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Application of a soil temperature model for simulating the effect of district heating pipes on drinking water pipelines

John van Esch[1,]* and Henk Kruse[1]

[1] Deltares, Delft, The Netherlands
* Corresponding author: John.vanEsch@Deltares.nl

According to Dutch legislation the drinking water temperature is required to be below 25°C at the tap to meet legionella prevention [1]. This requirement possibly limits the storage of heat in the subsoil and the transport of heat through pipelines. In order to asses the impact of heat transport pipelines on the drinking water temperature in adjacent drinking water pipelines, a soil temperature model was developed. This coupled micro-climate [2] and heat transport model relates atmospheric conditions to the temperature distribution in the sub-surface [3]. The subsurface part of the model is based on a finite element discretization of the transient heat conduction equation in a single phase material. The coupling of the subsurface part of the model with atmospherical part of the model requires that the sensible heat flux, the latent heat flux, net radiation and the subsurface heat flux are in equilibrium at the land surface. Simulation periods of a number of years are discritized in time steps of one hour. The model is validated by comparing the model results with a large number of field measurements in the Dutch city Rotterdam-Kralingen [3].

The validated model is used to predict the drinking water temperature in transport, primary and secondary pipeline networks. The transport networks supply heat and water to the primary networks. Primary networks distribute their heat and water to secondary networks that transport it to buildings.

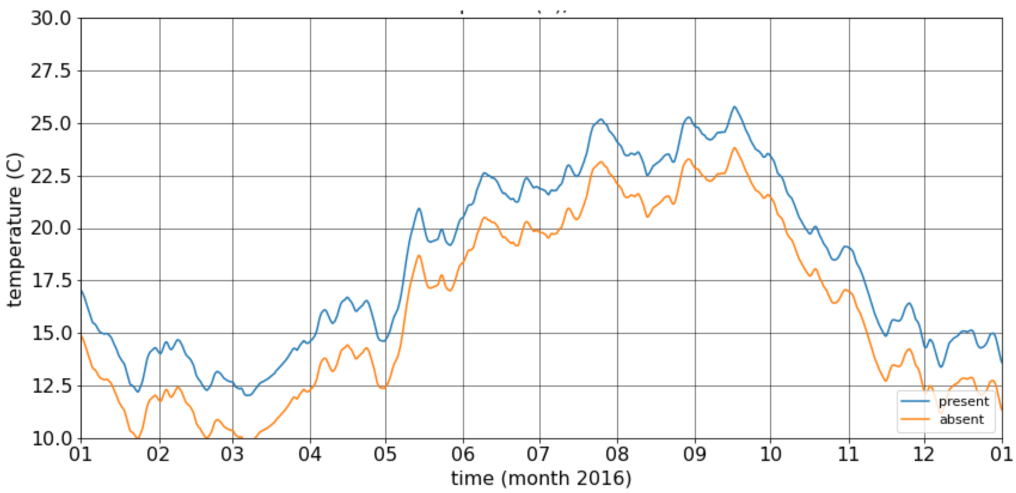

Figure 1: Drinking water temperature with and without heating pipelines.

Figure 1 presents the outcome of a simulation for a primary network. The figure shows the drinking water temperature for a case with and without heating pipelines parallel to drinking water pipelines, with a limited flow of drinking water. The inner diameter of the heat supply and return pipelines, which are usually located close to each other, is 160.3 mm. The heat supply temperature is 90°C and the return temperature is 70°C. The inner diameter of the drinking water pipelines is 152 mm. The heat transport pipelines consist of an inner steel pipe with a wall thickness of 4 mm, a PUR isolation of 56 mm and a PE sleeve of 4 mm. The finite element

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discretization captures the geometry of the insulated pipeline and associated effective thermal properties. Drinking water pipelines have a PVC wall with a thickness of 4 mm. The drinking water pipeline cover depth is 1.00 m, the distance in between the drinking water pipeline and heat return pipeline is 0.75 m and the soil cover of the heat supply pipelines is 1.00 m. Tiles cover a dry sandy soil for which the specific heat capacity is 800 J/kgK, the thermal conductivity is 1.6 W/mK and the density of the soil is 1600 kg/m^3. The figure shows a seasonal variation of the drinking water temperature of 13.8°C and an increase of the drinking water temperature due to the presence of the heat transport pipelines of 2.0°C, which is almost constant throughout the year. The maximum drinking water temperature is found in August and amounts to 23.8°C if the heat pipelines are absent and 25.8°C if they are present.

Table 1 presents the results of a study with variation of the drinking water pipeline soil cover, the distance in between drinking water pipeline and heat return pipeline and the soil cover of the heat supply pipelines. Based on this table decisions can be made on the type of construction and the effect of the heat transport pipelines on adjacent drinking water pipelines.

Table 2: Drinking water temperature for different configurations.

cover depth drinking water pipeline (m)	distance drinking water and heat transport pipeline (m)	cover depth heat transport pipelines (m)	maximal temperature without heat transport pipelines (°C)	maximal temperature with heat transport pipelines (°C)
1.00	0.75	1.00	23.8	25.8
0.75	0.75	1.00	24.8	26.4
2.00	0.75	1.00	20.6	22.7
1.00	0.25	1.00	23.8	27.0
1.00	2.50	1.00	23.8	24.4
1.00	0.75	0.75	23.8	25.9
1.00	0.75	2.00	23.8	25.8

The table shows that the cover depth of the drinking water pipeline strongly influences the increase of the drinking water temperature due to atmospheric conditions. A decrease of the soil cover from 2.00 m to 0.75 m raises the maximal temperature by 4.2°C. The presence of the heat transport pipelines increases the temperature of the drinking water by 1.7°C for the case of a small cover depth and 2.1°C for a large cover depth. A decrease of the distance in between the drinking water pipeline and the heat return pipeline from 2.5 m to 0.25 m raises the maximal drinking water temperature by 2.6 °C. The calculation results show that the drinking water temperature is not sensitive to the proposed cover depth variation of the heat supply pipelines. The computational results for all networks considered, are collected in an expert tool that can be accessed via: https://www.tkiwatertechnologie.nl/projecten/opwarming-van-drinkwater/.

Contributor statement

Methodology, software, writing – original draft: Author 1, conceptualization, writing – editing: Author 2.

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