Determining Optimal Hourly and Annual Coefficient District Cooling - One of the Aspects use of Green Technology

Šefik M.Bajmak [1], Aleksandar Ristovski [1], Bratislav Blagojević [2]

[1]*Univesity of Pristina , Faculty of Technical Science, Kosovska Mitrovica, Serbia*
[3] *Univerzitet of Niš, Mechanical Engineering Faculty, Niš, Serbia*

Abstract **– Work together more cooling source (refrigeration machines) the system of centralized supply cooling energy (SCSCE) is a way to achieve cost-effective operation and safe and rational supply consumption area with cool water for central cooling and air conditioning . Maximum energy needs cold water occurs rarely , because the extremely high temperatures occur rarely . Therefore , the total cooling load is divided into basic and peak . One of the main characteristics that define the justification of the use of coupled processes and sizes hourly coefficient centralized supply of cold water, temperature regime , or hour coefficient district cooling . Determination of Optimal hour coefficient district cooling is one of the most techno economic tasks at the design of the system of centralized supply cold water for air conditioning and industrial building social housing and business districts .**

***Key words*:** **coefficients district cooling, refrigeration machines, cold water**

1. Preliminary note

Economy refrigeration plant, depends largely on the time of use of its installed capacity, or the time of its operation under full load demand.The main cooling source is to work with a well balanced and as much as possible with longer time utilization of full load. Cover the peak load that occurs some days during the year in terms of investment,from cheaper generator cold water. Very significant impact on the economy of the merged process has characteristics of climatic conditions observed regions [1,2,8,9].The average amount of energy transferred to the consumer during one season, cooling and air conditioning systems are characterized diagram cooling burden of life, as seen in Figure 1, the conditions of Prizren.Sake of comparison in the same figure is given a diagram of heat load, for the same conditions. The diagram shows that the field (s) supplied from the main source of cold water, and the field (b) the peak source of cold water.Hourly and annual coefficient of district cooling and related work can be represented respectively the following expressions[1,3,4,14]:

$$\Omega_{\check{c},h} = \frac{Q_{OS}^{\check{c},h}}{Q_{\max}^{h}} \tag{1}$$

$$\Omega_{G,h} = \frac{Q_{OS}^{G,h}}{Q_{G,h}^{uk}} \tag{2}$$

$$\Theta_{\check{c},h} = \frac{Q_{VR}^{\check{c},h}}{Q_{OS}^{\check{c},h}} = \left(\frac{1}{\Omega_{\check{c},h}} - 1\right) \tag{3}$$

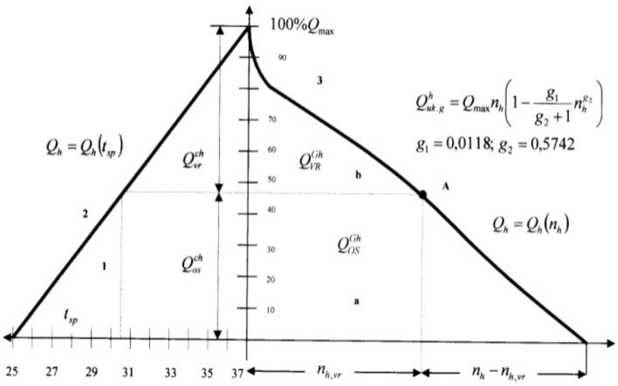

Figure 1. Diagram of the cooling load for the conditions of Prizren

$$\Theta_{G,h} = \frac{Q_{VR}^{G,h}}{Q_{OS}^{G,h}} = \left(\frac{1}{\Omega_{\check{c},h}} - 1\right) \tag{4}$$

To determine the optimal hourly coefficient of district cooling for a specific schedule of load for consumption area during the year, it is necessary to take into account all costs and to express them in function $\Omega_{\check{c},h}$ and vary them by $\Omega_{\check{c},h}$, for which the total cost of having your minimum that is[1,3,4,5,6]:

$$0\partial T_{uk}/\partial\Omega_{ch}=0 \quad (5)$$

2. Analysis of total and specific annual costs

The total annual cost of the system for the preparation of cold water for cooling systems and air conditioning (cooling energy), consists of the cost base and peak source, ie the investment and exploitation costs:

$$\begin{aligned}T_G &= (T_{RS,TK}^{OS}+T_{RKU}^{OS}+T_{RV}^{OS}+T_{LEP1}^{OS})+T_{PSHW}^{OS}+T_{PSRW}^{OS}+\underline{T_{THV}}++T_{RS,TK}^{ee}+T_{RKU}^{ee}+T_{PSHW}^{ee}+T_{PSRW}^{ee}+\\&+T_{THV}^{gub}+\underline{\underline{T_{OS}^{w}+T_{OS}^{rf}+T_{OS}^{ld}+T_{OS}^{am}+T_{OS}^{tr}}}+(T_{RS,AB}^{VR}+T_{RKU}^{VR}+T_{RV}^{VR}+T_{TV}^{VR})+T_{PSHW}^{VR}+P_{PSRW}^{VR}+\\&+T_{RS,ABM}^{ten}+T_{RKU}^{ee}+T_{PSHW}^{ee}+T_{PSRW}^{ee}\end{aligned} \quad (6)$$

These costs in equation (6) can be presented to the following expressions [1]:

$$T_{RS,OS}=(1+p_1+p_2)\left[\frac{T_{rm1}}{Q_{o1}}+\frac{T_{rk1}}{Q_{k1}}\cdot\overline{K}+\overline{T}_{RV}^{OS}+C_{rf}\cdot b_{rf}\right]r_{RS}\cdot Q_{OS}=\overline{T}_{TK,OS}\Omega_{ch}Q_{\max} \quad (7.1)$$

$$T_{RS,VR}=(1+p_1+p_2)\left[\frac{T_{rm1}}{Q_{o1}}+\frac{T_{rk1}}{Q_{k1}}\cdot\overline{K}+\overline{T}_{RV}^{VR}+C_{rf}\cdot b_{rf}\right]r_{RS}\cdot Q_{VR}=\overline{T}_{AB,VR}(1-\Omega_{ch})Q_{\max} \quad (7.2)$$

