development, planning documents of institutions in charge of city planning are used as layout plans for determining heat demand. In this case, this is Public Enterprise "Urbanizam", Novi Sad[1].

These documents usually define the lowest spatial unit "urban block" which will in this paper also represent a "consumption block" in the process of determining heat demand. This is a specific micro space within the limits of a construction area in the city which is defined in the Master Plan. For an urban, *i. e.*, consumption block, the following data are available:

– net area of consumption block (ha),
– total number of inhabitants,
– number of apartments,
– net housing surface (m_n^2), in particular for buildings with collective housing (number of floors larger than GF+1) (a so called high rise buildings) and for individual housing (number of floors up to GF+1) (a so called single family housing), and
– net area of commercial and accompanying premises (m_n^2), grouped per usual types of purposes.

This practically means that for determining heat demand it is necessary to have a normative according to some of above mentioned parameters. The most frequently used normative is the unit heat demand stated at the net area of the building's surface (W/m_n^2). This normative can significantly differ depending on the intended purpose of the building and thus their classification is very useful. It is usually done according to the following categories:

– residential buildings: collective housing and individual housing, and
– commercial buildings: health, culture, education, administration, larger offices, catering, manufacturing and other activities.

The normative for specific heat power for each of above categories of buildings is the function of: construction characteristics of a building, outside design and medium inside temperature of heated and air conditioned space.

For the heating and air conditioning normative, the key climate information is outside design temperature. According to applicable standards for design and construction of installations for heating of buildings, the outside design temperature for Novi Sad is –18 °C. Until 1970, the effective outside design temperature was –20 °C. Both design conditions were long

[1] The total population of the City of Novi Sad is some 300,000 inhabitants. Out of that number, around 250,000 people live at the city's territory which is mostly covered by the district heating system which has been developed for 50 years.

after 1970 used in practice. More recently, the professional circles are mentioning the justification for further increase of outside design temperature to –15 °C and even more. According to [1], coming into force of this regulation in 2011, the outside design temperature in Novi Sad will continue to be –14.8 °C. For a global character of heat consumption planning, the adopted medium inside design temperature is +20 °C as eligible for the calculation of consumption for all types of buildings.

This implies that in addition to urban data, determining heat demand requires normatives for above mentioned categories of buildings applicable at the time of their construction and in line with then applicable standards and design conditions.

Method of work and layout plans for determining heat demand

Generally speaking, heat demand in a certain district can be determined in several different ways:

- by analyzing and applying effective prescribed conditions for designing in the relevant period of construction (analytical method),
- by analyzing design documents,
- by analyzing issued approvals for connection,
- by using accepted normatives,
- by measuring at the threshold of heat delivery to buildings,
- by measuring at the threshold of heat delivery from the heating plant and by analyzing energy efficiency of the system and some of its units, and
- by combining several above mentioned methods.

Each of these methods has intrinsic specificities and cannot in a greater or lesser extent affect the accuracy of determined consumption. Only detailed measurements at the boundary of energy delivery to the building provide a completely realistic picture about the size of actual consumption in the given balance boundaries. However, this method requires many expensive and complex measurements and its application in planning is not justified. Planning does not require absolute accuracy and errors which occur by using some other methods are usually acceptable for planning analyses and preparation of planning documents.

Urban layout plans

In this paper, planning layout plans are used according to [2]. They define net built up surface of buildings in a district (consumption block, zone and city). Urban layout plans are official data provided by the Public Enterprise "Urbanizam" Novi Sad. They contain the situation found in 2009 and planned capacities for construction within the limits of the Master Plan for Novi Sad until 2021. The planned construction capacity implies maximum possible planned construction in compliance with Decisions on the Implementation of the Master Plan.

According to [2], the city is divided into 1113 urban blocks. Almost all blocks are located within the construction area of Novi Sad, *i. e.*, within the limits of the Master Plan until 2021. Data for blocks are taken from official plans and from plans which are undergoing the process of adoption. For blocks which are not included in any of the plans, basic guidelines are taken form the Master Plan. The groups of blocks comprise an urban zone. Among them, there are 25 residential and commercial zones, and the other ones are intended for economic activities, leisure, recreation and other activities.

