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ADVANCES IN CLEANER PRODUCTION
"INTEGRATING CLEANER PRODUCTION INTO SUSTAINABILITY STRATEGIES"

"Minimization of mass flow in district heating network equipped with one stage domestic hot water production substations"

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- Two stage hot domestic water production needs enough high temperature of water returning from the space-heating section in a district heating exchanger station. In contemporary space-heating installations the maximal temperature of water is significantly smaller than in the past. The majority of heating installation are equipped with thermostatic valves for indoor temperature control.
- Procedures for dimensioning heating installation (EN 12831) give over-surfaced heaters (about 25÷30%) in installations. In this standard internal heat gains in heated rooms are not taken into account. The cause of this is a significant decrease in the return water temperature in a heating installation.
- Critical conditions for two stage DHW production occur at the minimal supply water temperature. It is on the right side of the so called "breaking point" in temperature regulation curve. In this area we can notice a pure quantitative model of regulation, because of constant supply water temperature (about 70 °C).

- The mass flow is forced by control valves settings according to weather conditions and hot domestic water actual demands. It generates troubles in power plant with district heating network cooperation (Zarski, 2012).
- For some time in Poland several District Heating Companies have tried to replace two stage water production system with one stage ones. In existing district heating substations, designed in 70..90. XX. century, a decrease in hot domestic water consumption (from 120 kg/day to about 50 kg/day per person) caused over-surfacing of hot water heat exchangers – in fact, only the second stage of water preparing is good enough.
- The author's own contribution is to prove that two stage domestic hot water substations have no advantages in comparison with one stage heat exchanger stations in contemporary district heating systems.