$$T_{PSHW}^{OS}=10^{-3}\cdot r_{PS}\cdot\frac{(1+\beta_{hv}^{m})\cdot(1+m)\cdot C_{PS}\cdot L_{mr}^{hv}\cdot R_l}{c_w\cdot\Delta\tau_{hv}\cdot\rho_w\cdot\eta_{pu}}\cdot Q_{OS}=\overline{T}_{PSHW}^{OS}\cdot\Omega_{ch}Q_{\max} \quad (7.3)$$

$$T_{PSHW}^{VR}=10^{-3}\cdot r_{PS}\cdot\frac{(1+\beta_{hv}^{m})\cdot(1+m)\cdot C_{PS}\cdot L_{mr}^{hv}\cdot R_l}{c_w\cdot\Delta\tau_{hv}\cdot\rho_w\cdot\eta_{pu}}\cdot Q_{VR}=\overline{T}_{PSHW}^{VR}(1-\Omega_{ch})Q_{\max} \quad (7.4)$$

$$T_{PSRW}^{OS}=10^{-3}\cdot r_{PS}\cdot\frac{(1+\beta_{hv}^{m})\cdot(1+m)\cdot C_{PS}\cdot L_{mr}^{rv}\cdot R_l}{c_w\cdot\Delta\tau_{hv}\cdot\rho_w\cdot\eta_{pu}}\overline{K}_{RK}^{OS}\cdot Q_{OS}=\overline{T}_{PSRW}^{OS}\cdot\Omega_{ch}Q_{\max} \quad (7.5)$$

$$T_{PSRW}^{VR}=10^{-3}\cdot r_{PS}\cdot\frac{(1+\beta_{hv}^{m})\cdot(1+m)\cdot C_{PS}\cdot L_{mr}^{rv}\cdot R_l}{c_w\cdot\Delta\tau_{hv}\cdot\rho_w\cdot\eta_{pu}}\cdot\overline{K}_{RK}^{VR}Q_{VR}=\overline{T}_{PSRW}^{VR}(1-\Omega_{ch})Q_{\max} \quad (7.6)$$

$$T_{THV}=r_{mr}\left[aL_{THV}+\frac{1.129bL_{THV}}{(c\rho\Delta tW)^{0,5}}Q_{\max}^{0.5}+\frac{1.275cL_{THV}}{(c\rho\Delta tW)_w}Q_{\max}\right]=r_{mr}\left[\frac{f_{1THV}}{Q_{\max}}+\frac{f_{2THV}}{Q_{\max}^{0,5}}+f_{3THV}\right]Q_{\max} \quad (7.7)$$

$$T_{TV}^{VR}=r_{mr}\left[aL_{TV}+\frac{1.129bL_{TV}}{(c\rho\Delta tW)^{0,5}}Q_{AB}^{0.5}+\frac{1.275cL_{TV}}{(c\rho\Delta tW)_w}Q_{AB}\right]=r_{mr}\left[\frac{f_{1TV}}{Q_{tw}}+\frac{f_{2TV}}{Q_{tw}^{0,5}}+f_{3TV}\right]Q_{tw} \quad (7.8)$$

$$T_{LEP1}^{OS}=\frac{r_{lep}\cdot C_{lep}\cdot L_{lep}}{\varepsilon_{tk}\cdot\eta_{lep}}\cdot Q_{OS}=\overline{T}_{lep}\cdot\Omega_{ch}Q_{\max} \quad (7.9)$$

$$T_{THV}^{gub}=10^{-3}p_{gub}C_{hen}Q_{\max}n_h\left[1-(b_1n_h^{b_2}/b_2+1)\right]Q_{\max}=10^{-3}p_{gub}C_{hen}n_h\overline{K}_hQ_{\max} \quad (7.10)$$

$$T^{ee}_{TK,RS} = T^{ee}_{TK,OS} = \frac{n_h \cdot \overline{K}_{6h} \cdot C_{ee}}{\varepsilon_{tk} \cdot \eta_{ee}} \cdot Q_{OS} = \overline{T}^{ee}_{TK,OS} \Omega_G Q_{\max} \quad (7.11)$$

$$T^{ten}_{AB,RS} = T^{ten}_{AB,VR} = \frac{n_h \cdot \overline{K}_{6h} \cdot C_{ee}}{\xi_{ab} \cdot \eta_{gut}} \cdot Q_{VR} = \overline{T}^{ten}_{AB,OS}(1-\Omega_G) Q_{\max} \quad (7.12)$$

$$T^{ee}_{RKU,OS} = \overline{E}^{ee}_{RKU} C_{ee} Q_{con} = \overline{E}^{ee}_{RKU} C_{ee} \overline{K}_{OS} Q_{OS} = \overline{E}^{ee}_{RKU} C_{ee} \overline{K}_{OS} \Omega_{ch} Q_{\max} \quad (7.13)$$

$$T^{ee}_{RKU,VR} = \overline{E}^{ee}_{RKU} C_{ee} Q_{con} = \overline{E}^{ee}_{RKU} C_{ee} \overline{K}_{OS} Q_{VR} = \overline{E}^{ee}_{RKU} C_{ee} \overline{K}_{OS} (1-\Omega_{ch}) Q_{\max} \quad (7.14)$$

$$T^{ee}_{PSHW} = 10^{-3} \frac{\left(1+\beta^m_{hv}\right) \cdot C_{ee} \cdot L_{hv} \cdot Z_{pu} \cdot R_{lhv}}{c_w \cdot \Delta\tau_{hv} \cdot \rho_w \cdot \eta_{pu}} \cdot Q_{os} = \overline{T}^{ee}_{PSHW} \cdot \Omega_{ch} Q_{\max} \quad (7.15)$$

$$T^{ee}_{PSHW} = 10^{-3} \frac{\left(1+\beta^m_{hv}\right) \cdot C_{ee} \cdot L_{hv} \cdot Z_{pu} \cdot R_{lhv}}{c_w \cdot \Delta\tau_{hv} \cdot \rho_w \cdot \eta_{pu}} \cdot Q_{VR} = \overline{T}^{ee}_{PSHW} (1-\Omega_{ch}) Q_{\max} \quad (7.16)$$