Normatives for heating and air conditioning

In this paper, normatives obtained by combined methods will be used for residential buildings as a basis in the same way as they are used in the study [3] however, with corresponding corrections. This combined method uses results of the following procedures for determining normatives:

- analytical procedure – calculation of heat losses – according to design conditions applicable in the period 1980 – 1988 [3],
- by accepting calculated estimated heat losses for three typical buildings from the period 1980 – 1988 [3],
- results of analytical procedure by Public Enterprise "Urbanizam" Novi Sad for buildings in the period up to 1985 – estimated heat losses [3], and
- according to the analysis of the development of the system in Novi Sad until 1971 – really installed in radiators [4].

The normative for specific installed power for heating and air conditioning in non-residential buildings are also used according to [3]. This normative is established on the basis of the sample of randomly selected 160 buildings constructed until 1988 with totally installed power of 160 MW and total net surface of 540,000 m_n^2. Data about installed power are taken from the Novi Sad Heating Plant Registry and data about surfaces are taken from the Registry of the Town Planning Office for the same buildings. Normatives are determined for different categories of nonresidential buildings and during the calculation of heat demand, individual values for each of them will be used. Normatives determined in the above manner for 25 residential zones are given in tab. 1.

If heat characteristics of a building remain unchanged during time, the value of the normative based on this influence will not be change. The values presented in tab. 1 obviously confirm differences in normatives for the area of housing from various periods of construction. With unchanged conditions of inside design temperature, and due to climate changes and raised outside temperature (from –20.0 °C to –18.0 °C), the established normatives from the period of validity of outside design temperature of –20.0 °C (practically until 1988) should be corrected to new design conditions.

Table 1. Design normatives of specific heat power for heating and air conditioning

№	Type of building	Normative for the construction period	
		Until 1988	From 1988 to 2010
		q_1 [Wm_n^{-2}]	q_2 [Wm_n^{-2}]
1.	Residential buildings		
	1.1. Collective housing	in the range of 130-160	90
	1.2. Individual housing	200	120
2.	Non-residential buildings		
	2.1. Education institutions	190	190
	2.2. Administrative institutions	165	165
	2.3. Commercial buildings	200	200
	2.4. Catering facilities	200	200
	2.5. Healthcare facilities	190	190

A question can be raised whether such a correction is realistically achievable with reference to the functioning of installations and heating of the building. The answer is positive. The user of heated space or the owner of a substation may ensure technical conditions for newly established outside design temperature by means of regulators in the substation or on radiators. At that, the same inside temperature will be insured. If it is not done, the space will be overheated (inside temperatures in heated space will be higher than +20 °C). The value of the correction factor for such a conversion of the normative is:

$$k_f = \frac{t_u - t_{spp2}}{t_u - t_{spp1}} = 0.95 \tag{1}$$

where k_f is the correction factor for raised outside temperature (from –20.0 °C to –18.0 °C) [–], t_u – inside design temperature (20.0 °C) [°C], t_{spp1} – the outside design temperature in the period until 1988 (–20.0 °C) [°C] and t_{spp2} – the outside design temperature in the period after 1988 (–18.0 °C) [°C].

By applying the correction factor (k_f) to normatives given in tab. 1 for buildings constructed in the period until 1988, an acceptable normative is obtained for planning calculations of design heat energy consumption for heating and air conditioning of a situation found until 2009 (eq. 2).

$$q_{1c} = q_1 k_f \tag{2}$$

where q_{1c} [Wm_n^{-2}] is the corrected normative for the period of construction until 1988, and q_1 [Wm_n^{-2}] is the normative for the period of construction until 1988 (tab. 1).

The evidence of installed heat power in substations for belonging consumption areas provide more precise data regarding the designed consumption of heat energy users. For the purpose of evaluating the required capacity of the energy source, this database must be carefully analyzed by taking into account the following facts:

The design practice is teaching us that the design capacities of thermal substations are usually oversized,

Most often the connected consumption is much lower than the designed one, and

The experience regarding functioning of the district heating system indicates that the effective heat consumption is always lower than the calculated one.

