Mode of getting Thermal Energy Depending of the Average Outside Temperature on the City of Bitola

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***Abstract* – This research was based on the latest achievements in the development of energy technologies, such as: efficiency, energy saving, ecology and flexibility. The study used data from the measurements of external temperature for the city of Bitola in the period 1996 - 2010 year. The research covers a range of activities: assessment of the required heat consumption and defining the curve thermal load under ambient conditions of Bitola. The analysis of the research is based on the calculation and assessment of the required heat for heating curve according to the outside temperature. It is the basis for defining the mode of operation of a plant for production of thermal energy.**

***Keywords* – outside temperature, heat consumption, curve, heat, coefficient of heating**

1. Introduction

In recent years electricity consumption has increased significantly here in the region and in Europe and the world as well. Therefore, the priority is to improve the energy efficiency of the existing units whose main function is the production of electricity and the production and supply with thermal energy.

Moreover, in the last years the work is directed towards finding new sources of energy in terms of environmental protection, while the newly designed plants will use the primary energy more efficiently, lowering energy losses.

Therefore, in order to reduce the electricity consumption for heating and to infuence the environment, the possibilities for the production of thermal energy for district heating plants in the city with a high degree of efficiency are being explored [6], [4]. For this purpose it is necessary to estimate the required heat consumption of the city, and the change of the required heat for heating during the heating period depending on the outside temperature. This would mean defining the optimal mode of the heating plant.

The realization of the research is conducted in four phases.

In the first phase, an assessment and a review of the required heat consumption of Bitola and the surrounding area are made. An analysis is performed on the existing thermal capacity and the actual and the future possible heat requirements are observed. [1]. In the second phase, a review of the temperature of the outside air of the city of Bitola is performed for the period 1996-2010 (from the Hydrometeorological Institute - Bitola). Using analytical and numerical methods for the considered period, the basic features of the thermal heating of the city (average daily, monthly and annual mean, "degree day" and the relative length of the duration of temperature intervals) are defined.

The third phase includes defining the curve of the average hourly temperature of the outside air and the analysis of the consumption of the heat, depending on the curve.

In the fourth and final phase, the conclusions of this research are presented.

2. Assessment of the required heat consumption (for Bitola and its surrounding)

Currently the residential, public, commercial and industrial sectors are supplied with thermal energy in a decentralized manner. Most households use firewood, light oil (for households) and electricity for heating. Only a small part of the public sector is equipped with appropriate installations (pipes, radiators, etc.), and some of them are connected to the local sources of thermal energy.

From the technical viewpoint, Bitola is an urban environment with good opportunities for implementation of central heating, due to the relatively high population density in some parts of the city. For this purpose, it is necessary to define the optimal solution to the plant (combined cogeneration plant with natural gas) that will satisfiy the heating needs of the city and the environmental protection.

One of the most important tasks when defining the selection criteria for the plant which will produce heat for heating the city is appropriate estimatation of the total heat consumption.

According to some estimation of experts from the municipality, more than 65% of households in collective residential buildings will be ready to connect to the district heating system in the medium term (5 years). About (10-15)% of households living in private facilities are also ready to be connected to the central heating system [9].

Also, it is assumed that a significant number of commercial and industrial buildings and businesses will be connected to the central heating system. The assessment of possible future need of heat by different users is given in Table 1.[1].

Table 1. Assessment of the required heat consumption in Bitola (actual and possible future requirements)

Description	**Installed heat capacity**	**Assumed future development**	**Total**
	MW	MW	MW
Collective residential buildings with internal installations (pipes, radiators, etc.) associated with the existing boilers for heating	35 (26)	5 (10)	40
Collective residential buildings with internal installations, and are not related to existing boilers for heating	5 (13)	-	5
Collective residential buildings without internal installations and connected with existing heating boilers	5	15	20
Individual residential buildings (houses)	10	10	20
Public buildings (schools, administrative buildings)	20	2	22
Commercial buildings	5	5	10
Hospitals, health facilities, etc.	10	2	12
Industry	15	20	35
Agricultural production (greenhouses)	5	30	35
Total	**110**	**90**	**200**

We can conclude that , the maximum need of heat in the future or heat consumption of Bitola and the surrounding area is 110/200 MW. The heat consumption during the year is variable according to climate change.

3. The important meteorological characteristics of the city for heat consumption

In order to determine the actual need of heat for the city of Bitola, the meteorological data from daily measurements of external temperature for a period of 15 years (1996- 2010) is analysed and the following findings about the basic meteorological data for the city are received [5], [9]:

Average air temperature during the heating

The temperature of the air is one of the basic climate elements and provides some insight on the thermal state of the atmosphere.