$$T^{ee}_{PSRW} = 10^{-3} \frac{\left(1+\beta^m_{hv}\right) \cdot C_{ee} \cdot L_{hv} \cdot Z_{pu} \cdot R_{lhv}}{c_w \cdot \Delta\tau_{hv} \cdot \rho_w \cdot \eta_{pu}} \cdot \overline{K}_{OS} Q_{OS} = \overline{T}^{ee}_{PSRW} \cdot \Omega_{ch} Q_{\max} \quad (7.17)$$

$$T^{ee}_{PSRW} = 10^{-3} \frac{\left(1+\beta^m_{hv}\right) \cdot C_{ee} \cdot L_{hv} \cdot Z_{pu} \cdot R_{lhv}}{c_w \cdot \Delta\tau_{hv} \cdot \rho_w \cdot \eta_{pu}} \cdot \overline{K}_{VR} Q_{VR} = \overline{T}^{ee}_{PSRW} (1-\Omega_{ch}) Q_{\max} \quad (7.18)$$

$$T^{w}_{OS} = \dot{V}^{w}_{OS} C_w Q_{OS} = \dot{V}^{w}_{OS} C_w \Omega_{ch} Q_{\max};(7.19); T^{ld}_{OS} = S_{ld} m_{ld} Q_{OS} = S_{ld} m_{ld} \Omega_{ch} Q_{\max}\,(7.20)$$

$$T^{aam,tr}_{OS} = 1{,}2\left(p^{'}_{gr} p^{''}_{gr} + p^{'}_{op} p^{''}_{op}\right) Q_{OS} = 1.2\chi \Omega_{ch} Q_{\max} \quad (7.21)$$

3. Detrmination of the link between hourly and annual coefficient district cooling

Formulate a diagram for the climatic conditions of the considered region in relative coordinates, and that, relative temperature and relative time[1] :

$$\Delta\bar{t}_h = \frac{t_h - t_{po}}{t_{sp} - t_{po}} \; (8) \quad \Delta\bar{n}_h = \frac{n_h}{n_{gr}} \; (9)$$

For conditions town of Prizren these relative coordinates can be presented expressions[1]:

$$\Delta\bar{t}_h = 0{,}0833\left(t_h - 25\right) \; (9); \; \Delta\bar{n}_h = 0{,}00045 n_h \quad (10)$$

In accordance with equations (8) and (9) and the well-known Characteristics of climate defined in the diagram of external temperature, can form a climate curve diagram of the relative sizes of the areas affected, as shown in Figure 2. Depending on the climate curve can be represented diagrammatically and sizes hour coefficient district cooling in the form of [1,14,15]:

$$\Omega_{\check{c},h} = f_1\left(\Delta\bar{n}_h\right) = \frac{Q^h_{td.ob}}{Q^h_{\max}} = \frac{t^h_{pr} - t_{up} + q_{utd}/Y_{hl}}{t^h_{\max} - t_{up} + q_{utd}/Y_{hl}} \quad (11)$$

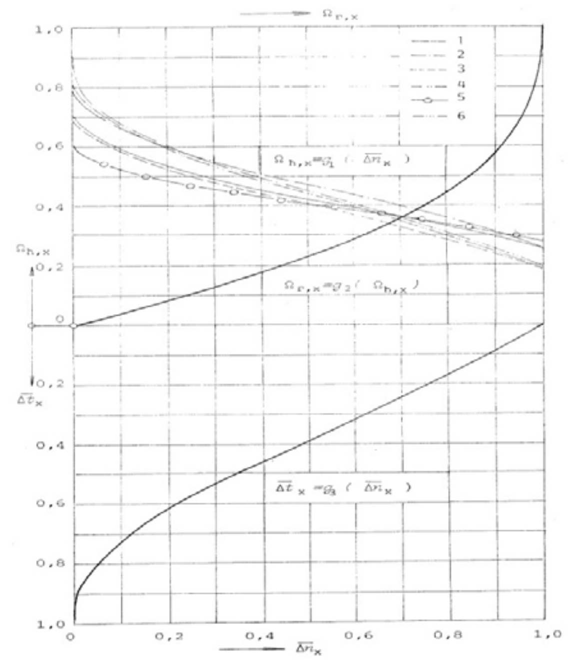

Figure 2. Summer climatic characteristics of our requirements and the graphical representation of the fun -ctional connections $\Omega_{\check{c},h} = g_1(\Delta\bar{n}_h)$ *and* $\Omega_{g,h} = g_3(\Delta\bar{n}_h)$.

Cooling of the object and the temperature of the interior surfaces of external walls of partition structures [2,3,10] at temperatures of the project, can be present expressions [3,4]:

$$Y_{hl} = \frac{\alpha_{un}\left[2m_1h_1\left(1-\mu_f+\frac{1-\mu_b}{m_2}\right)+e\right]}{m_1\cdot h_1\cdot e\cdot(1-\mu_{pok})} \qquad (12)$$

$$\tau_{pr}^{sr} = \frac{m_2\cdot e\cdot\tau_{kr}}{2\cdot m_1\cdot h_1\cdot(m_2+1)+m_2\cdot e}+$$
$$+\frac{m_1\cdot h_1}{2\cdot m_1\cdot h_1\cdot(m_2+1)+m_2\cdot e}\cdot \qquad (13)$$
$$\cdot\begin{bmatrix} m_2(1-\mu_f)(\tau_{sz}^{f1}-\tau_{sz}^{f2})+(1-\mu_b)\cdot(\tau_{sz}^{b1}-\tau_{sz}^{b2})+ \\ +2(m_1\cdot\mu_f+\mu_b)\tau_{pr} \end{bmatrix} =$$

Temperature glass surface depends on the properties of solar radiation leaks and those without major mistakes can be inferred that the same temperature of the external air. The temperature of the interior surfaces (walls, roof, etc.) defined by the formula[3,4]:

$$\tau_{up} = t_{un} + \frac{K_{pr}}{\alpha_{un}}\left(t_s - \frac{P\cdot J}{\alpha_s} - t_{un}\right) \qquad (14)$$

Considering the expressions (13) and (14), after rearrangement, the expression (11), we have that hour coefficient of district cooling is equivalent to[1,3,4,5]:

$$\Omega_{\check{c},h} = \frac{M_1\cdot t_{sh}+M_2-U_6-t_{up}}{M_1t_{sp}+M_2+M_3-U_6-t_{up}} \qquad (15)$$