The first issue is difficult to qualify as it depends on the habits of certain designers, calculated values of the building's heat capacity, standardized values of capacities of certain devices in substations, desired designers "safety of heating system's operations" and many other factors. Empirically, it is known that in practice, the installed heat capacity of radiators for heating of buildings is selected 5-15% and often even 20% higher than calculated heat losses for the building. The installed heat capacity of house installations is registered as a connected heat power and it is the basis for getting energy approval and permits for connection.

In fact, actually connected consumption is lower than the calculated one because of the situation that some of the users simply do not connect to the network and look for some other ways of supplying heat energy. This is especially typical for residential buildings with business premises. The heating is designed for the whole building and substations are sized in line with that. Later, it happens that some parts of the building fail to be connected to the system.

This objectively causes overly sized the whole installation of the district heating system starting from house installations to boiler plants. In such conditions, the surplus energy delivered by the system causes overheating of space and increased losses to the surroundings (through the building envelope, excessive opening of windows and the like).

The situation that effective, engaged heat consumption in design conditions differ from calculated heat capacity of the building has been noticed in the development of the district heating system in Germany[1] and this resulted in the introduction of a so called coincidence factor for the calculation of the network and heat sources in relation to the calculated consumption. This term defines the difference between engaged and calculated consumption in design conditions and not the "simultaneous use of the system" as the term may be interpreted. The usual values of the coincidence factor are:

– for heating and air conditioning 0.80
– for sanitary hot water 0.93

This analysis should be complemented by the aspect of genuine coincident utilization of installed capacities for building heating. In the period when the payment was done exclusively according to the heated surface or installed capacity of users of building heating service, this aspect did not have any influence. Service users did not have any interest in rational use of services and heating was done in the way in which the heating plant organized heat energy delivery.

The beginnings of charging according to taken over energy first in commercial buildings and then in business premises of residential buildings whose owners are gradually changing the approach towards the use of these services. The general growth of fuel prices at the global market is affecting heating plant services which are becoming more and more expensive. This leads to the increase of prices for heating and its proportion in the costs of living of citizens and costs of business operations of users of business premise.

Such a situation encourages users of heating service to reduce these costs. The business premises in Novi Sad even presently have billing according to delivered energy and thus an impulse for the management of heating in order to have more rational use and reduce costs for heating and air conditioning (using of the service only in the parts of premises in which it is necessary during some periods and as long as it is necessary).

It is inevitable for such an approach to be applied in the housing category of service users. This means that this group of users will also be charged according to the supplied amount of energy. Therefore, there will be an additional need to employ the coincidence factor. This time, the meaning of the term will be used in a proper way.

The numerical value of the coincidence factor is the result of practical activities. It is affected by numerous things and primarily by:

– technological capacities of the heating system,
– level of cooperation between energy supplier and energy users,
– social status of users,
– their level of knowledge and awareness of the need, possibilities and manners for controlled utilization of the district heating system in every heated room separately according to current requirements, and
– media activities in this field, and the like.

Therefore, it is difficult to expect universally applicable figure. Regional and local specificities have crucial influence on its formation. The influence of this factor will certainly be of even higher importance for future planning. In present conditions, primarily with the payment according to m^2 of heated area, the use of this correction factor is not necessary. It is practically equal to 1 since users of heating and air conditioning services do not have any motive to take measures for the rational use of services. This particularly refers to actual heating of premises only when they are truly used. This is the approach taken in this paper.

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[1] Collection: FUCHBUCHREIHE HLS-TECHNIK: WARMEVERSORGUNG VON STADTEN, VEB VERLAG, BERLIN, 1972.

Normative for centralized preparation of sanitary hot water

Only part of the Novi Sad Heating Plant consumers also has central preparation of sanitary hot water (SHW). It is customary that the normative for SHW preparation for residential buildings is given in dependence on the number of dwelling units. For nonresidential buildings, it is most often the percentage of the heat power for heating and air conditioning.