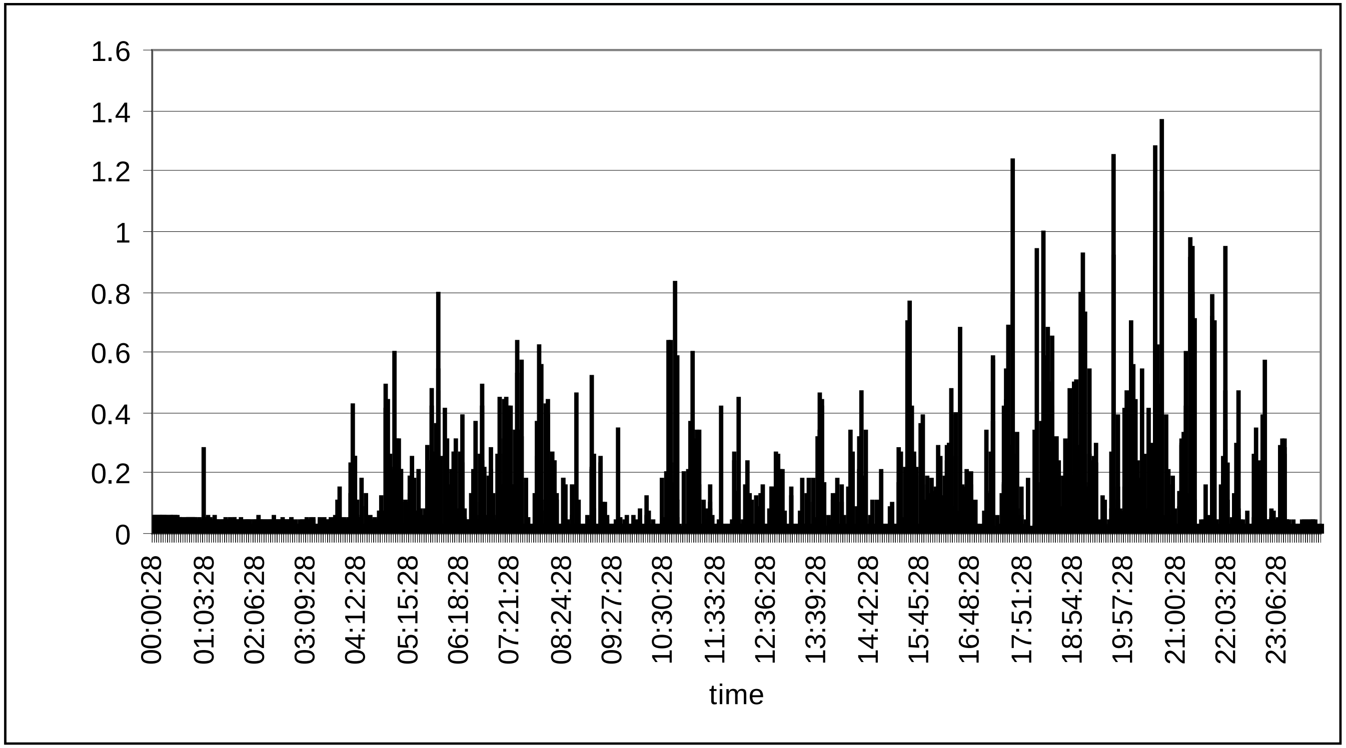

Fig. 1. Typical distribution of DHW (vertical axis – kg/s) in residential building – time period: 1 minute, maximum: 1.37 kg/s

