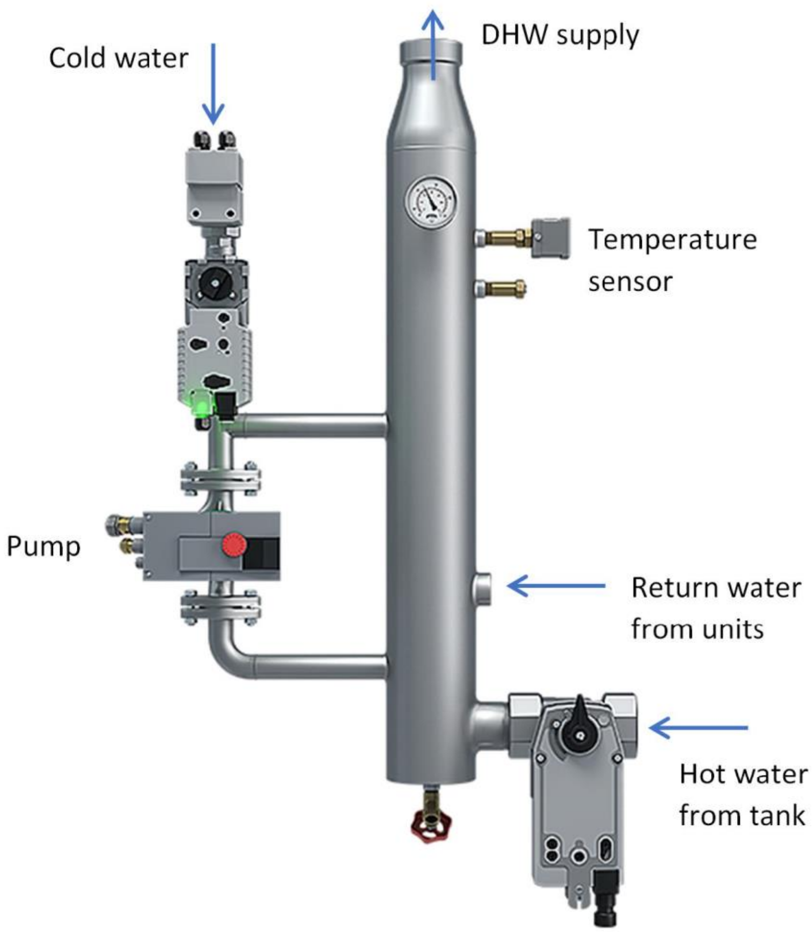


Flowmix performance

COMPARED TO A TMV

Ali Rahmatmand, Marin Vratonjic, Pierre Sullivan | University of Toronto | 05/12/2019

Contents

Summary....2
1. Introduction....2
2. Methodology....3
3. Results....4
3.1. Energy saving....4
3.2. Cold water consumption....5
3.3. Total recirculation and reheat line flowrates....6
3.4. Pressure drop in the system....7
4. Conclusion....8
5. Future work....8
References....8
Appendix....10

Summary

In this report, a brief overview of our research finding and results obtained from field data measurements is presented. Replacing a TMV with a Flowmix results in

- Energy saving of approximately 25%
- Reduction of cold water consumption by an average of roughly 6 GPM
- Significant lower pressure drops and consequently lower pump costs
- Comparing the reheat-water flowrate between a Flowmix and a TMV arrangement

Field data presented in this report is collected from the Lansdowne building (a one zone building with 297 units).

1. Introduction

The residential building sector energy consumption accounts for 16-50% of total energy consumption in most countries [1, 2]. National Resource Canada reported that in Canada, buildings consume approximately 30% of all secondary energy (energy used by final consumer). More than half of this amount (54%) was used by residential buildings while the rest was consumed by commercial and institutional buildings. Of the residential building portion, 18% is used in apartment buildings [3].

To reduce this environmental impact, energy and water consumption of high-rise buildings should be optimized. Domestic Hot Water (DHW) demand accounts for a large portion of energy and water consumption of such buildings. However new regulation and standards have made it challenging to find an optimum solution to reduce DHW energy cost of buildings.