In this paper, the normative according to [3] will be used. It is estimated that the normative established in this manner is convenient for Novi Sad conditions. It is formed on German norms and experiences and it has been confirmed in the practice of the Novi Sad Heating Plant. The expression which defines the heat power of SHW consumers for all types of residential buildings in a residential block is given as:

$$Q_{tpv} = 8.4n\left(\frac{\sqrt{n}}{n} + 0.16\right)10^{-3} \tag{3}$$

where Q_{tpv} [MW] is the heat power of SHW consumptio, $n = n_k + (n_i/1.5)$ – the number of dwelling units and n_k, and n_i – number of apartments in collective (n_k) and residential (n_i) housing in a block (zone or the whole city).

Due to specific conditions of SHW consumption in non-residential building, it is customary that the normative for SHW consumption is expressed as a percentage in relation to the heat power for heating and air conditioning of the building. This is adopted for calculations in this paper and according to [3] this normative for a particular category is:

– education 0%
– administration 0%
– commercial 15%
– healthcare 20%

Heat demand – situation in 2009

Planning analyses of heat energy consumption for heating and air conditioning at the level of the city are usually done with average normatives for particular types of buildings in the city and average time periods in which the analyses are made. This approach can cause certain divergence of local values in some of the blocks but at the level of the city and the whole system this can be neglected. There are two reasons for that. The first "mixed" or representative normative for desired section which contains in itself buildings constructed in different periods will have the value between the boundary values. Boundary values are also obtained by analyses and their value is always the result of compromise of many different arguments. Therefore, these values cannot be fully accurate. The other reason is that the representative normative for the city has been created on the basis of calculation of all samples and thus fully represents the whole. Because of all this, deviation of the representative sample for the whole city, from the "imagined" accurate value will not jeopardize the level of planning analysis. The value adopted in the above manner considerably simplifies all analyses and it is sufficiently accurate for the preparation of planning documents and ensures clear overview of changes of normatives which occur in time during the development of the system.

The representative normative for the specific heat powers for heating and air conditioning of buildings for the city (q_p), for the section time in 2009 are determined according to eq. 4 and amounts to:

- Residential buildings :
  - collective Housing 140 Wm_n^{-2}
  - individual Housing 200 Wm_n^{-2}
- Non-residential buildings :
  - education and culture 190 Wm_n^{-2}
  - administration 165 Wm_n^{-2}
  - commercial 200 Wm_n^{-2}
  - catering 200 Wm_n^{-2}
  - healthcare 190 Wm_n^{-2}

$$q_p = \frac{\sum_{o}^{j} A_j \, q_j}{\sum_{0}^{j} A_j} \tag{4}$$

where q_p [MW] is the single design normative for the whole city – situation in 2009, q_i [MW] – the single design normative for the j^{th} category of buildings for a zone and given period of construction, and A_i [m^2] – the net area of the j^{th} category of buildings for a zone and given period of construction.

Now, the design heat consumption for heating and air conditioning in a block is calculated according to eq. 5 and in a zone according to eq. 6. In these equations, the category of space is divided according to the type of buildings [1].

$$Q_b = \sum_{0}^{x} A_n^i \, q_{pi} \tag{5}$$

$$Q_z = \sum_{o}^{y} Q_b \tag{6}$$

where Q_b [MW] is the installed heat power for heating and air conditioning in a block, Q_z [MW] – the installed heat power for heating and air conditioning in a zone, $A_n{}^i$ [m^2] – the net surface of the i^{th} category of space in a block, q_{pi} [Wm^{-2}] – the design normative for heating and air conditioning of the i^{th} category of space – situation in 2009, x – block number, and y – zone number.

Engaged power for the consumption of heating and air conditioning in design conditions is calculated according to eq. 7 and for the zone, according to eq. 8.

$$Q_{ba} = Q_b \; f_j \tag{7}$$

$$Q_{za} = Q_{za} \; f_j \tag{8}$$

where Q_{ba} [MW] is the engaged heat power for heating and air conditioning of a block, Q_{za} [MW] – the engaged heat power for heating and air conditioning of a zone, and f_j – the coincidence factor for heating and air conditioning.