In order to determine the daily, monthly and annual heat consumption it is necessary to determine the values of the hourly, the average daily, the monthly and the annual average temperatures in the heating period and the minimum and maximum temperature [3]. The average daily temperature is determined according three observations during the day in defference to 7 hours and in 7, 14 and 21 hours [2],[5].

Data on air temperature obtained by measurements during the day and for each month in the heating season on the territory of the municipality of Bitola for a period of fifteen years (1996-2010).

The average daily temperature is determined according to the equation :

$$t_{sr} = \frac{t_7 + t_{14} + 2t_{21}}{4} \quad [^{\circ}C] \qquad [1]$$

On the basis of the average daily temperatures, the monthly average temperature and the average temperature of the analysed period are being analysed. The average values of the monthly air temperatures are represented in the diagram in Figure 1. [5]. From the presented tables and diagrams for individual months, we can see that the temperature of the outside air oscillates considerably in almost all months which gives an idea of instability. Even in the months with very low temperatures there is a big difference in the daily temperatures.

Table 2 Average values of air temperatures by months

Month	January	February	March	April	May	September	October	November	Декемв.
t_{srm} [°C]	+0,4	+2,0	+6,6	+10,8	+16,7	+22,7	+12,0	+6,6	+1,8
t_{srg} [°C]	**+5,7**								

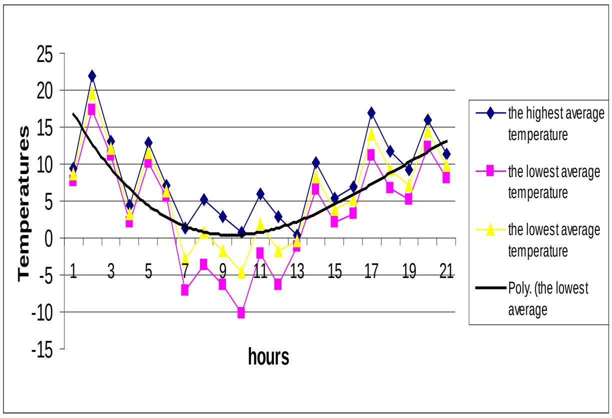

Figure 1. Diagram of the average monthly temperatures for a period from October to April 7, 14 and 21h

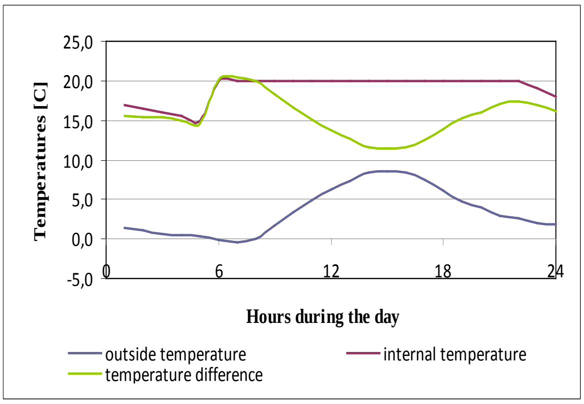

Figure 2. Diagram of the temperature difference in the day between internal and external temperature

This moment has a significant impact on the average annual temperature for the heating period. The average outdoor temperature in the presented period of 15 years is -19,28 ° C, and the lowest temperature in some years has reached the value under -27,6 ° C. Based on the recorded data about the external temperature (in the city) to fifteen-year period we received a diagram of the temperature difference between the internal and external ambient temperature during the day, which is especially important for the daily heat consumption,Figure 2[5].

Temperature of the outside air

To determine the daily, monthly and annual heating consumption and the heating mode, we need to know the outside air temperature. The average external design temperature can be determined by the criterion of Chapljin average annual minima [2].

$$t_{sp} = 0{,}4 * t_m + 0{,}6 * t_{\min} \, [^{\circ}C] \qquad (2)$$

t_{sp}[°C]– average external temperature design;
t_m [°C]–average monthly minimum temperature in the last 15 years (11,3°C)
t_{min} – the lowest recorded temperature in the analyzed period (-27,6°C)

According to the processed meteorological data for a period of 15 years from 1996 to 2010, project external (minimum) temperature from -19,28°C has been determined due to the fact that we have measured the lowest external temperature at the time.

Number "degree day"

The curve on the outside air temperature annually is determined based on data from a multi-year period and it's climatic character of the place to which it refers.

Based on these data, the number of days at defined ambient temperature is determined, which should provide heating. These two quantities depend on the heat consumption and fuel consumption in the heating season and they are directly dependent on the number "degree day" which is determined by the following equation:

$$Z = n(t_u - t_{sr}) \quad (3)$$

n [/] – number of days in the heating period;
t_u [°C] – temperature in the heated room;
t_{srg} [°C] – average annual temperature.

Based on the above, the value of the number "degree day" significantly affects the efficiency of the plant for production of heat for heating the city.