2. Building standards and regulations

To ensure health and safety for high-rise buildings' residents, new Ontario building regulations and World Health Organization (WHO) mandate buildings: (a) to deliver hot water to resident units not hotter than 49°C (120°F)" to avoid tap water scald burns [4], and, (b) to store hot water at 60°C (140°F) or higher to avoid bacterial contamination (e.g., Legionella) [5-6].

Consequently, stored hot water at 60°C needs to be mixed with cold water to deliver DHW to units at the required temperature (49°C). In this report, the performance of traditional thermostatic mixing valve is compared with that of Flowmix in terms of energy (gas) and water consumption.

2. Methodology

A 14-story building with one zone of DHW (i.e. one loop provides DHW to all the floors) was selected for this study. To compare the performance of Flowmix and TMV units, the building's DHW system was operating for a week with a TMV while data was recorded, and then it was replaced by a Flowmix unit. The data was also recorded during the next 7 days with a Flowmix unit in the system.

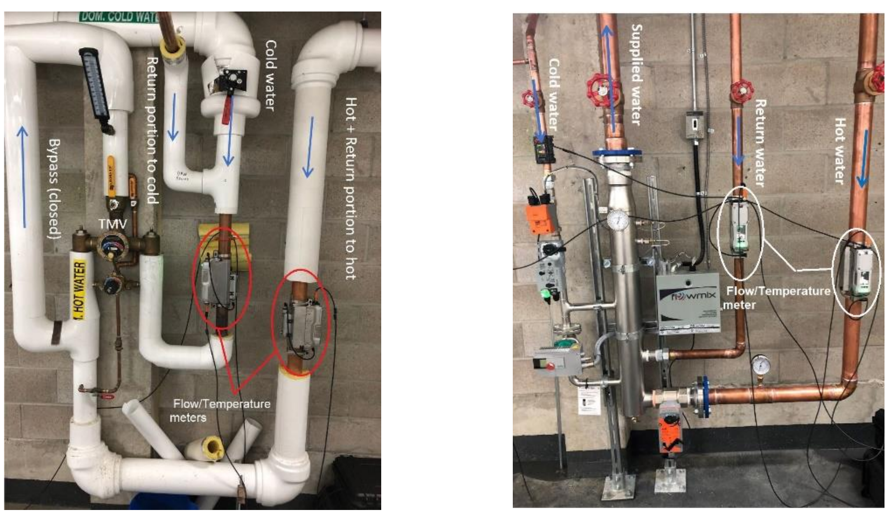
The piping system for the TMV/Flowmix part is shown in Fig.1. A DHW boiler heats and stores water in a hot water tank. The return water from units is partially mixed with the pressurized cold water at 370 kPa with the remaining return water returned to the hot water tank. The mixed cold and return water enters the TMV and is mixed with the hot water coming from the hot water tank at 370 kPa. Flowrate and temperature of each stream entering the TMV/Flowmix was measured for 7 days using an ultrasonic clamp-on flow/temperature meter (KEYENCE flowmeter FD-R80).

The flowmeter stored the maximum and minimum flowrate/temperature in 5 minute intervals. Assuming a normal distribution for data in each 5-minute span, uncertainty of the flowrate and temperature measurements are:

$$u_{flowrate} = \pm\sqrt{{u_{cal_f}}^2 + {u_{af}}^2 + {\sigma_{mf}}^2 + {\mathrm{Res_f}}^2} = \pm 1.8\ (L/min)$$

$$u_{Temp.} = \pm\sqrt{{u_{cal_T}}^2 + {u_{aT}}^2 + {\sigma_{mT}}^2 + {\mathrm{Res_T}}^2} = \pm 1.6°C$$

where u_{cal} is the calibration uncertainty , u_a is the accuracy, σ_m is the standard deviation of the mean and resolution of the DAQ, Res (subscripts f and T are for flow and temperature respectively) [1].