Forecast of heat demand

Further development of heat demand for heating and air conditioning will depend on several factors: economic development of the city, expansion of the construction region in the city, growth of population in the city, intensity of investments into future construction of residential buildings, possibilities for the investment in particular energy systems, price of particular fuels and energy, economic and social position of population, energy policy of the city, development of competitor systems, *etc.*

In relation to the calculation which is done in line with the methodology presented in this paper, the City's heat demand in 2009 was:

– residential buildings – total:	1067 MW
– collective housing	632 MW
– individual housing	436 MW
– nonresidential buildings – total:	612 MW
– healthcare	36 MW
– education	68 MW
– culture	12 MW
– administration	271 MW
– large business centers	87 MW
– catering	33 MW
– manufacturing	105 MW
– other	111 MW
TOTAL DEMAND	1790 MW

According to this calculation methodology and taking into account all zones in which the district heating system has been developed, the total heat demand of the district heating system includes:

- total demand for heating and air conditioning in the heating system 975 MW
- engaged demand for heating and air conditioning in the heating system 780 MW
- total consumption of sanitary hot water in the heating system 65 MW

In 2009, according to the records of the Novi Sad Heating Plant, the total heating and air conditioning demand was 831 MW. This is less by 144 MW or 14.8% (975 – 831 MW = 144 MW). This difference occurs because of the fact that urban layout plans give total housing area (including non-heated space such as 50% of terrace areas and 75% of loggia areas which can be as much as 5% of the housing area), then, not all buildings in marginal blocks of the district heating system are connected to the system although it is partially or completely developed in these blocks and this is unused available capacity for the district heating system and finally, because business premises can be disconnected from the system if the owners opt for that. In the conditions of unrealistically low prices of electricity this happens quite often and the Heating Plant does not prevent such a practice. According to the evaluations made by the Novi Sad Heating Plant (based on net area of buildings), not connected or subsequently disconnected consumers are less than 10% of the connected consumers but there are no precise records thereof. Based on presented results for demand estimates and above given explanations, the proposed method for demand calculation can be considered as sufficiently accurate for planning purposes of the system's development.

At the same time, it is necessary to have in mind that the present situation with respect to energy efficiency of all types of buildings is unsatisfactory. Due to inevitable and considerable growth of costs for heating, it is to be expected to have forthcoming investments for the purpose of:

- improving the quality of envelopes in existing buildings,
- increase energy efficiency of installations for heating and air conditioning, and
- improving the manner of utilization of services according to current requirements of relevant premises.

In the approach towards the construction of new buildings, there is a growing application of different measures aimed at reducing energy requirements of buildings. This implies concurrent:
- minimization of losses through building envelope,
- application of modern energy, management and other technologies in buildings,
- production of energy in a building itself,
- employment of "passive heating" effects,
- implementation of renewable energy sources in order to meet energy requirements without the use of fossil fuels, and
- utilization of all other available ways for achieving "zero consumption".

Correction of normatives for the future calculations

It is quite realistic to expect extreme changes in the field of energy in buildings in general. The changes in all buildings are not practical as this requires high investments and various changes in the society. However, it is realistic that certain measures will be applied on a large scale in a considerable number of old buildings and in the majority of future ones. Thus, the average normative for each category of buildings or space will have to be reduced with reference to the current value. Taking into considerations all above stated, the essential planning issues is the realistic extent of this reduction. This paper is prepared with the forecast that average future buildings with reference to buildings which are built now (valid normative for 2009) will have the normative for heating and air conditioning lower by:
- residential buildings 40%
- non-residential buildings 50%

In case of non-residential buildings, it is possible to expect somewhat more pronounced reduction of the normative. The argument for this statement is in the fact that the normative for residential buildings has already been considerably reduced for buildings which have been built after 1988 in relation to the previous period. For non-residential buildings this is not the case (tab. 1).