Wherein:

$$M_1 = \frac{K_{pr}}{\alpha_{un}}(2U_1U_2+2U_1U_3)+U_5\frac{K_{kr}}{\alpha_{un}}+U_1U_4;$$

$$M_2 = \frac{K_{pr}}{\alpha_{un}\alpha_{sp}}U_1\left[U_2\left(J^{f1}+J^{f2}\right)+U_3\left(J^{b1}+J^{b2}\right)\right]+$$
$$+U_5\frac{K_{kr}}{\alpha_{un}\alpha_{sp}}J^{kr}$$

$$M_3 = \left(1-\frac{K_{pr}}{\alpha_{un}}\right)2U_1(uU_2+U_3)t_{un}+U_5t_{un}\left(1-\frac{K_{pr}}{\alpha_{un}}\right)$$

$$U_1 = h_1/[2h_1(m_2+1)+m_2b];\ U_2 = m_2(1-\mu_f);$$
$$U_3 = (1-\mu_b);U_4 = 2m_2(m_2\mu_f+\mu_b);$$
$$U_5 = m_2b/[2h_1(m_2+1)+m_2b];\ U_6 = q_{ud}/Y_{oh}; \qquad (16)$$

Depending on the form of the object, its thermal characteristics, place of location and climatic conditions, the diagram in Figure 2 shows the dependence of the coefficient hour $\Omega_{\check{c},h}$ district cooling in operation τ_s^h or $\Delta\bar{t}_h$. Starting from the diagram of outer temperature, the total amount of cooling energy is defined by the expression[1,14,15]:

$$Q_{uk.g}^h = Q_{OS}^{g.h}+Q_{VR}^{g.h} = Q_{\max}n_h\left(1-\frac{g_1}{g_2+1}n_h^{g_2}\right) \qquad (17)$$

and the annual coefficient of district cooling can be defined by the expression:

$$\Omega_{gh} = \frac{Q_{OS} n_{OS} + \int_{n_{OS}}^{n_h} Q(n)dn}{Q_{\max} n_h \left(1 - \frac{g_1}{g_2 + 1} n_h^{g_2}\right)} \qquad (18)$$

Or after rearrangement, the expression (18) we have the relationship between hourly and annual coefficient of district cooling in the form of:

$$\Omega_{g,h} = 1 - \frac{g_2}{g_1^{1/g_2}\left(1 + g_2 - g_1 n_h^{g_2}\right)}\left(1 - \Omega_{č,h}\right)^{(g_2+1)/g_2} \qquad (19)$$

For conditions of Prizren expression (19) has the form:

$$\Omega_{g,h} = 1 - \left(1 - \Omega_{č,h}\right)^{2,7415} \qquad (20)$$

Dependence $\Omega_{g,h}$ of $\Omega_{č,h}$ is shown in Figure 2. To numerically determine the surface that is covered by this guilty lines it is necessary that it is to their mathematical form. Configuration wrong $\Omega_{h,h} = \varphi(\Delta\overline{n})$ and $\Omega_{g,h} = f(\Omega_{h,h})$ can be described with sufficient accuracy analytic function of the form [1]:

$$\Omega_{č,h} = C_{1h} \cdot (\Delta\overline{n})^x - C_{2h} \cdot (\Delta\overline{n})^y \qquad (21)$$

$$\Omega_{g,h} = 1 - C_{3h} \cdot \left(C_{4h} - \Omega_{č,h}\right)^z \qquad (22)$$

Climate-town of Prizren, said coefficient and exponents have the following values [1]:

$C_{1h} = 0,32; C_{2h} = 0,00; C_{3h} = 1,00; X = -0,33;$
$Y = 1,00; Z = 2,75;$

4. Detrmining optimal coefficient district cooling

To perform the analysis of hourly and annual coefficient of district cooling and the relationship of the base and the peak energy, adopt energy structure of the system of centralized supply of cooling energy (SCSCE) urban areas, as shown in Figure 3.For analysis adopt two sources of cooling energy as follows[1,12,13,14,]:

- Turbo compressor cooling stations (TCCS)
- Absorption cooling stations (ABCS)

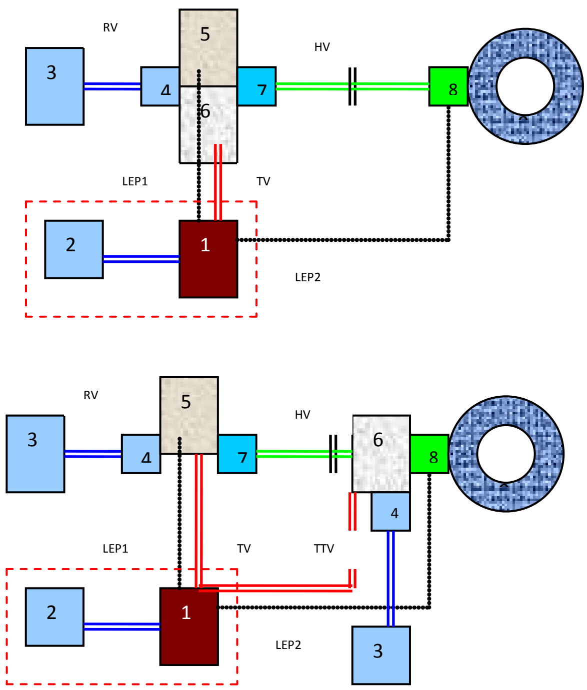

Figure 3. Structural scheme SCSC urban areas (1-TEC, 2-cooling kulaTEC; 3 cooling tower cooling stations, 4-pumping station cooling water, 5-cooling cells-the main source, 6-cell cooling-peak source; 7-pumping station cold water, 8-pumping station chilled water consumption area, 9-consumer cooling energy; RV-distribution pipe cooling towers, HV-line cold water; LEP-electric transmission lines, TV-heating system, TTV-transit heating system;)