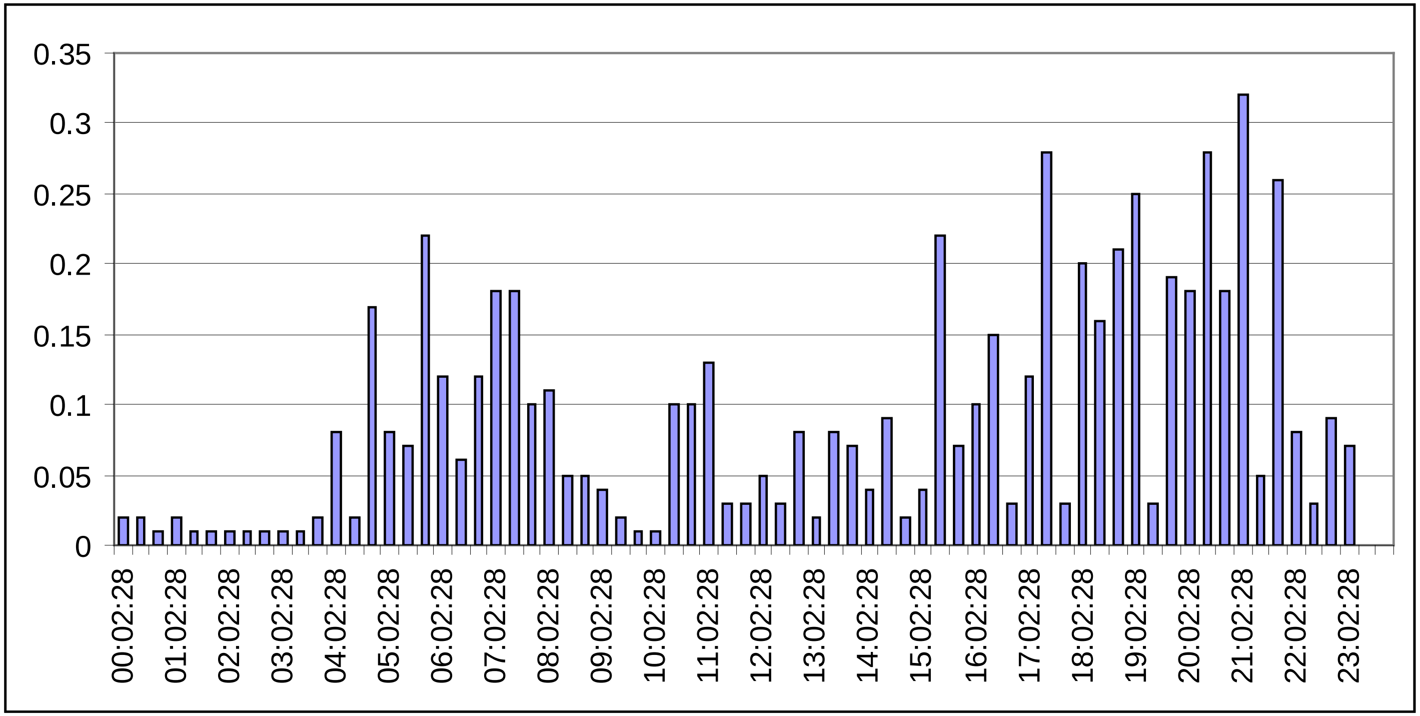

Fig. 2. Typical distribution of DHW (vertical axis – kg/s) in residential building – time period: 20 minute, maximum: 0.32 kg/s

$$m_h = \frac{m_d}{24}$$

m_d – daily water consumption, kg/day,
m_h – hourly water consumption, kg/h.

$$m_{20} = N_{20} \cdot m_h$$

m_{20} – maximum mass flow of DHW in 20 minutes time period, kg/h or kg/s,
N_{20} – peaking factor, calculated as

$$N_{20} = 10.96 \cdot (n_f)^{-0.231}$$

n_f – number of flats.

$$q = a(\Sigma LU)^b$$

The mass flow m_{20} is a parameter for heat exchanger dimensioning

The volume flow rate q is a parameter for hydraulic calculation

According to Euroheat & Power standard (EUROHEAT & POWER, 2008) the maximum volume of flow rate of DHW for heat exchanger selection is calculated in dependence on the number of apartments at max-min range.

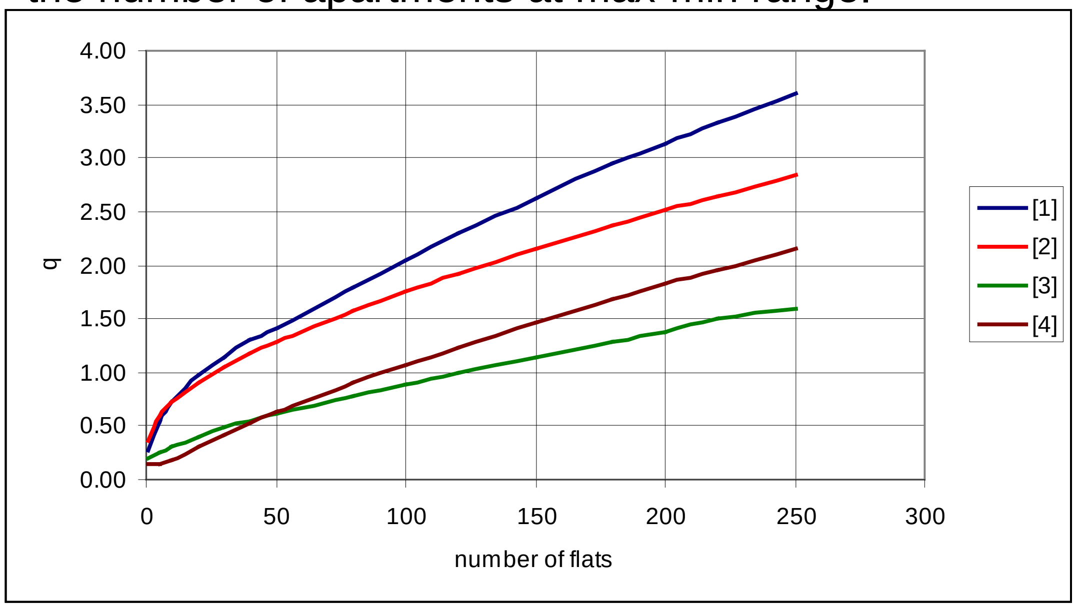

Fig. 3. Flow capacity of warm water (q [dm^3/s]) in residential buildings derived from different formulas, 1 – EN 806, 2 – upper slope (Euroheat), 3 – lower slope (Euroheat), 4 – author's proposition