The other reason is for the change of unit consumption is the modification of the outside design temperature. According to [15], outside design temperature for Novi Sad is still –14.8 °C. With reference to the current –18.0 °C, this will reduce future design capacities for heating and air conditioning in buildings for the value of the correction factor (k_{f1}), which is:

$$k_{f1} = \frac{t_u - t_{spp3}}{t_u - t_{spp2}} = 0.9158 \tag{9}$$

where k_{f1} is the correction factor for raised outside design temperature (from –18.0 °C to –14.8 °C), t_u [°C] – the inside design temperature, t_{pp2} [°C] – the outside design temperature for the period before 2012 (–18.0 °C), and t_{pp3} [°C] – the outside design temperature for the period after 2012 (–14.8 °C).

The change in design conditions will affect in time changes in the engaged power in buildings constructed until 2012 through their regulation of maximum power for heating and air conditioning in the future. This impact should be borne in mind and taken into account when calculating the engaged power in the future.

As a result of this analysis, the design heat consumption for heating and air conditioning of an urban block and zone for planned built up area in the future will be calculated in line with eqs. 10 and 11.

$$Q_{bp} = k_1 k_{f1} \sum_0^x A_{n1}^i (1-l_1) q \cdot 10^{-6} + (1-k_1) k_{f1} \cdot \\ \cdot \sum_0^x A_{n1}^i q \cdot 10^{-6} + k_{f1} \sum_0^x A_{n2}^i m_1 q \cdot 10^{-6} \tag{10}$$

$$Q_{zp} = \sum_o^y Q_{bp} \tag{11}$$

where Q_{bp} [MW] is the design installed heat power for heating and air conditioning of a planned block, Q_{zp} [MW] – the design installed heat power for heating and air conditioning of a planned zone, $A^i{}_{n1}$ [m^2] – the net area of the i^{th} category of space constructed until 2009, $A^i{}_{n2}$ [m^2] – the net area of the i^{th} category of space constructed after 2009, q [Wm^{-2}] – the representative deign normative for heating and air conditioning of the i^{th} category of space for the period until 2009, $k_1 = 0.3$ – the correction factor which includes the proportion of net surface with increased energy efficiency by reconstructions after 2009 *(30% – expected reconstructed buildings)*, $l_1 = 0.3$ – the the correction factor for the change of normative for heating and air conditioning i^{th} category of space from the construction period until 2009 because of increased energy efficiency in buildings which are reconstructed after 2009 *(30% – expected average increase of energy efficiency of reconstructed buildings)*, m_1 – the correction factor for the change of normative for heating and air conditioning of the i^{th} category of space from the construction period until 2009 because of increased energy efficiency of new buildings which will be constructed after 2009 and which is: 0.60 for residential buildings and 0.50 for commercial buildings, k_{f1} – the correction factor increased outside design temperature (from –18.0 °C to –14.8 °C) [–], x – number of block, and y – number of zone.

The engaged heat consumption for heating and air conditioning of a block and zone for planned built up area in the future in design conditions will be calculated in line with the eqs. 12 and 13.

$$Q_{bap} = Q_{bp} f_j \tag{12}$$

$$Q_{zap} = \sum_o^y Q_{bap} \tag{13}$$

where Q_{bap} [MW] is the engaged heat power for heating and air conditioning of a block in design conditions for planned built up area, Q_{bap} [MW] – the engaged heat power for heating and air conditioning of a zone in design conditions for planned built up area, and f_j – coincidence factor for heating and air conditioning.

In relation to the calculation which is done in line with the methodology presented in this paper, the future projected heat demand of the city capacity according to the Master Plan until 2021 is:

– residential buildings – total:	1719 MW
– collective housing	788 MW
– individual housing	931 MW

- non-residential buildings – total: 1016 MW
  - healthcare 45 MW
  - education 80 MW
  - culture 11 MW
  - administration 435 MW
  - large business centers 160 MW
  - catering 32 MW
  - manufacturing 253 MW

TOTAL DEMAND 2735 MW

Forecast of heat demand

The main question is when design capacities for calculated construction will be realized. This depends on further dynamics for the city's development. Whether the current dynamics, shown in [3, 5, 6] and [7, 8], is more achievable even in the similar manner and to what extent.