We will assume that both cooling stations operate as a base or peak cooling energy source. Dismissal of those costs from (7.1) to (7.16) in equation (6) with the corresponding costs of individual members and after ordering a general form independent source of cooling energy for the primary and that the peak regime we have that the specific annual cost equal to the formula [1]:

$$T_{uk}^{i,j} = \left(F'_{i,j}\right)\Omega_{h,h} + \left(F''_{i,j}\right)\left[1 - \left(1 - \Omega_{č,h}\right)^{2,75}\right] + F'''_{I,J} \qquad (23)$$

From the condition $\partial\overline{T}_{uk}^{i,j} / \partial\Omega_{č,h}$ find the optimal coefficient hour and district cooling for the adopted energy structure in the form of:

$$\Omega_{č,h}^{op.i.j.} = 1 - 0.561\left(-\frac{F'_{i.j}}{F''_{i.j}}\right)^{0,5714} \qquad (24)$$

From the condition $\partial^2\overline{T}_{uk}^{i,j} / \partial\Omega_{č,h}^2 > 0$ find the minimum of the function (23) that is, for $-4.812\left(1 - \Omega_{č,h}\right)^{0,75} F''_{i.j} > 0$, or $F''_{i.j} < 0$, function (23) has its optimum value. If, as a main source in the scheme of centralized supply of cooling energy for TCCS as peak source ABCS then that the function

(23) had its optimum value is necessary to fulfill the following conditions:

1. basic and peak energy resources are in one place (system 1a)

$$C_{EE}/C_{TEH} < 1/\left\{\xi_t^{AB}\eta_{gu}\left[1/\varepsilon_g\eta_{ee} + \overline{E}_{ee}^{rk}\left(\Phi_{os} - \Phi_{vr}\right)\right]\right\} \quad (24a)$$

2. basic and peak energy are outlying from the camp from one another (system 1b)

$$\frac{C_{ee}}{C_{ten}} < \frac{1/\xi_t^{AB}\eta_{gu} - 10^{-3} p_{guh} L_{hv} C_{hen}/C_{ten}}{1/\varepsilon_{tk}\eta_{ee} + \overline{E}_{ee}^{rk}\left(\Phi_{os} - \Phi_{vr}\right)} \quad (24b)$$

function (23) has a coefficient optimanu district cooling, where the $F_{i.j}^{'} > 0$.

If, as a main source in the scheme of centralized supply of cooling energy for ABCS as a peak source TCCS then that the function (23) had its optimum value it is necessary that the following conditions are met:

1. basic and peak energy resources are in one place (system 1a)

$$C_{EE}/C_{TEH} > 1/\left\{\xi_t^{AB}\eta_{gu}\left[1/\varepsilon_g\eta_{ee} + \overline{E}_{ee}^{rk}\left(\Phi_{os} - \Phi_{vr}\right)\right]\right\} \quad (24c)$$

2. basic and peak energy are outlying from the camp from one another (system 1b)

$$\frac{C_{ee}}{C_{ten}} < \frac{1/\xi_t^{AB}\eta_{gu} - 10^{-3} p_{guh} L_{hv} C_{hen}/C_{ten}}{1/\varepsilon_{tk}\eta_{ee} + \overline{E}_{ee}^{rk}\left(\Phi_{os} - \Phi_{vr}\right)} \quad (24d)$$

function (23) has optimanu coefficient of district cooling, with the $F_{i.j}^{'} > 0$.

Other optimal coefficients after adjustments to the expression (20) or (3) and (4) are:

$$\Omega_{g,h}^{op.i.j} = 1 - 0.205\left(-\frac{F_{i.j}^{'}}{F_{i.j}^{''}}\right)^{1,579} \quad (25)$$

$$\Theta_{č,h}^{op.i.j} = \frac{0.561\left(-\frac{F_{i.j}^{'}}{F_{i.j}^{''}}\right)^{0.5741}}{1 - 0.561\left(-\frac{F_{i.j}^{'}}{F_{i.j}^{''}}\right)^{0.5741}} \quad (26)$$

$$\Theta_{g,h}^{op.i.j} = \frac{0.205\left(-\frac{F_{i.j}^{'}}{F_{i.j}^{''}}\right)^{1.579}}{1 - 0.205\left(-\frac{F_{i.j}^{'}}{F_{i.j}^{''}}\right)^{1.579}} \quad (27)$$

Wherein $i = 1,2;\ j = a,b$.

5. Results of analyzes, calculations and tests

Analysis and calculation is performed for the following values of the variables size [114,15,16,17]:

$r_{RS} = r_{ps} = 0,11(1/god);\ p_1 = 15\%;\ p_2 = 5\%;$
$T_{rm1}/Q_{01} = 250(Eu/KW); T_{rk1}/Q_{rk1} = 130(Eu/KW);$
$\overline{K}_{TKRS} = 1.088; \overline{K}_{ABRS} = 2,225; C_{rf} = 10(Eu/kg);$
$b_{rf} = 0,2(kg/KW); \beta_{hv}^{m} = 0.; C_{ps} = 500(Eu/KW);$
$R_l = 200(Pa/m); L_{MR}^{hv} = 4000(m); \Delta\tau_{hv} = 6^0 C;$
$\eta_{pu} = 0,75; \eta_{ee} = 0,93; a = 50(Eu/m); b = 2450(Eu/m);$
$c = 3036(Eu/KW); W = 3(m/s); L_{MR}^{rv} = 200(m);$
$Q_0 = 10MW; Q_k = 10,9MW; C_{lep} = 0,4(Eu/KWm);$
$L_{lep} = 4000(m); \Delta\tau_{ttv} = 50^0 C; C_{ee} = 0,15(Eu/KWh);$
$C_{te} = 0,072(Eu/KWh); C_{hen} = 0,134(Eu/KWh);$
$\overline{K}_{6h} = 0,477; C_w = 1(Eu/m^3); \xi_{abm} = 0,807;$
$\eta_{te} = 0,92; \beta_{hv}^{m} = 0,25; Z_{pu} = Z_{rku} = 1650(h/god);$
$m = 0,1; S_{ld} = 0,6(Eu/godrad); N_{ABRS}^{ra} = 20;$
$N_{TKRS}^{ra} = 15; \overline{E}_{RKU}^{ee} = 0,0134(KWhee/KWhte);$
$n_h = 2201(1/god); p_{gr}^{'} = 3\%; p_{gr}^{''} = 8\%; p_{op}^{'} = 15\%;$
$p_{op}^{''} = 85\%; \varepsilon_{gh} = 5,5;$

