1.

The optimal primary schedule (the primary supply temperature as function of the outside temperature) of a district heating system operated with variable mass flow can be determined from the minimum of the cost function $\dot{K}_{veszt} = k_{hő}\dot{Q}_{veszt} + (k_{vill} - k_{hő}) * \dot{V} * \Delta p$, the function of the costs of heat transport. The developed form of cost function shows, that the cost member depending on t_2'' secondary returning temperature does not depend on primary mass flow. This results, that the secondary temperatures do not influence the optimal primary mass flow, only the optimal primary supply temperature. Increasing the secondary temperatures needs increasing the primary temperatures' with unchanged mass flow. Increasing the secondary temperatures increases the cost of the heat transport.

Developing the cost functions results, that the optimal primary schedule of systems with earth-laid pipelines does not depend on the temperature of the ground near the pipelines. No reason to determine the primary schedule as function of ground temperature. The ground temperature influences the costs of heat transport, but does not influence the optimal primary schedule.

2.

I have determined the expression of the optimal primary schedule of mass flow and supply temperature for direct consumers supplied with above ground level pipeline:

$$\dot{m}_1 = \sqrt[4]{\frac{k_{hő}}{(k_{vill} - k_{hő})} \frac{k_l \dot{Q} d^5 \Pi^2 \rho^2}{48\lambda(1+Z)c}}$$

$$t_1' = t_1''(t_k) + \frac{\dot{Q}(t_k)^{0,75} \dot{Q}_0^{\,0,25}}{\dot{m}_1(t_{k,0})c}.$$

The $\dot{m}_1(t_{k,0})$ optimal value of the nominal primary mass flow can be determined from the expression of mass flow. This expressions are able to determine the optimal schedule not only for district heating, but for other systems with variable mass flow as well.

These expresssions result, that the usual design procedure for constanat flow rate in district heating pipelines does not result cost minimum.

3.

To determine the optimal primary schedule needs to know the relation between the necessary primary supply temperature and primary mass flow of a heat exchanger to produce the heat output and secondary supply temperature. If the expression of Φ Bosnjakovic coefficient as function of the primary and secondary mass flows is unknown, the $t_1' = t_1'(\dot{m}_1)$ and $\dot{m}_1 = \dot{m}_1(t_1')$ expressions can be determined with some approaching. I determined, in the case of the outside temperature and the secondary parameters are known and fixed, the best approaching are these functions:

$$t_1'(\dot{m}) = \frac{A}{\dot{m}^n} + B;$$

$$\dot{m}(t')_1 = \sqrt[n]{\frac{A}{t_1' - B}}$$

From the A, B and n factors determined for different fixed outside temperatures can be determined the $A(t_k)$, $B(t_k)$, $n(t_k)$ functions of t_k outside temperature with regression. This functions are linear. The neccessary primary supply temperature $t_1' = t_1'(\dot{m}_1)$ as function of the primary mass flow for optional outside temperature can be approached with :

$$t_1'(t_k) = A_1 + A_2 t_k + \frac{B_1 + B_2 t_k}{\dot{m}_i^{n_1 + n_2 t_k}}$$

This approaching is sufficient if the secondary schedule is linear and the secondary mass flow is constant.

4.

I have developed the simplified method of Dr. László Garbai to determine the optimal primary schedule for systems, where the parallel coupled heat exchangers can be arranged in two groups (in practice typical in groups for heating and for producing domestic hot water /DHW). Every heating and DHW heat exchangers are reduced in each substituting heat exchanger. To determine the optimal primary supply temperature we must determine the minimum of the function:

$$\dot{K} = k_{hő}\left(t_1' + t_1'' - 2t_k\right)\sum \frac{1}{R_{t,i}} + (k_{vill} - k_{hő}) R_H \left(\frac{\dot{W}_f + \dot{W}_{HMV}}{\rho c}\right)^3 \rightarrow \text{min!};$$

where:

$$t_1' = \frac{\dot{Q}_f}{\Phi_f \dot{W}_{1,f}} + t_{2,f}',$$

$$t_1'' = \frac{\dot{Q}_f(\frac{1}{\Phi_f} - 1) + \dot{W}_{1,f} t_{2,f}' + \dot{W}_{1,HMV} t_{2,HMV}' + \dot{Q}_{HMV}(\frac{1}{\Phi_{HMV}} - 1)}{\dot{W}_{1,f} + \dot{W}_{1,HMV}}$$

$$\dot{W}_{1,HMV} = \frac{\dot{Q}_{HMV}}{\Phi_{HMV}(\frac{\dot{Q}_f}{\Phi_f \dot{W}_{1,f}} + t_{2,f}' - t_{2,HMV}')}.$$

After the substitution t_1', t_1'' and $\dot{W}_{1,HMV}$ the function the only once unknown in the expression is the primary heat capacity flow $\dot{W}_{1,f}$. The other parameters can be determined easily from the operational parameters of the system operating with non-optimal schedule. From the minimum of the function the optimal primary heat capacity flow can be determined, from this the optimal primary supply temperature. The optimal primary schedule can be determined step by step in the domain of outside temperature.

5.
I have worked out a computer program to determine the optimal primary schedule with optional accuracy.

6.
I have pointed out, that in systems with good heat insulation and big pressure loss, prominently if the cheap heat-energy results unfavourable cost factor, the optimal primary supply temperatures are higher than usual. If the optimal primary supply temperature higher than admissible (for example limited by pressurizing limits), the possible highest temperature is to realize. To realize the optimal operation the nominal mass flow must be changed.