According to the projections for the City's further development and the growth of population [9-13] at the territory of the City of Novi Sad until 2034, there will be (247,407-257,547) inhabitants. With reference to 252,675 inhabitants in 2009, this means a change from –2.08% to +1.93%. That is, it is not expected that the population will significantly change in the period of the next 25 years.

Based on data from the database of urban blocks [12], it is expected that there will be gradual increase of the average size of apartments in buildings for collective housing. Until 2030, the size of an average apartment will be around 60 m^2. At the same time, it has been predicted that the number of household members will be reduced from the current 3.0 to 2.8. This indicates the increase of the comfort of living and more pronounced separation of households. There are no doubts that these changes will cause changes in the size of heating consumers. The growth of population will not result in crucial changes of consumption but the increase the average size of apartments and separation of households with the enrichment of accompanying contents of housing which goes along with the growth of standard should contribute to the growth of consumption.

The projections of city planners [9] until 2030 point out to the overall growth of installed power of consumption by 47%. However, this projection does not include measures for the increase of energy efficiency of buildings. This segment should be additionally calculated and thus, make the design consumption more realistic.

When evaluating the growth of heat consumption, it is also necessary to take into account effective construction trends from the immediate past. Moreover, it is necessary to consider possible other impacts which may affect changes in the design and construction of buildings. The average annual growth of consumption in the previous period (from 2005 to 2009) was different in various heating districts in the City and amounted to (0-2.94)% depending on the intensity of construction in the certain parts of the City (at the territory of the HP North, South and East, the average is 1.54% and at the territory of the HP West, the average is 2.94%).

The assessment of the growth of heat consumption for heating and air conditioning in the period up to 2032 until fill up of capacities in particular blocks is given under the following conditions:

- Base year is the existing situation in 2009.
- Average growth of the intensity of construction in the next period will be 50% of the average in the period from 2005 to 2009 (the falling rate has been registered since 2010).

- Starting from 2013, the construction will be done according to new standards which will assume higher energy efficiency of building envelopes. It is supposed that for these buildings normatives for heating and air conditioning will be on the average 50% in relation to the situation found in 2009.
- Starting from 2012, it is assumed that the new higher outside design temperature will be applied.
- It is also assumed that after 2015, there will be planned improvement of energy efficiency of envelopes in old buildings. We are going to elaborate three options:
  - *Optimistic – Every year, starting from 2015, in **2.5%** of old buildings, measures for increasing energy efficiency of the envelope will be implemented and thus reduce heating demand in these buildings by some 30%.*
  - *Moderate – Every year, starting from 2015, in **2%** of old buildings, measures for increasing energy efficiency of the envelope will be implemented and thus reduce heating demand in these buildings by some 30%.*
  - *Conservative – Every year, starting from 2015, in **1.5%** of old buildings, measures for increasing energy efficiency of the envelope will be implemented and thus reduce heating demand in these buildings by some 30%.*

The evaluated dynamics established in the above manner (2.5%, 2.0%, 1.5% and 0% of the old buildings refurbishment per year) for the growth of heat consumption for heating and air conditioning in the future is given in figs. 1 to 3.

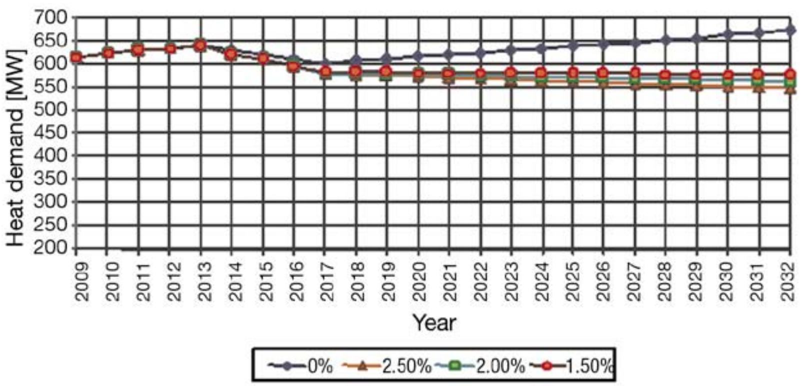

Figure 1. Projection of connected heat demand for heating and air conditioning of consumption areas of TP North, TP South, and TP East