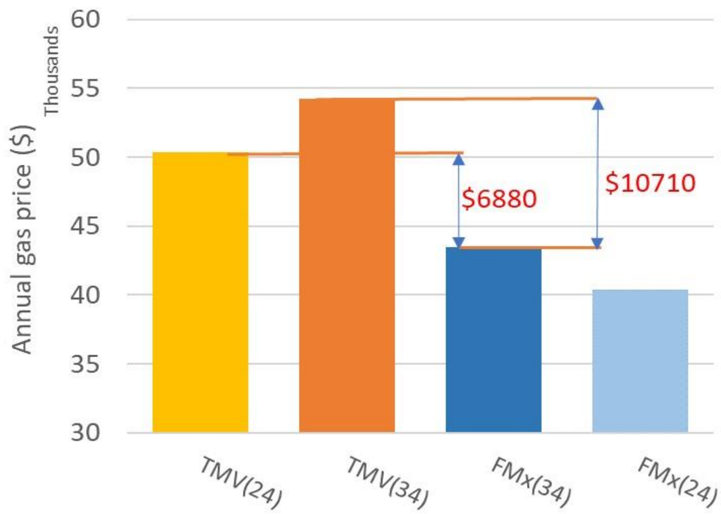
a) DHW system with the TMV   *b) DHW system with the Flowmix*

Fig.1. DHW systems tested in a 14-story

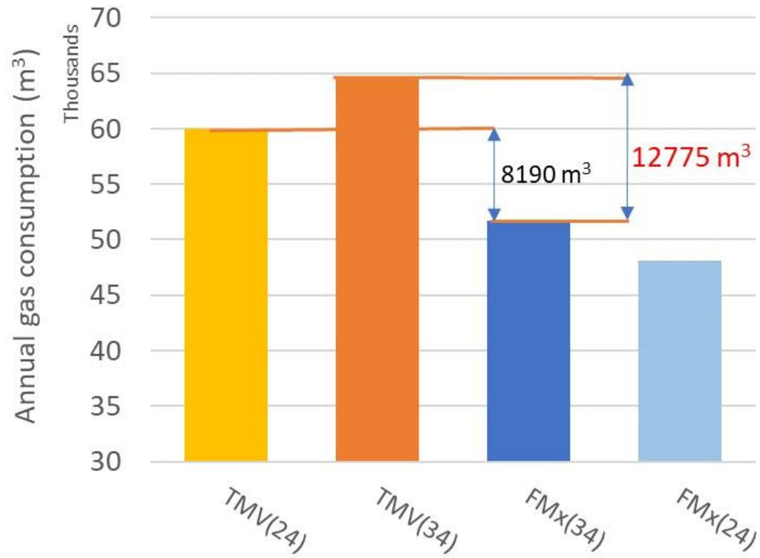
3. Results

3.1. Energy saving

The annual energy/gas consumption for providing hot water to the building is calculated by using the field measurements data for both TMV and Flowmix unit (refer to Appendix. 1). Two additional cases are also simulated in which 1- TMV (TMV(34)) is operating with the same recirculation flowrate (34GPM) as the Flowmix, 2- Flowmix operates at lower recirculation flowrate of 24GPM (FMx(24)) same as TMV to have a more accurate comparison (Fig.2).



a) Annual gas price of the building considering several recirculation flowrate (GPM) for TMV and Flowmix (FMx)



