Slide 1

This is the electric equivalent scheme of each zone. Here the thermal capacitance is connected to the external environment through the conductance G, heat is provided to the system by the two actuators, respectively the valve, which controls the flowrate of the fluid inside the main grid, and the secondary heater.

Both these actuators are regulated by a PI controller in a daisy chain fashion, prioritizing the valve over the heater, in order to reduce the overall power consumption.

The temperature in each zone is governed by this non-linear differential equation which we linearized around these values, for the reasons above, in fact, we imposed no usage of the heater and average usage of the valve.

The PI controller is tuned in order to cancel out the pole introduced by the system’s dynamics whereas the gain is tweaked empirically based on the results of the simulations.

Slide 2

Here we can see the temperature set point tracking of the two zones, in particular during the transients from night to day both temperatures have small amplitude oscillations which do not affect the comfort at all, and a tiny temperature drop of zone 1 before entering the night.

During the shift from day to night the temperature in the first zone has the same behavior while the second zone takes almost 40 minutes to reach a steady state, this discrepancy is due to the different physical parameters of the two zones, mainly the different length of the pipes exchanging heat with the fluid in the main grid.

Slide 3

As we said before we tried to minimize the usage of the heater and we managed to completely nullify it, as we can see from the control signal plot. In fact, the valve has a periodic pattern and never reaches saturation.

Slide 4

Regarding the overall power consumption, at first we have a great power usage due to the main heater, which, as we’ve seen, has to heat up all the fluid in the network. Then the power consumption decreases and presents a pattern with spikes due to the shifts from night to day.

The average consumption, instead, after a 10-day transient settles down to about 2 kW.

Slide 5

The total power is split between the main heater (red line), the two secondary heaters, which as we said aren’t getting used at all, and the pump which draws a constant amount of power.

And finally, the purple line represents the power lost to the environment.