5.1. Primary source cooling energy is TCCS and peak cooling energy source is ABCS and they are next to each other, the system 1a

Whereby are specified cost equals izarzu:

$$F_{1a}^{'} = \overline{T}_{rs}^{os} - \overline{T}_{rs}^{vr} + \left(\Phi_{os} - \Phi_{vr}\right)\left(\overline{T}_{ps}^{rvz} + \overline{T}_{mr}^{rvz} + \overline{T}_{ee}^{prv}\right) + + \overline{T}_{lep}^{os} - \overline{T}_{mr}^{ttv} + \overline{T}_{w}^{os} - \overline{T}_{w}^{vr} + \overline{T}_{ld}^{os} - \overline{T}_{ld}^{vr} + \overline{T}_{amtr}^{os} - \overline{T}_{amtr}^{vr} \quad (27a)$$

$$F_{1a}^{''} = \overline{T}_{ee}^{tk} + \overline{T}_{ee}^{rk}\left(\Phi_{os} - \Phi_{vr}\right) - \overline{T}_{teh}^{ab} \quad (27b)$$

Since the expression of $\left(1-\Omega_{čh}\right)^{0,75} > 0\,11$ it must be the expression of $F_{1a}^{'} > 0$ and $F_{1a}^{''} < 0$ respectively for the expression of the value of the expression (24a) we have the optimal value of the quotient hour district cooling, and therefore the other coefficients that is, $\Omega_{G,h};\ \Theta_{ch};\ \Theta_{G,h}$. When the system works by structural scheme 1a shows the specific costs, which amount to $F_{1a}^{'} = -35\left(Euro/KWgod\right);$ $F_{1a}^{''} = -71{,}3\left(Euro/KWgod\right)$.Starting from these previous conditions can be seen that the system does not have the optimal parameters.

5.1. The main source of cooling energy is TCCS and peak cooling energy source is ABCS and they are distant from each other, peak cooling energy source of the with consumers cooling energy system 1b

Wherein the Specified Costs the same formula:

$$F_{1b}^{'} = \overline{T}_{rs}^{os} - \overline{T}_{rs}^{vr} + \overline{T}_{ps,os}^{hv} + \left(\Phi_{os} - \Phi_{vr}\right)\left(\overline{T}_{ps}^{rv} + \overline{T}_{mr}^{rv} + \overline{T}_{ee}^{prv}\right) + \overline{T}_{mr,os}^{hv} + \overline{T}_{lep}^{os} + \overline{T}_{ee,os}^{phv} + \overline{T}_{w}^{os} - \overline{T}_{w}^{vr} + \overline{T}_{ld}^{os} - \overline{T}_{ld}^{vr} + \overline{T}_{amtr}^{os} - \overline{T}_{amtr}^{vr} - \overline{T}_{mr,vr}^{ttv} \qquad (27c)$$

$$F_{1b}^{''} = \overline{T}_{ee}^{tk} + \overline{T}_{ee}^{rk}\left(\Phi_{os} - \Phi_{vr}\right) - \overline{T}_{teh}^{ab} + \overline{T}_{guh}^{os} \qquad (27d)$$

Since the expression of $\left(1-\Omega_{čh}\right)^{0,75} > 0$ it must be the expression of $F_{1b}^{'} > 0$ and the term $F_{1b}^{''} < 0$ ie the value of the expression (24b) we have the optimal value of the quotient hour district cooling, and thus the other coefficients, ie: $\Omega_{G,h};\ \Theta_{ch};\ \Theta_{G,h}$. When the system works by structural scheme 1b shows the specific costs, which amount to $F_{1b}^{'} = 24{,}655\left(Euro/KWgod\right)$, $F_{1a}^{''} = -47{,}24\left(Euro/KWgod\right)$55; Starting from these previous conditions shows that the system has the optimum parameters, and they are as follows:

$$\Omega_{ch} = 0{,}614;\ \Omega_{G,h} = 0{,}927;\ \ \Theta_{ch} = 0{,}629;\ \ \Theta_{G,h} = 0{,}08;$$

5.3. Primary source cooling energy is ABCS and peak cooling energy source is TCCS and they are next to each other, the system 2a

Wherein the Specified expenses equal to the formula:

$$F_{2a}^{'} = \overline{T}_{rs}^{os} - \overline{T}_{rs}^{vr} + \left(\Phi_{os} - \Phi_{vr}\right)\left(\overline{T}_{ps}^{rvz} + \overline{T}_{mr}^{rvz} + \overline{T}_{ee}^{prv}\right) - \overline{T}_{lep}^{os} + \overline{T}_{mr}^{ttv} + \overline{T}_{w}^{os} - \overline{T}_{w}^{vr} + \overline{T}_{ld}^{os} - \overline{T}_{ld}^{vr} + \overline{T}_{amtr}^{os} - \overline{T}_{amtr}^{vr} \qquad (27e)$$

$$F_{2a}^{''} = \overline{T}_{ten}^{ab} + \overline{T}_{ee}^{rk}\left(\Phi_{os} - \Phi_{vr}\right) - \overline{T}_{ee}^{tkrs} \qquad (27f)$$

Since the expression of $\left(1-\Omega_{čh}\right)^{0,75} > 0$ it must be the expression of $F_{2a}^{'} > 0$ and the term $F_{2a}^{''} < 0$ respectively the value of the expression (24c) we have the optimal value of the quotient hour district cooling, and therefore the other coefficients, ie: $\Omega_{G,h};\ \Theta_{ch};\ \Theta_{G,h}$. When the system works by structural scheme 2a shows the specific costs, the value of the function is: $F_{2a}^{'} = 33\left(Euro/KWgod\right)$, $F_{2a}^{''} = 77{,}2\left(Euro/KWgod\right)$. To be filled with the condition $F_{2a}^{''} < 0$ must satisfy the following relationship, expression (24c), after replacement values for priomenljive size we have that relationship $C_{ee}/C_{ten} > 7{,}65$ .For this value relationships energiaj system can have optimal parameters. For example the value of the power outage $C_{ee} = 0{,}15\left(Eura/KWh\right)$ and the value of the thermal energy $C_{ten} = 0{,}o\left(Eura/KWh\right)$ (The case of subsidized investments, for example in spaljiona waste) we have that the $F_{2a}^{''} = -28{,}76\left(Eura/KWgod\right)$ system has optimum parameters, and they are as follows: $\Omega_{ch} = 0{,}404;\ \Omega_{G,h} = 0{,}76;\ \ \Theta_{ch} = 1{,}474;\ \ \Theta_{G,h} = 0{,}317;$