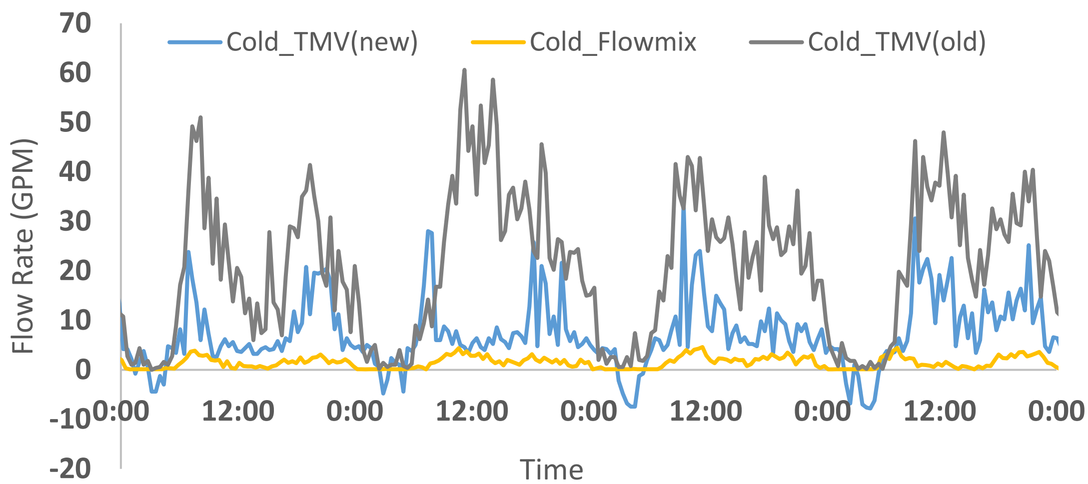
b) Annual gas consumption of the building with different recirculation flow rate (GPM)

Fig. 2 Annual gas saving and energy consumption of the building with Flowmix vs TMV considering several recirculation flowrates (24 and 34 GPM) for TMV and Flowmix (FMx)

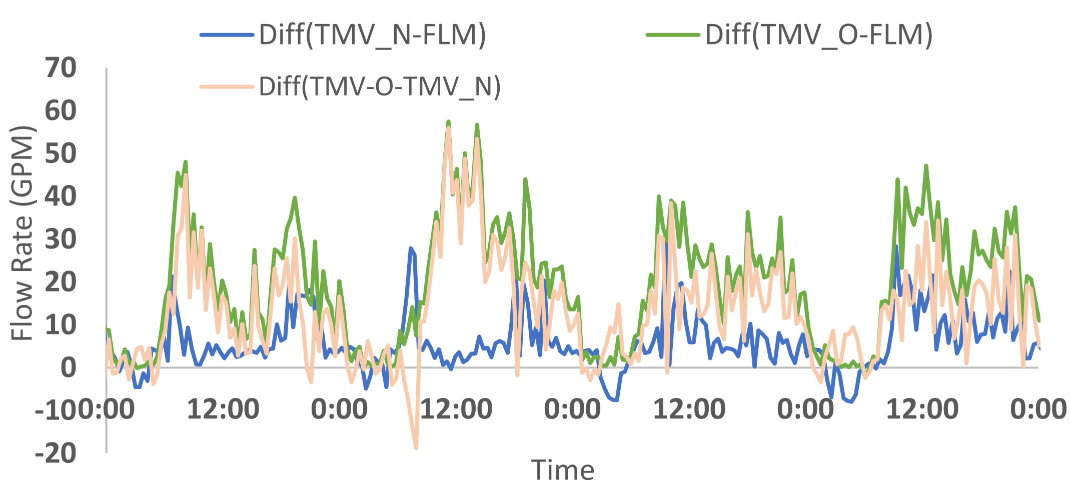
The energy saving between the Flowmix (FMx(34)) and TMV(34) (which operates under the same recirculation flowrate, 34GPM) is very significant. The lowest energy consumption is for Flowmix with the circulation flowrate of 24 GPM. It should be noted that Flowmix can operate at lower flowrates than 24 GPM to increase the energy saving.

3.2. Cold water consumption

Replacing the TMV with a Flowmix unit can reduce the amount of cold water used in the hot water loop. In addition, before installing the Flowmix, the old TMV was replaced by a new TMV for a week to collect some data. Fig. 3 compares the cold water injected to the system by the old TMV, new TMV and Flowmix unit during several days.



a) Cold water injected to the system for old TMV, New TMV and Flowmix



b) Cold water consumption difference between systems

Fig. 3. Cold water consumption

Average of differences between cold water consumption is presented in Table 1.