4. Defining and analysis of the curve on the average hour temperatures of the outside air

For defining the optimal production and consumption of thermal energy, it is necessary to determine the curve of hourly temperature of the outside air to the research period of 1995-2010 as well as the basic thermal characteristics of the city: the relative length of the duration of the temperature ranges, and coefficient of the thermal load.

The relative length of the duration of the temperature ranges

However, for defining the curve it is very important to calculate the relative length of the duration of the temperature ranges that are represented on the diagram in Figure 3.

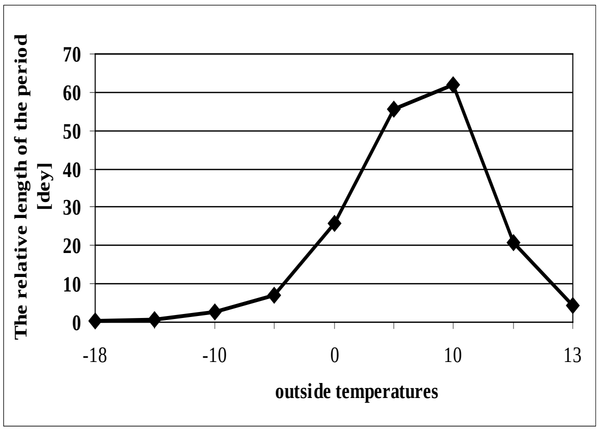

Figure 3. Diagram of the relative length of the duration of the temperature ranges in the heating season

The diagram shows that in the heating season the most days are with outside temperature between 5 ° C to 10 ° C. Total days: 62.1 . Such distribution will significantly affect the coefficient of thermal load and choosing the correct plant for heat.

Coefficient of thermal load

Based on the analysis of the daily average outdoor temperatures in the analyzed period, the thermal load in the heating period is obtained. The dependence of the thermal load of the outside temperature is shown on diagram in Figure 4.[9].

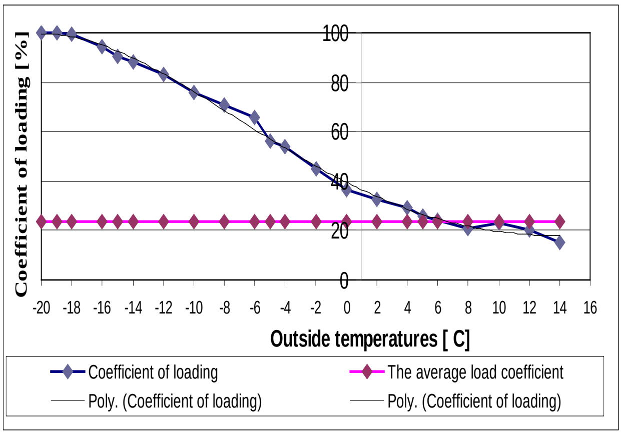

Figure 4. Diagram of the thermal load coefficient depending on external temperatures

In the diagram in Figure 4.,we represent the average coefficient of the thermal load on the heating period too, which is KTG = 22,34%.

Curve of the hour average temperature of the outside air

The course of the curve is represented in the diagram on Figure 5.