One or two stage of DHW production

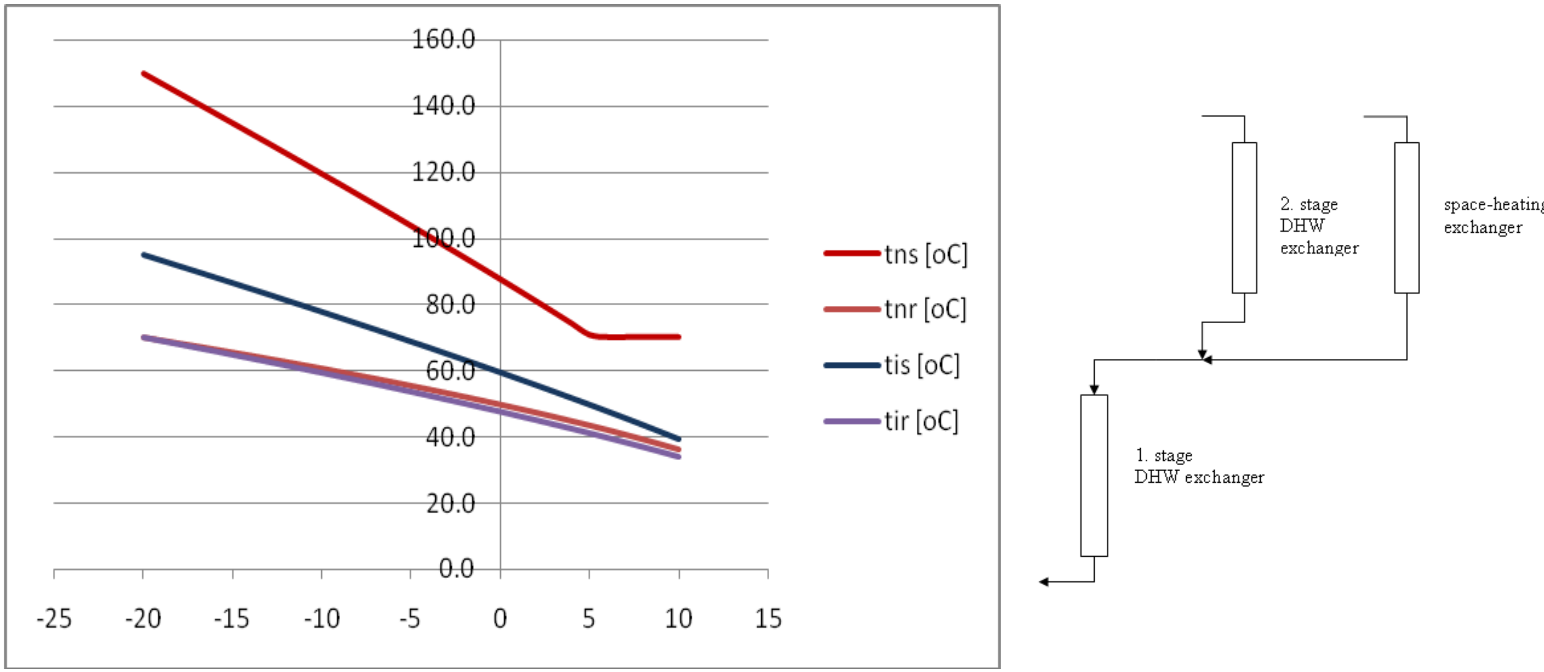

Fig. 4. Operating temperature diagram in past district heating systems and building installations
(3. climatic zone in Poland)

