Supplementary Material S1

S1.1. Water supply system temperature

The water supply system temperature (t_{WSS}) varies during the year, which depends on a type of water source (either deep or surface) and the layout characteristics of the water supply system (i.e. the heat exchanged with the environment). To separate the heat demand for domestic hot water (DHW) and space heating (SH) as accurately as possible, the water supply system (WSS) temperature is needed. The latter affects the heat consumption for the DHW preparation. Based on data analysis from the year 2019, for a building located 3 km from the studied buildings, it was found that the difference between the minimum and maximum values of the WSS temperature (during the year) is about 11 K. Using this data, the WSS temperature was estimated from the outdoor air temperature. The relationship was only available for the 24-hour average values, as in the rest of the analysis. Figure S1 shows the correlation between the estimated and the measured values of the WSS temperature, for which an R^2 coefficient with a value of 92% is determined. The approximation that were obtained was considered sufficient.

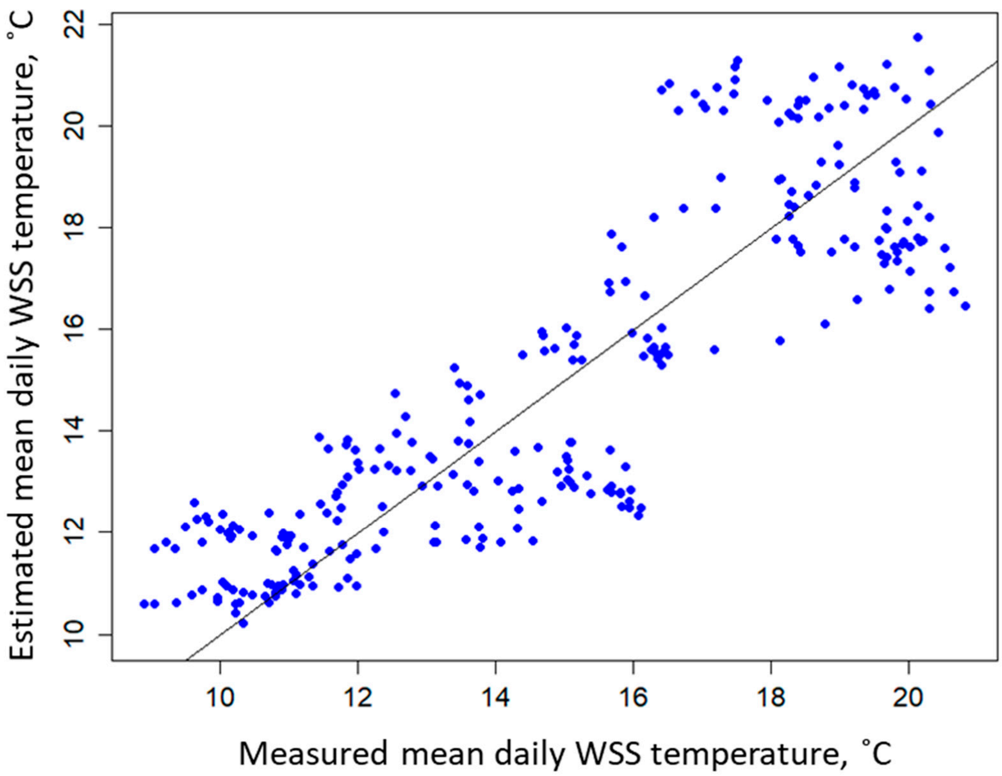

Figure S1.1. Correlation between the measured and the estimated average daily WSS temperature.