Table 1. Average of differences between cold water consumption of TMV and Flowmix systems

	Average cold-water consumption difference (GPM)
(TMV_old)- (TMV_New)	13
(TMV_Old)- (Flowmix)	19
(TMV_New)- (Flowmix)	6

Table 1 shows the significant difference between cold water injected to the system by the TMV versus Flowmix. Using a Flowmix unit can reduce cold water usage and consequently energy consumption.

3.3. Total recirculation and reheat line flowrates

Fig. 4 compares the portion of recirculation flowrate directed to the hot water tank for both old TMV and Flowmix systems. TMV system directs higher portion of return water to the hot water tank resulting in more energy consumption as shown in the energy saving section.

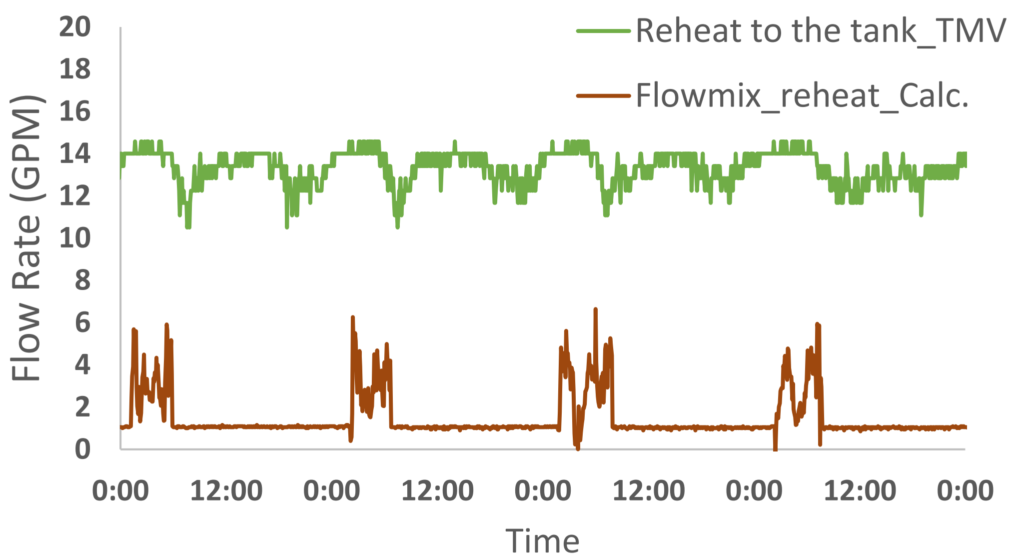


Fig.4. Reheat line flowrate for TMV and Flowmix

3.4. Pressure drop in the system

Flowmix does not restrict the hot water stream from the tank (controlled by pressure) which results in lower pressure drop in the entire hot water system as compared to a TMV. As a result, the residents at the furthest point in the building (with respect to the boiler room) can also have proper pressurized hot water. In buildings with a TMV, it has been observed that after a certain period, high pressure loss in the TMV can cause issues in delivering hot water to the building's residents.

Fig. 5 shows the total recirculation flowrate in the same building with the TMV and the Flowmix. Replacing TMV with the Flowmix increased the recirculation flowrate by almost 40% showing less pressure drop in the Flowmix as compared to the TMV.