One or two stage of DHW production

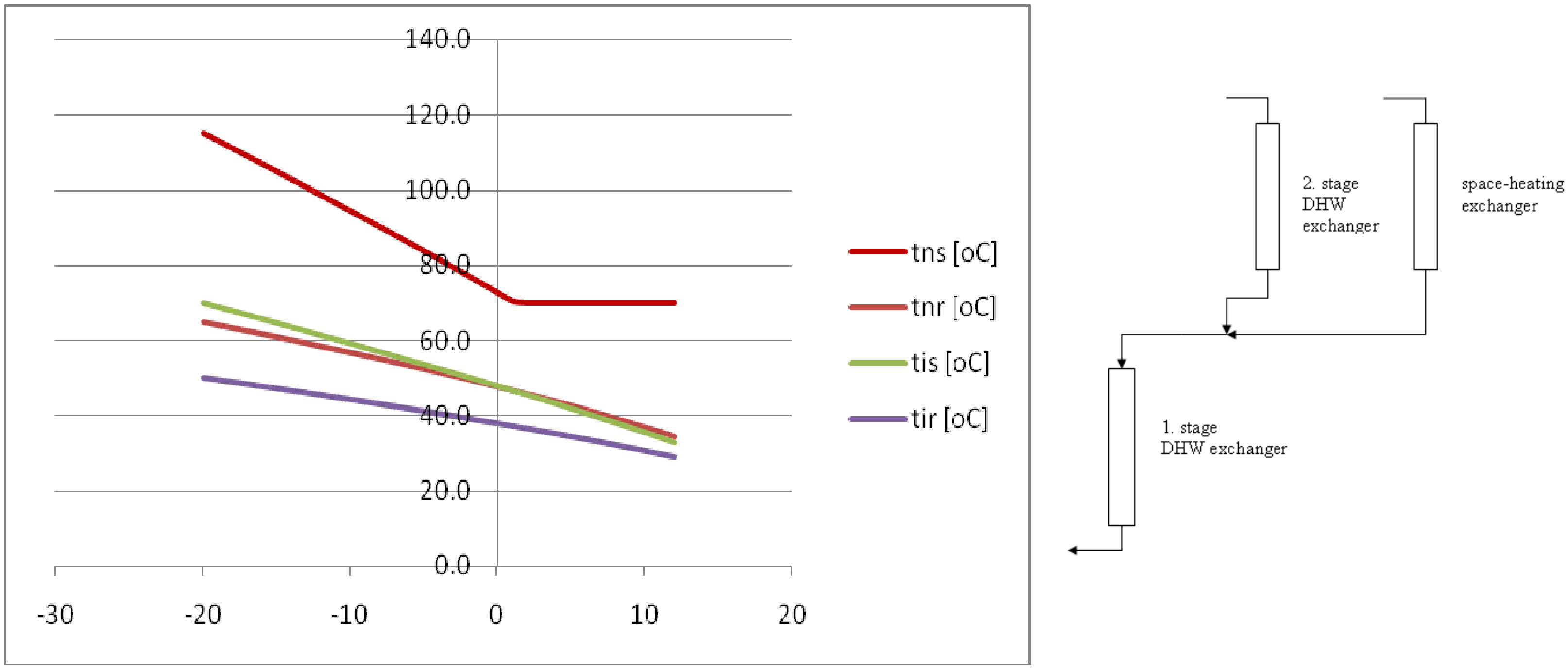

Fig. 6. Typical contemporary operating temperature diagram in district heating systems and building installations (3. climatic zone in Poland)

One or two stage of DHW production

Tab. 1. Real return temperature in space-heating section (grey) (Hexact, 2013)

t_e [ºC]	t_{ns} [ºC]	t_{nr} [ºC]	t_{is} [ºC]	t_{ir} [ºC]
1	70.5	41.9	46.8	37.3
2	70.0	39.9	45.6	36.6
3	70.0	38.8	44.4	35.9
4	70.0	37.7	43.2	35.2
5	70.0	36.7	42.0	34.5
6	70.0	35.7	40.8	33.8
7	70.0	34.6	39.5	33.0
8	70.0	33.6	38.3	32.3
9	70.0	32.6	37.0	31.5
10	70.0	31.6	35.7	30.7
11	70.0	30.6	34.4	29.9
12	70.0	29.5	33.0	29.0