S1.2. Supply temperature for residential thermal station (RTS) and SH

The gas boilers operation variables were recorded, which included the supply ($t_{HN,sup}$) and return ($t_{HN,ret}$) temperatures of the heat network (HN), the mean daily heating power of the HN ($\dot{Q}_{HN}$), and the mean daily volume flow of heating water in HN ($\dot{V}_{HN}$). Data from the residential heat meters enabled a determination of the mean daily heating power ($\dot{Q}_D$) that is transferred to 101 out of the 108 apartments. Based on the heat loss coefficients (H_{tr}) of the non-metered dwellings and staircases, a correction coefficient was determined that enabled estimation of the heat delivered to all the dwellings and staircase radiators (k_{Htr}). Heat losses in the HN arise from both the supply ($\dot{Q}_{HN,loss,sup}$) and return pipes. Based on the temperature difference between the supply and return temperatures of the HN and the outdoor temperature, it was estimated that the losses from the supply pipes is 56% of the total heat losses from the HN. Based on the balance equation for heat losses in the HN, the mean supply temperature for the RTS ($t_{\mathrm{RTS},sup}$), and also for the SH in the dwellings, was determined as:

$$\dot{Q}_{HN,loss,sup} = 0.56\left(\dot{Q}_{HN} - k_{Htr}\sum \dot{Q}_D\right)$$

$$\dot{Q}_{HN,loss,sup} = \dot{V}_{HN}\rho_{water}(t_{HN,sup})c_w(t_{HN,sup})(t_{HN,sup} - t_{\mathrm{RTS},sup})$$

$$t_{\mathrm{RTS},sup} = t_{SH,sup} = t_{HN,sup} - \frac{0.56(\dot{Q}_{HN} - k_{Htr}\sum \dot{Q}_D)}{\dot{V}_{HN}\rho_w(t_{HN,sup})c_w(t_{HN,sup})} \qquad \text{(S1.1)}$$

The equations for the density and specific heat capacity of water as a function of temperature were taken from [38].

S1.3. Separation of heat consumption for SH and DHW

The heat meters recorded the total heat consumption for a given dwelling, which was used for both DHW and SH purposes. An algorithm was developed to separate the heat consumption for SH and DHW purposes, which accounted for the dynamics of the consumption during the week and the influence of the WSS temperature dynamics on the heat consumption for DHW heating. The whole algorithm, displayed in Figure S2, is described below.