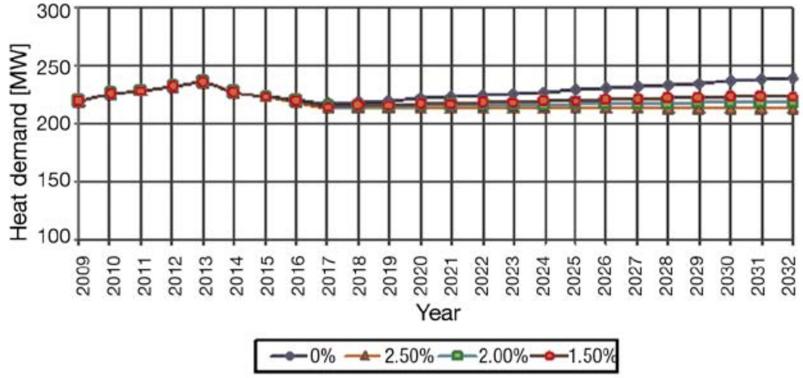

Figure 2. Projection of connected heat demand for heating and air conditioning of the consumption area of TP West

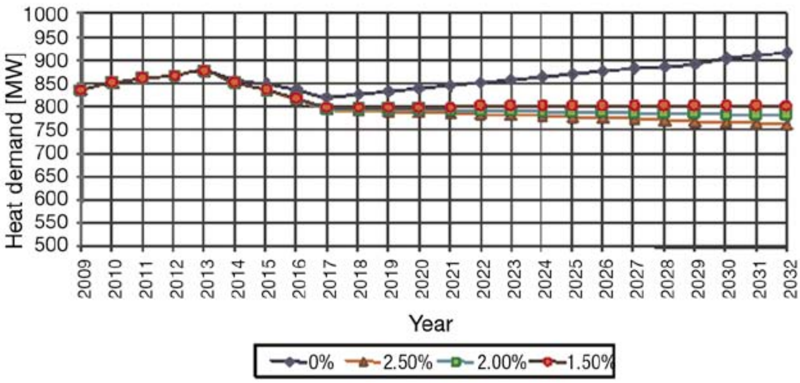

Figure 3. Projection of connected heat demand for heating and air conditioning of consumption areas of TP North, TP South, TP East, and TP West

Conclusions

The structure of the heat consumption in cities is generally always very complex. It is affected by numerous factors. The most influential ones are: structure, intended purpose and type of buildings, period of construction, standards, regulations and other technical conditions which used to be effective at the time of construction and are the result of climatic and other conditions.

The selection of buildings per types and conditions in which they were built and according to urban districts is a good basis for defining reprehensive normatives for establishing heat consumption. At that, it is suitable to deal with available data for smaller urban units (blocks and zones) and their use for determining average normatives for cities as a whole.

The projection of heat energy consumption is additionally complicated because of really achieved changes in the conditions of building construction which will be in the future more and more affected by the growth of energy prices and the necessity for the increasing energy efficiency in buildings. One of potentially influential measures is also the change of design conditions.

All this results in the need to correct normatives for the projection of the size of the heat energy consumption in the future or generally speaking, to make changes in the heat energy consumption.

The normatives established in this paper can be used as a sufficiently accurate average for estimates in cities with similar climatic and other characteristics. Also, it is established and presented here the methodology and manner for the calculation of design heat energy consumption in the future as a good roadway for planning purposes and sufficiently accurate prognoses. In this paper, this has been confirmed with the City of Novi Sad as an example.

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