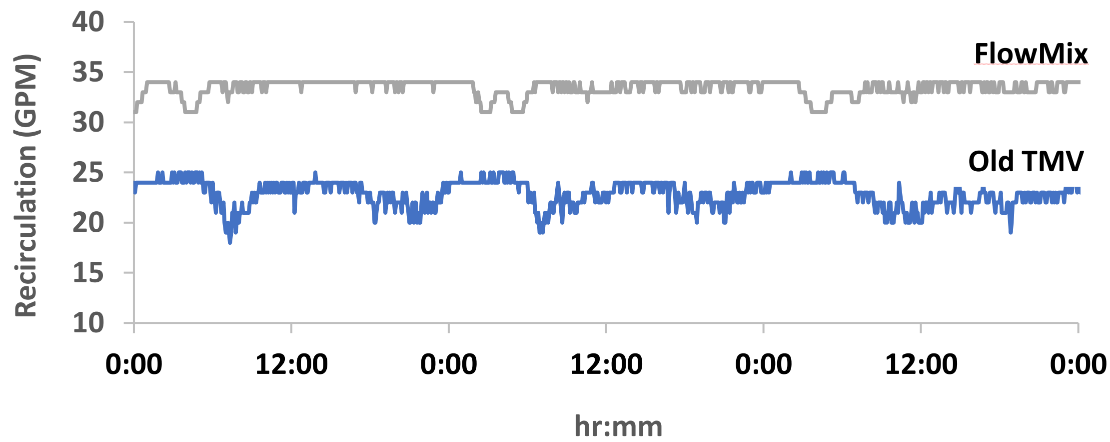


Fig.5. Total recirculation flowrate for the system with the TMV and the Flowmix

Using computational fluid dynamics, we also simulated the Flowmix and the TMV unit. Fig. 6 shows the pressure loss difference in a new TMV, a clogged (old) TMV and the Flowmix unit. Pressure loss is approximately 10 times less in a Flowmix unit. It should be noted that 87 psi pressure drop shown in Fig. 6 for the clogged TMV is under the assumption of constant flowrate of hot and cold streams to keep output temperature at 120°F (even if it is clogged). However, in reality, if the TMV is clogged, the DHW system may not be able to provide the required flowrate by restricting the recirculation flowrate, as the cold water pressure source (cold water booster pump) may not provide more than 50 Psi. Therefore, it means that the hot or cold water stream would be cut off and not only the tempered water pressure is lower than the design pressure, but also the output temperature will not meet the set value (120°F).

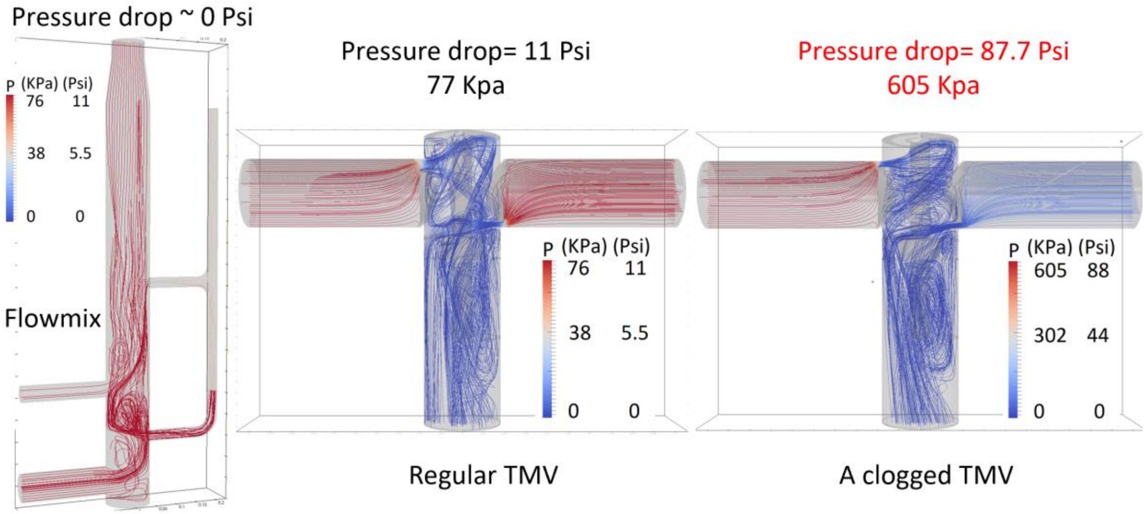


Fig.6. Comparing pressure loss in a TMV and a Flowmix

4. Conclusion

In summary, we can conclude that the Flowmix unit can lead to saving energy and water consumption in a building. A Flowmix unit does not cause any obstruction in the piping line between the hot water tank and the Flowmix which results in less pressure drop in the entire DHW system (A Flowmix controls the output temperature by controlling the cold and return water flowrates). As a result, a resident residing at the furthest point of the building (in respect to the boiler room) can have hot water with proper pressure.