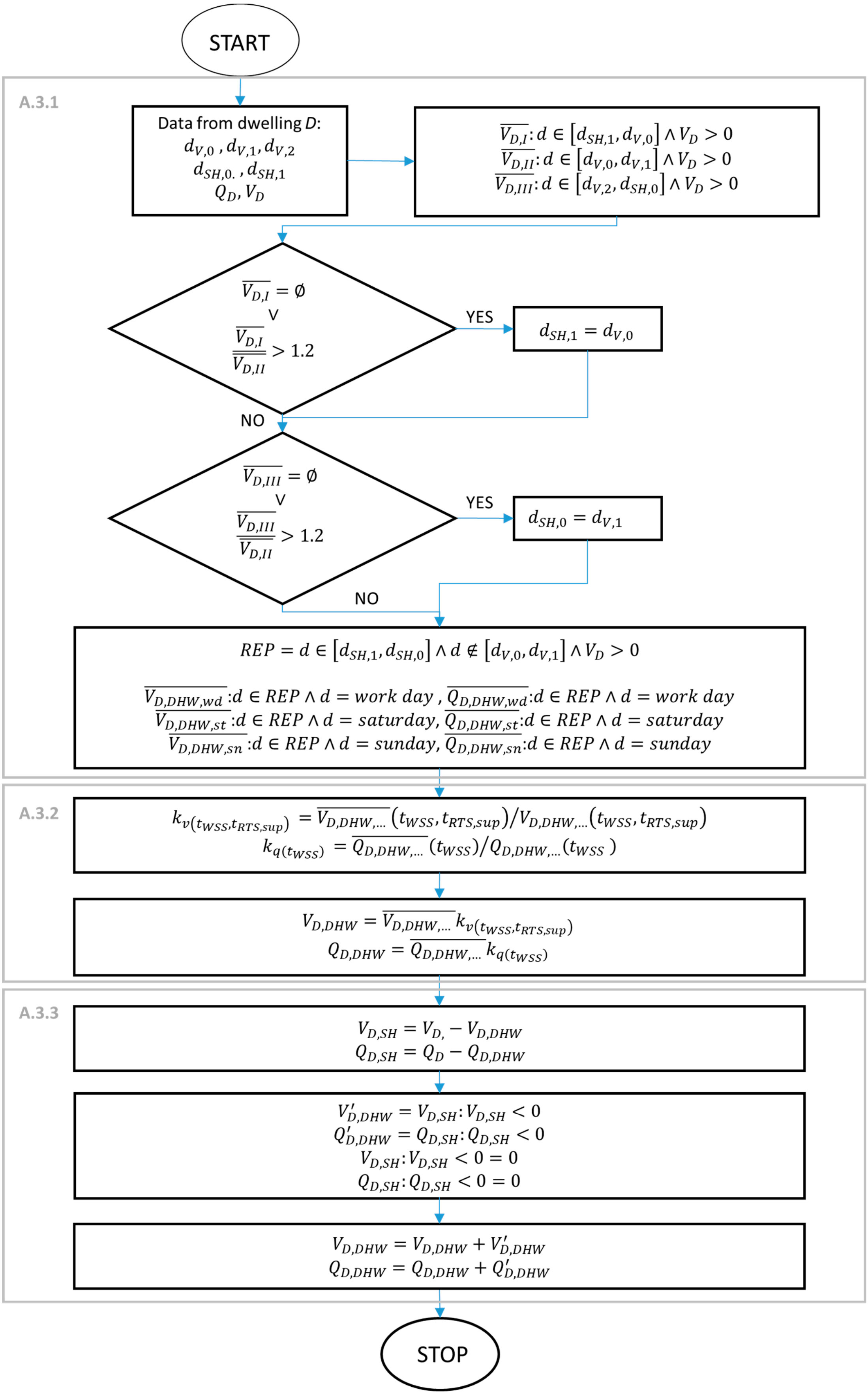

Figure S1.2. Algorithm of the heat input and heating water flow separation for the purpose of DHW and SH. Grey colored boxes indicate sections in which particular parts of the algorithm are described.

S1.3.1. The exploration of a typical DHW intake

Five dates were defined: the estimated beginning of the vacation season ($d_{V,0}$ = 1st of June 2015), the beginning ($d_{V,1}$ = 25th of June 2015) and the end of the school vacations ($d_{V,2}$ = 1st of September 2015), the estimated beginning of the heating season ($d_{SH,0}$ = 30th of September 2015), and the estimated end of the heating season ($d_{SH,1}$ = 1st of May 2015). Based on these dates, three sets of daily use of heating water values for a given dwelling (V_D) were identified: $I = [d_{SH,1}, d_{V,0}]$, $II = [d_{V,0}, d_{V,1}]$, and $III = [d_{V,2}, d_{SH,0}]$. For each set, a daily heating water consumption greater than 0 was averaged ($\overline{V_{D,I}}$, $\overline{V_{D,II}}$, $\overline{V_{D,III}}$). The set $[d_{SH,1}, d_{V,1}] \cup [d_{V,2}, d_{SH,0}]$ was implicitly assumed to represent the typical DHW consumption. However, if there were consumption equal to 0 in set I or $\overline{V_{D,I}} > 1.2\overline{V_{D,II}}$ then $d_{SH,1} = d_{V,0}$. Conversely, if there were consumption equal to 0 in set III or $\overline{V_{D,III}} > 1.2\overline{V_{D,II}}$ then $d_{SH,0} = d_{V,1}$. For the representative set defined in this way, the mean daily DHW and the heating water consumption for the working days $\overline{V_{D,DHW,wd}}$, $\overline{Q_{D,DHW,wd}}$, Saturdays $\overline{V_{D,DHW,st}}$, $\overline{Q_{D,DHW,st}}$, and Sundays $\overline{V_{D,DHW,sn}}$, $\overline{Q_{D,DHW,sn}}$ were calculated.