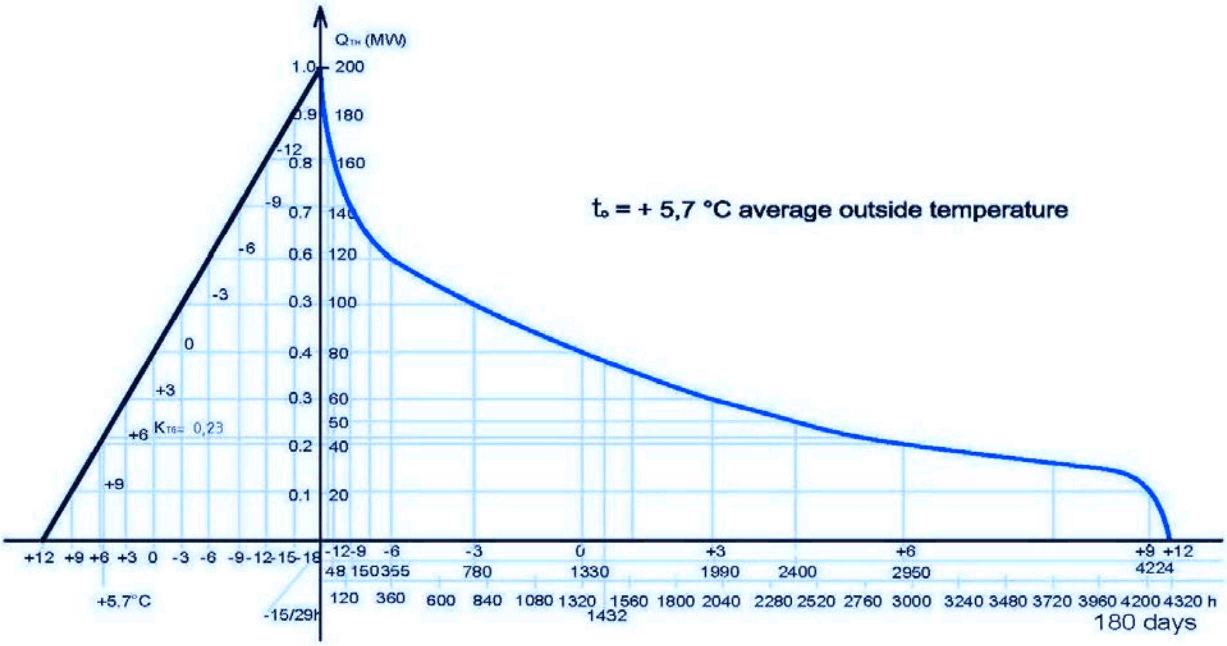

Figure 5. Curve of hour average temperature of outside air

According to the curve, with high precision can be said how the required heat for heating is being reduced when the external temperature of -18°C is being raised. The number of working hours at temperatures below -18°C is very small and it is 5 hours (heating consumption 200MW). The number of hours when the outside air temperature is lower than -15 °C is only 17 hours (the required heat consumption at -15 °C is 180 MW).

By raising the temperature of the outside air -9 °C, -6 °C, ie 0 °C, heat consumption of 200 MW is significantly reduced. For example, the number of hours of operation of the plant at a temperature of outdoor air lower than -9 °C is only 150 hours (heat consumption drops to just 140 MW).

The number of working hours at a temperature of outdoor air lower than -3 °C is only 780 hours (heat consumption drops to only 100 MW or 50% of the nominal).

The number of working hours at a temperature of the outside air lower than 0 °C is only 1330 hours (heat consumption drops to only 80MW). This means that from the total number of hours of duration of the heating season (4320 h), during 2990 working hours the heat consumption will be less than 80 MW. It is 70% of the heating season. For this purpose, it is necessary to determine the average heat load in the heating period [7], [9].

Degree of heating in the heating period

The coefficient of heating is one of the main thermal features that significantly affect the plant for heat [7],[8]. The coefficient of the heating for Bitola for project conditions is 37%. But for the analysed period during 1996-2010 acording the curve of the average hourly consumption coefficient of heating is 23.4%, which is especially favorable for a long term operation of the plant for heat [7],[8].

5. Conclusion

Based on the research, analysis and calculations the following conclusions can be adopted:

- The outdoor conditions are defined i.e. the curve of the average hourly temperatures of the outdoor air is being created based od the processed data in terms of the average daily temperatures for the period from 1996 -2010. (for the city of Bitola).

- The curve of heat load during the heating period, obtained on the basis of the curve on hourly outside air temperatures is being defined (for Bitola). In that way the coefficient of average load Bitola is being defined too. For the city of Bitola for project conditions is 36.67%, and for the analysed period (during 1996-2010) is 23.40%. In fact, the coefficient of the average load on the heating period influences the defining the optimal operation of heating systems [8], [9].

- This research opens the possibility for a new research in terms of definition of technically feasible and economically justified solution to the plant for the production of heat for heating the city of Bitola and the surrounding area. Such a solution would have a positive impact on the environment [6].

References

[1] Norsk Energi, ELEM-Skopje, TPP REK Bitola, Center for climate Change – Skopje (2010)*: Bitola District Heating with Thermal Energy from TPP Bitola.*

[2] B.Todorović (2005): *Designing the plant for central heating* Faculty of Mechanical Engineering, Beograd .

[3] ASHRAE : *NONRESIDENTIAL COOLING AND HEATING LOAD CALCULATIONS, CHAPTER 18* Copyright ©2009.

[4] E.Sokolov (1982): *Toplofikatsija and heat networks*, Energoizdat, Moskva.

[5] UNIS-ENERGETIKA ,D.O.O.Sarajevo,(2008*): Study Techno-economic justification the realization of the heating system townSrebrenik.*

[6] The European Educational Tool on Cogeneration: *EDUCOGEN*, Second Edition, December 2001.

[7], „Official Journal of Republic of Macedonia ", No. 61 *Strategy for Energy Development in the Republic of Macedonia until 2030*/2010.

[8] K. Dimitrov and Z. Tarevska*:Eergy policy of the Republic of Macedonia: Gasification and legal framework* - MACEF, R.Macedonia.

[9] *Energy Balance of the Republic of Macedonia for the period from 2015 to 2019,* Official Journal of RM, No. 192 from 24.12.2014 .