Tab. 2. Real return temperature in installation in case of heaters over-surfacing (10%), design temperature: 70/50 oC, (Hexact, 2013)

t_e [°C]	t_{is} [°C]	t_{ir} [°C]
1	46.8	25.0
2	45.6	24.2
3	44.4	23.3
4	43.2	22.5
5	42.0	21.7
6	40.8	21.0
7	39.5	20.5
8	38.3	20.2
9	37.0	20.0
10	35.7	20.0
11	34.4	20.0
12	33.0	20.0

Total mass flow in common (connection) section with priority of DHW may be calculated as

$$m_{nw} = x \cdot m_{nh} + m_{nDHW}$$

x –mass flow decreasing factor,
m_{nh} – mass flow in primary space heating circuit, kg/s,
m_{nDHW} – mass flow in primary domestic hot water circuit, kg/s.

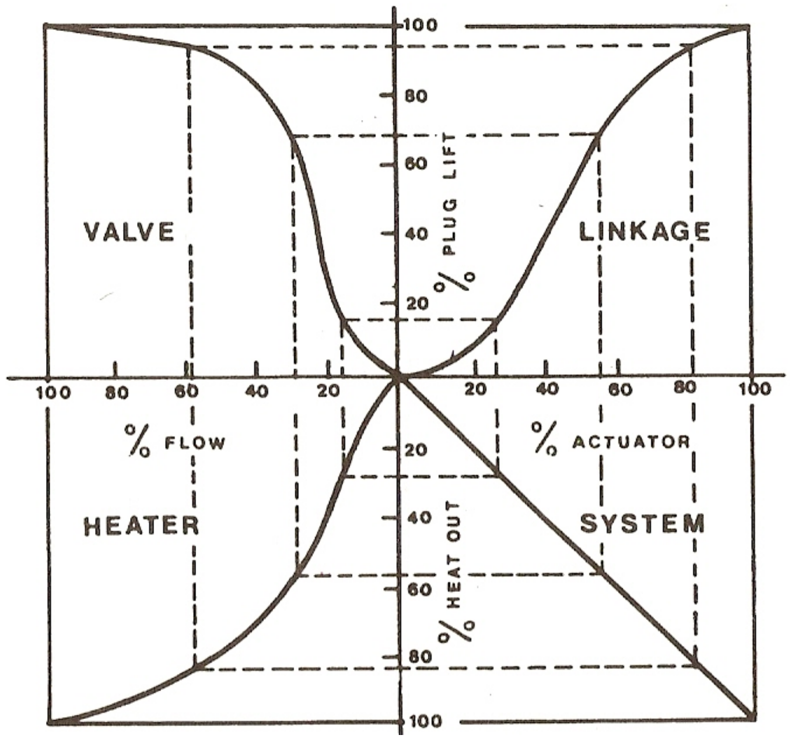

Fig. 7. Characteristics of complex heating system (Harvey, 1993)

Plug lift [%]1	Mass flow [%]
0	0
10	12
20	18
30	20
40	24
50	28
60	30
70	34
80	40
90	50
100	100

Tab. 3. Dimensionless correlation between plug lift and mass flow in case of logarithmic plug profile (on the basis Harvey, 1993), red letters – preferred values (Zarski, 2013)

In case of DHW priority we can expect smaller energy consumption for pumping the heating medium. If we assume the time of exceeding hourly average hot domestic water demands as 3 hours per day, we may calculate the rate of energy saving in a year.