S1.3.2. Temperature correction of DHW and heating water consumption

In the analyzed system, the heat and the heating water flow that was consumed during DHW preparation were affected by both the WSS temperature (t_{WSS}) and the supply temperature of the RTS ($t_{RTS,sup}$) from HN. A modification in these temperatures also affects the changes in heat input and heating water flow for the DHW heating. For an assumed constant DHW temperature (t_{DHW}) that is equal to 40°C at the tapping point and based on the heat exchanger specification card, the following relationships were determined:

- WSS temperature and RTS supply temperature and the flow of heating water through the RTS for DHW preparation,
- WSS temperature and heat consumption for the DHW preparation.

The correlations that enable the conversion of typical DHW heat and heating water consumption into consumption throughout the year, which accounts for the dynamics of the WSS and HN temperature, are found by use of the correction coefficients $k_{v(t_{WSS}, t_{RTS,sup})}$ and $k_{q(t_{WSS})}$.

S1.3.3. Determination of heat and heating water consumption for SH and DHW

The heat and heating water consumption for the DHW preparation, which is determined for each day of the year (accounting for the differences in weekdays and the dynamics of the WSS and HN temperatures) were subtracted from the total consumption. The following values were obtained in this way: $V_{D,SH}$, the daily flow of heating medium through the SH installation, and $Q_{D,SH}$, the daily heat consumption by the SH installation. If, as a result of this subtraction, some of the heat loads for the SH have a negative value, those heat loads are reset to zero and the corresponding DHW loads are reduced by that value. The cumulative effect (for the whole estate) of these calculations is shown in Figure S3.

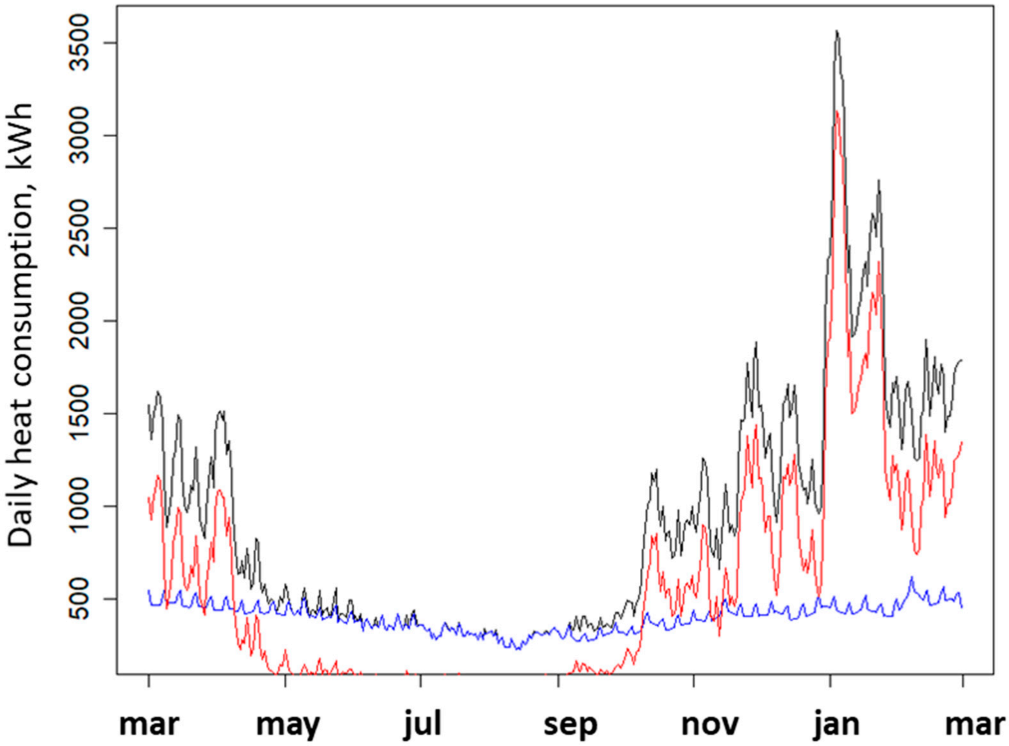

Figure S1.3. Total daily heat consumption of the metered dwellings (black line) and the heat consumption for the DHW (blue line) and for the SH (red line).