Higher performance of a Flowmix unit as compared to a TMV can provide more comfort for the building's residents in terms of hot water delivery.

5. Future work

In the next step, we will study the performance of a DHW system with a high-performance hot water tank and Flowmix. In addition, we will consider more complex systems with several zones and potentially heat exchangers. The goal is to test Flowmix under different circumstances to examine its performance and capacity for delivering hot water.

References

[1] R. Saidur, H. H. Masjuki, M. Y. Jamaluddin, An application of energy and exergy analysis in residential sector of Malaysia, Energy Policy 24(2007) 1050–1063.

[2] K. Ahmed, P. Pylsy, J. Kurnitski, Monthly domestic hot water profiles for energy calculation in Finnish apartment buildings, Energy and Buildings 97 (2015) 77–85.

[3] G. Finch, E. Burnett, W. Knowles, Energy consumption in mid and high rise residential buildings in British Columbia, Building Enclosure Science & Technology (BEST2) Conference, 2010.

[4] Ontario government, Ontario building code, The Ontario Gazette: March 6, (2004)

[5] B. L′evesque, M. Lavoie, J. Joly, Residential water heater temperature: 49 or 60 degrees Celsius? Canadian Journal of Infectious Diseases and Medical Microbiology 15 (2004) 11–12.

[6] World Health Organization, Legionella and the prevention of legionellosis, WHO Press, (2007)

Appendix

In this section, the method for calculating the energy consumption of the building is described. The energy required to heat the water is called Q. As there is no energy added to the system outside of the hot water tank, the hot water tank is considered as the control volume (CV) assuming that the energy required to heat the water is added to the system through the tank. According to Fig. A1, the total energy used in the system can be calculated by using the recirculation, cold and hot water flowrates and temperatures as follows.

$$\dot{Q} = \dot{m}_H T_H - \dot{m}_R T_R - \dot{m}_C T_C$$

$$\dot{m}_H = \dot{m}_R + \dot{m}_C$$

where C, R and H stand for cold, return and hot streams to and from the tank respectively. Combining these equation gives:

$$\dot{Q} = \dot{m}_H (T_H - T_R) + \dot{m}_C (T_R - T_C)$$

$$Q = \dot{Q} \times t$$

where t is the time.

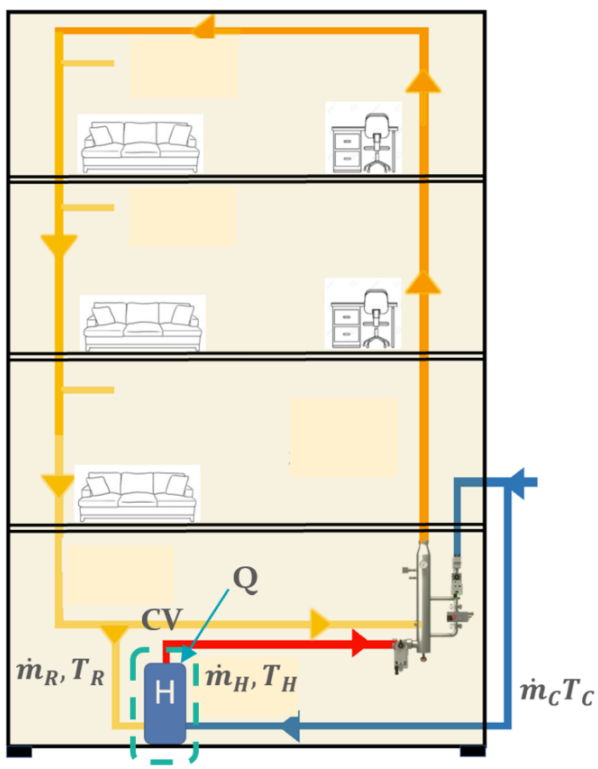


Fig. A1. Schematic of a building