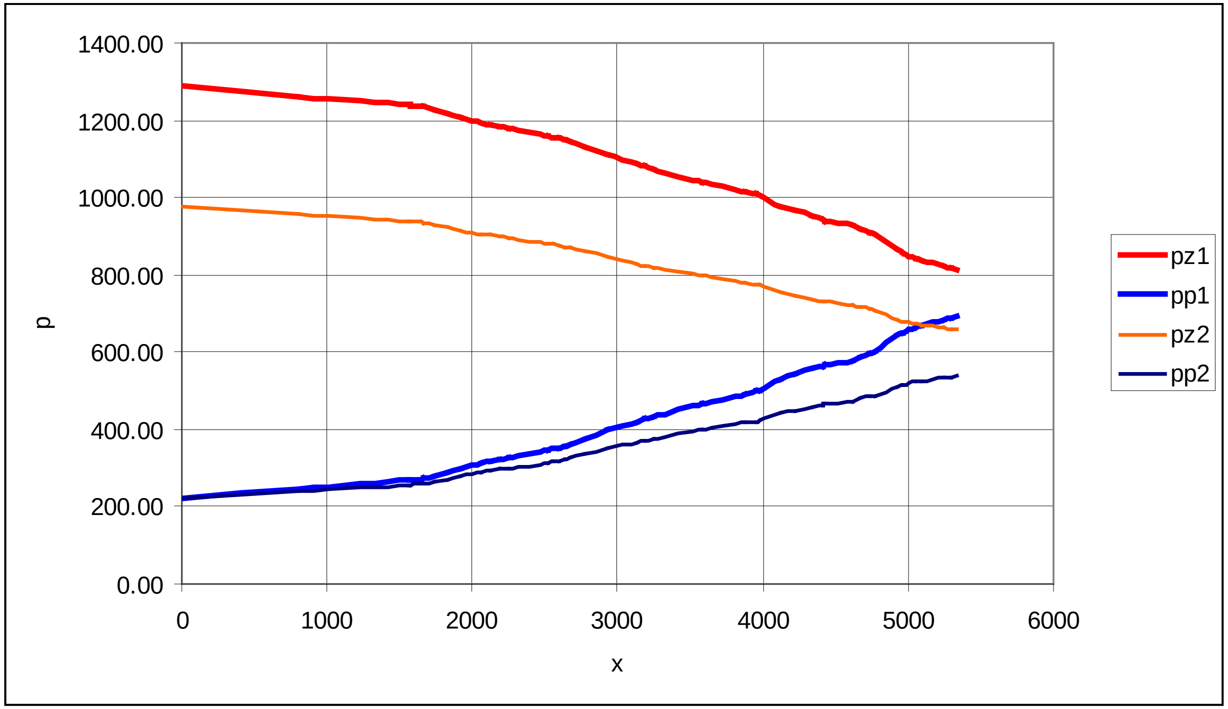

Fig. 8. Pressure diagram in district heating network with and without domestic hot water priority, pz – pressure in supply pipeline, pp – pressure in return pipeline, index "1" – without DHW priority, index "2" – with DHW priority, p – pressure [kPa], x- distance [m]

	Without DHW priority	With DHW priority
Total mass flow, t/h	1411.95	1225.16
Differential pressure, kPa	1066.95	754.78
Electrical energy consumption (efficiency of 70%), kWh	253195	412483
Annual energy saving, kWh		159288
Annual energy saving, %		38.6

Tab. 4. Energy consumption in a year for pumping water with and without DHW priority

- In the author's opinion in contemporary district heating system we **have no condition** for two stage domestic hot water production.
- District heating substations with one stage of DHW production is **simpler and cheaper** than the one with two stages.
- The total mass flow in district heating substation with one stage of DHW and domestic hot water production is **not larger** than in a two stage station.
- Priority DHW function gives a **significant rate** of saving electrical energy for pumping water in urban district heating systems.
- In an example the annual energy saving rate is about 40%.
- It is a **significant** value, regarding technical, economic and environmental requirements and international regulations.

Thank you for attention

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