5.4. The main source of cooling energy is ABCS and peak cooling energy source is TCCS and they are distant from each other, peak cooling energy source of the with consumers cooling energy system 2b

$$F_{2b}^{'} = \overline{T}_{rs}^{os} - \overline{T}_{rs}^{vr} + \overline{T}_{ps,os}^{hv} + \left(\Phi_{os} - \Phi_{vr}\right)\left(\overline{T}_{ps}^{rv} + \overline{T}_{mr}^{rv} + \overline{T}_{ee}^{prv}\right) + \overline{T}_{mr,os}^{hv} + \overline{T}_{mr}^{ttv} + \overline{T}_{ee,os}^{phv} + \overline{T}_{w}^{os} - \overline{T}_{w}^{vr} + \overline{T}_{ld}^{os} - \overline{T}_{ld}^{vr} + \overline{T}_{amtr}^{os} - \overline{T}_{amtr}^{vr} - \overline{T}_{mr,vr}^{ttv} \qquad (27g)$$

$$F_{2b}^{''} = \overline{T}_{ter}^{ab} + \overline{T}_{ee}^{rk}\left(\Phi_{os} - \Phi_{vr}\right) - \overline{T}_{ee}^{tkrs} + \overline{T}_{guh}^{os} \qquad (27h)$$

Since the expression of $\left(1-\Omega_{\check{c}h}\right)^{0,75} > 0$ it must be the expression of $F_{2b}^{'} > 0$, and the expression $F_{2b}^{''} < 0$,ie the value of the expression (24d) we have the optimal value of the coefficient hour district cooling,and therefore the other coefficients have optimal value,namely: $\Omega_{G,h}$; Θ_{ch}; $\Theta_{G,h}$.When the system works by structural scheme 2b shows the specific costs, the value of the function is: $F_{2b}^{'} = 83\left(Euro/KWgod\right)$;

$F_{2a}^{''} = 95\left(Euro/KWgod\right)$. To be filled uslov $F_{2a}^{''} < 0$ must satisfy the following relationship, equation (24c). After the replacement value of variable sizes have the $C_{ee}/C_{ten} > 5,86$ .For this value of the ratio of energy system can have optimal parameters. For example the value of electricity $C_{ee} = 0,15\left(Eura/KWh\right)$ and the value of heat $C_{ten} = 0,0\left(Eura/KWh\right)$ (case of subsidized investments, for example in spaljiona waste) we have that the $F_{2a}^{''} = -77,4\left(Eura/KWgod\right)$ system has the optimum parameters, and they are as follows:

$$\Omega_{ch} = 0,404;\ \Omega_{G,h} = 0,76;\ \ \Theta_{ch} = 1,474;\ \ \Theta_{G,h} = 0,317;$$

6. Conclusion

Optimal coefficients district cooling $\Omega_{h,h};\Omega_{g,h};\Theta_{h,h};\Theta_{g,h}$ depend on the current and design of an external air temperature, internal project tempareture, intensity of solar radiation, thermal and structural characteristics of the facility, which has air conditioning, internal heat gains and adopted energy structure of supply cooling energy urban environment. The analysis included TCCS and ABCS working as a basic and peak cooling energy source adjacent to each other (Fig. 3a) and at a distance from each other (Fig. 3b). Based on the analysis of the system adopted in order to have optimal hourly coefficient district cooling and other district cooling coefficient, must meet the following conditions:

1. The difference of specific investment cost base and peak cooling energy sources must be greater than zero that is $F_i^{'} > 0$. The main source of supply of cooling energy in terms of investments have to be expensive; a peak source, in terms of investment cheaper, It is the $F_i^{'} > 0$

2. Exploitation costs of primary sources must be less than the exploitation costs of peak cooling energy sources, It is the $F_i^{''} < 0$.

From the second condition we find that the hourly coefficient district cooling depends on the relationship cost price of electricity and thermal energy that recharges the cooling machines. The ratio of the price depends on the coefficient of cooling TKRM, thermal coefficient abrMate, loss of heat and electricity, cost of cooling energy, length water cold water and coefficients $\overline{K}$ and E_{ee}^{rk}.

