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Saving cold drinking water in residential hot water distribution systems

Sistema para redução de desperdício de água em serviços residenciais de água quente

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Abstract

In homes that have instantaneous gas heaters to heat water, cold water is wasted in the first seconds of using hot water fixtures. This waste is caused due to the large lengths of piping between the hot water fixtures and the heater that feeds them. The water in such pipes suffers thermal losses over time. When turning on the fixtures, this drinking water, because it is cold, is rejected by users, especially when using showers. This work deals with the conformation of a system that avoids wasting water in residential hot water services. To establish this conformation, a usual plumbing design was analysed to verify the changes proposed in order to optimise the operation of the system. The gas-heated hot water pipes are currently installed so that the pipes start at the heater and run through the entire house to the hot water fixtures furthest from the heater. It was found that the waste of water in a water fixture decreases if there is the consumption of hot water previously in one of the water fixtures of the house. To avoid this waste, according to the configuration of the current plumbing systems, it is necessary to install an additional set of electronic equipment that automatically redirects the cold water – that would be wasted – to a water tank for later use. The system proposed is composed of a solenoid valve located at the end of the hot water pipe. This valve has the function of letting flow to the water tank the approximate amount of cold water that would be wasted. Through a radio frequency signal sent when a button located near the hot water fixtures is pressed, the system recognises which water fixture was turned on and the approximate amount of cold water that must be released through the valve until the arrival of hot water from the heater. Then, there must be a pipe that collects the water that flows through the solenoid valve. Such pipe will be connected to a vertical pipe, responsible for collecting water from all flats and directing the water to the water tank. The installation of the system is based on the recommendations of the standards used in Brazil and the most frequent configuration found in homes. This work also serves as a guide for installing the system in homes other than the example shown herein.

Keywords: Instantaneous gas heaters; Structural Waste; Waste of Cold Water; Water Redirecting; Hot Water.

Resumo

Em residências que possuem aquecedores de passagem a gás para o aquecimento da água, há desperdício de água nos segundos iniciais da utilização dos aparelhos sanitários. Este desperdício é causado por conta dos grandes comprimentos de tubulação entre os pontos de consumo de água quente e o aquecedor que os alimentam. A água parada nesta tubulação, sofre perdas térmicas. Ao acionar os equipamentos sanitários, esta água potável, por estar fria, é rejeitada pelos usuários, principalmente quando se faz o uso de chuveiros. Este

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trabalho trata da conformação de um sistema que evita o desperdício de água em serviços residenciais de água quente. Para estabelecer esta conformação, analisou-se um projeto hidráulico usual para verificar as alterações propostas a fim de otimizar o funcionamento do sistema. As tubulações de água quente aquecida por gás atualmente são instaladas de modo que o ramal inicie no aquecedor e percorra a residência toda até os pontos de consumo mais afastados do aquecedor. Foi possível também verificar que os desperdícios de água nos pontos de consumo diminuem caso ocorra um consumo de água quente previamente em um dos pontos de consumo da residência. Para evitar este desperdício, de acordo com a configuração dos sistemas hidráulicos atuais, necessita-se a instalação adicional de um conjunto de equipamentos eletrônicos que redirecionem para um reservatório, de forma automatizada, a água fria que seria desperdiçada. Este reservatório deve garantir a utilização posterior desta água. O sistema proposto é composto por uma válvula solenóide localizada no final do ramal de instalação hidráulica da residência. Esta válvula tem a função de direcionar para o seu devido fim a quantidade aproximada de água fria que seria desperdiçada por um determinado aparelho. Por meio de um sinal de radiofrequência enviado ao se acionar um botão próximo ao ponto de consumo de água quente desejado, o sistema reconhece qual ponto de consumo foi acionado e a quantidade aproximada de água fria que deve liberar por meio da válvula até que ocorra a chegada da água quente do aquecedor. Por último, deve haver tubulações que coletam a água que flui através das válvulas solenóides. Esta tubulação será conectada a uma tubulação vertical, responsável por coletar a água de todas as unidades habitacionais e direcioná-la ao reservatório inferior de água potável da edificação. A instalação do sistema se baseia nas recomendações das normas vigentes atualmente no país e na configuração mais frequente encontrada nas residências. Este trabalho serve também como uma orientação para a instalação do sistema em residências diferentes do exemplo demonstrado no texto.

Palavras-Chave: Aquecedor de passagem a gás; Desperdício estrutural; Desperdício de água fria; Redirecionamento de água; Água quente.

1 Introduction

The Brazilian standard NBR 13103 (ABNT, 2013) recommends that gas heating appliances be installed in places with appropriate ventilation. This recommendation means that homes must be designed so that heaters are installed in the laundry or outside the building. Therefore, longer hot water pipe lengths from the heating source to the water fixtures are necessary. Besides, Lutz (2005) reports that residential building practices typically ignore water and energy losses caused by a poorly designed hot water distribution system. The water that accumulates in the pipeline between the heating system and the water fixtures suffers thermal losses over time and, as it does not reach the water fixtures at a temperature desired by the user, it ends up being wasted at a temperature considered low for consumption. It is noteworthy that similar wastes also occur in backup systems for solar heating, either using electricity or gas when it is not equipped with a recirculating system.