7. Tags and index

a,e-width and length of the building m; b_{rf}-thr mount of refrigerant heat capacity per one refrigerating machine Eu/KW; C_{ee}-electricity price, $Eu/KW\,h$; C_{rf}-cost price refrigerant, Eu/kg; C_{LEP} -specific cost price of electric transmission lines (LEP), $Eu/KW\,km$; C_{ten} -cost price of thermal energy, Eu/GJ; C_{hen} -cost price cooling energy, Eu/GJ; $\overline{E}_{RKU}^{ee}$-consumption of electricity per kWh of cooling tower cooling capacity capacitor, $\left(KWh/year\right)/\left(KWh/year\right)$ $f_1, f_2, f_3, f_1^{'}, f_2^{'}, f_3^{'}, f_1^{''}, f_2^{''}, f_3^{''}$ -would mean ; $\overline{K}$- production of heat condenser cooling machines per kWh cooling capacity of the evaporator cooling machines $\left(KWh/year\right)/\left(KWh/year\right)$ $\overline{K}_{6h}$- Constant; K_{pr}- Heat transfer coefficient Pipeline, W/m^2K ; L-length, m; n_h-the annual number of hours of district cooling, $h/year$; n_{gr} -the annual number of hours of heating, $h/year$; P - coefficient of absorption of solar radiation by the partition structure,/; p -percent deduction for the relevant papers,%; p_1-percentage of construction work in the total mass of investment,%; p_2- percentage of mechanical work in the total mass of investment,%; p_{guh} -loss of cooling energy per meter of pipeline cold water, W/m; $Q_{\check{c}h}$-hour cooling load the appropriate sources, KW; $Q_{g,h}$-annual cooling load the appropriate sources, KW; $Q_{o,1}$-cooling capacity of one refrigeration machines, KW; Q_{rku1}- cooling capacity of one cooling tower, KW; Q_0- installed cooling capacity corresponding check cooling machines, KW; Q_{max} -maximum cooling capacity, KW; r -Factor eturn on equity, $1/year$; S_{ld} -average annual personal income one worker, $Eu/year$; τ_{pr}^{sr} -temperature on the inside of the fire wall at design conditions, ^{o}C; T_{uk} -the total annual cost, $Eu/year$; $\overline{T}$ -corresponding specific costs, $Eu/KWyear$, $Eu/km\,year$; $U_1, U_2, ..., U_3$ -Would mean a lot; $\dot{V}_w$ -annual water consumption, $m^3/year$; z -duration of the proper equipment, $h/year$; η -efficiency coefficient (KKD) appropriate equipment /; ξ_{AB} -thermal coefficient absorber cooling machines, /; $\varepsilon_{g,tk}$ -cooling coefficient turbochargers,/; h_1 -height of the building, m; J -intensity solar radiation equivalent surface, W/m^2; m_{ld} -workers, workers; m_1 -number of floors of the building; m_2 -length ratio (a) to the width (e) of the object; α - coefficient heat transfer , W/m^2K; μ_f, μ_b -coefficient glazing façade and side walls of the building; Y_{hl} -cooling characteristics of the object, W/m^3K;

RS -cooling station ; PS- pumping station ;MR-network ; LEP - electric transmission lines ;BARS - absorber cooling station ;TKRS - turbo compressor cooling station ;PHV -pumping cold water ;PRV-pumping cooling water ; RCU - cooling tower ;GUB - losses ;W- Water ;LD- personal income ;AM-depreciation ;TR- current overhaul ;OS - basic;VR - peak; in-investment ; ek - exploitation ;hw - cold water ;rw - cooling water ; ttv- transit heating system ;ten-heat;rm- cooling mašian ; rf- rshladni fluid;rk - cooling tower ;ee- electricity;tk- turbo compressor ;pu - pump ;gut- heat loss ;rcu- cooling tower ;lep - electric transmission lines ;abrm - absorption refrigeration machine ;gr- building ;op - equipment ;un -interior ;sp-exterior ; f -facade ;B - side ; sp-exterior design ;ten-heat energy;tr - current overhaul ; v- water ; mp - peak ;uk-total ;mr- network; m - meat ;op - equipment ;ld - personal income ;am-depreciation ;ek - exploitation ;een -electric power ;m - meat ;

References

[1] Šefik,M.Bajmak, *Analysis and optimization of effectiveness and district heating and district cooling systems using energy obtained from the combustion of municipal waste hard*, Ph.D. thesis, Pristina, 1994;

[2] Aršakjan, D.T., *Optimizacija shema teplosnabženija gorodov i promišljenih rajonov* , Teploenergetike , 1972., No. 6, pp. 58-60;

[3] Melikjan, Z.B., *Centralizovannoe teplohlado snabženie graždenskih i promišljenih sooruženii*, Strjoizdat, str.200., Moskva 1985.

[4] Rozenfeld, L.M., Geršković, F., *Analiza efektivtosti teplohladifikacionih sistem*, Vodosnabženie i sanitarnaja tehnika, 1973., No. 4, pp. 16-20;

[5] Tihonov,B.S.,*Centralizovannoe teplogazosnbženie i ventilacija*, str. 187., Moskva, 1968;

[6] Reknagel-Sprteneger-Herman:*Grejanje i klimatizacija* , IRO-Gra]evinska knjiga, pp. 1652, Beograd ,1987;

[7] Bogoslovskij V.N.;Kokorin O.J.;Petrov L.V;Kondicinirovanie vozduha i holdosnabzenie , Moskva, Strojiydat 1985.

[8] www.diva-portal.org/smash/.../FULLTEXT01.pd.

[9] www.engr.psu.edu/.../energy_use_in_**district_coo**

[10] "District Cooling System", as HVAC system of Sustainable India **;** (visited on November 10th, 2013.) www.ramboll.com/energy

[11] http://www.modon.gov.sa/ (visited on November 10th, 2013.)

[12] http://www.svenskfjarrvarme.se (visited on November 10th, 2013.)

[13] Zabala, Elixabet Sarasketa. "Technological and economic evaluation of district cooling with absorption cooling systems in Gävle (Sweden)." (2009). Mastres Thesis in Energy Systems

[14] District cooling Keeping the city cool during summer periods; Copenhagen Cleantech Cluster ;Web: www.cphcleantech.com ; City of Copenhagen ;Web: www.kk.dk ; HOFOR A/S ;Web: www.hofor.dk

[15] Yoshinor Hida, Seiji Shibutani, Matsuyuki Amano, Noriyasu Maeharam, *District Cooling Plant with High Efficiency Chiller and Ice Storage System*, www.mhi.co.jp/technology/review; (visited on November 11th, 2013.)

[16] District Heating Cooling, Strategic Research Agenda, Dhc - Technology Platform; c/o Euroheat & Power Avenue de Tervuren 300;1150 Brussels, www.dhcplus.eu;

[17] New Technology of Cooling Systems for Future Facilities in Qatar ; 9th World Conference on Sport and the Environment , 2011.

[18] http://www.techstreet.com/ashrae; (visited on November 12th, 2013.)

[19] Green Building Regulations & Specifications, http://www.dewa.gov.ae/images/greenbuilding_eng.pdf (visited on November 13th, 2013.)

[20] Bard Skagestad, Kattner/FVB District Energy Inc. Canada Peter Mildenstein,Sheffield Heat and Power Group, UK ;International Energy Agency Iea District Heating and Cooling ,Programme of Research, Development and Demonstration on District Heating and Cooling, District Heating and Cooling Connection Handbook;

Corresponding author : Šefik M.Bajmak
Institution: University of Prishtina , Faculty of Technical Science , Kosovska Mitrovica, Serbia
E-mail: bajmak@yahoo.com