Lutz (2011) and Klein (2006) define two types of losses for water waste during a shower. The cold water that is located in the hot water pipe between the heater and the water fixtures, and that is wasted after hot water consumption, represents structural losses. Water that is hot enough, but continues to be wasted before the user starts using the shower, represents behavioural losses. This loss is related to the activities performed by the user while he/she waits for the hot water to reach the fixture, such as brushing teeth, shaving, undressing, etc.

There are two ways of measuring the waste of water and energy due to the use of hot water in homes. One way is to analyse only the flow trace of the fixtures without analysing the water temperature in which these wastes occur. Through a flow trace analysis of 26,000 showering events, Lutz (2005) concluded that, on average, 13.17 litres of water per shower are wasted. Data were obtained in homes in twelve cities in the United States and Canada during the summer and winter months. For the analysis of waste through taps, the author found that, on average, 4.31 litres of cold water are wasted. Lutz (2011) was one of the first researchers to collect data on water waste directly at the place where hot water is used. By monitoring flow and temperature during showering events in three single-family homes in California during the winter months, Lutz (2011) found that 30% of water was wasted. The author considers a joint analysis of temperature and flow; therefore, there is no standard temperature that exactly defines behavioural and structural wastes.

Sherman (2014) identified an average behavioural waste equal to 47 seconds in showering events in homes in the state of California in winter months. Therefore, the hot water has already reached the water fixture, but users are starting the shower 47 seconds later. Wood and D'Acquisto (2015) found in a sample of 574 showers in homes in the state of Pennsylvania, that the behavioural waste was, on average, 59 seconds and the structural waste was, on average, 64 seconds during the winter months. For a shower with an average flow equal to 0.157 litres/second in a single-family house, the annual water waste can be approximately 3,774 litres. Ally and Tomlinson (2002) conducted a study in five houses in the municipality of Palo Alto, in California, to verify the efficiency of the water recirculation system using the Metlund D'MAND © system technology. In one of the houses, it was possible to estimate savings of approximately 11,500 litres of water per year in a bathroom tap.

As for researches carried out in Brazil, Gonçalves et al. (1989), in a specific analysis in a given case study, obtained a time of 70 seconds for the hot water to reach the farthest water fixture, wasting approximately 13 litres of cold water. Chaguri Junior (2009) conducted a similar case study in a flat located in the city of Ribeirão Preto (SP). The author identified that 76 seconds was the time to get hot water in the farthest water fixture, wasting 10 litres of cold water. Ioris (2018) verified the waste of cold water that occurs before the flow of hot water in seven showers in three different buildings in Florianópolis in summer months. A comparison was made between the waste estimated considering the plumbing designs and the waste obtained by means of in-situ measurements. For the flats analysed, the average waste of water was 6.3 litres when considering that the water coming out of the shower suffered some variation in its temperature. For the water to come out of the shower at a temperature equal to 30ºC, 9.3 litres of water were wasted on average.

As a way to minimise or avoid losses caused by users and water fixtures, some companies have developed accessories for plumbing systems. Canada-based company Taco has developed a system (Taco Genie®) composed of a recirculating pump and a valve that joins the cold water pipes with the hot water pipes. Therefore, there is no need for additional pipes to recirculate the water. The valve, which can be programmed to operate at times of higher hot water consumption, is usually installed at the hot water fixture farthest from the heater. A component quite similar to the Taco Genie system was developed in the United States. Firstly called the ACT Metlund D'MAND © system, producers currently produce their recirculating pump designed specifically for this function and the product is called Chilipepper CP2011. The manufacturer ensures that the system can pump water at a flow rate of approximately 11.0 litres per second. Its operation can be initiated by Wi-fi mode or simply by pressing a remote button (CHILIPEPPER, 2020).

Another component available on the market is the ShowerStart TSV3 valve (Thermostatic Shut-off Valve) developed by the company Evolve (THINKEVOLVE, 2020). Unlike the Taco Genie® system, this valve is designed for use in showers only. It is also installed close to water fixtures, and its function is only to avoid behavioural losses. This valve identifies when the temperature of the water flowing through the shower reaches 35ºC, then interrupting the flow. To restart the water flow, the user must simply pull a rope that comes with the equipment. The valve automatically restarts the operation for the next use.

Another alternative to avoid this waste of cold water in the bath, proposed by the FORTLEV company, is the FORTLEV eco-collector. This collector is a container with a capacity of six litres of water that must be placed below the shower. After collecting the cold water, the container has a favourable anatomical format to use the collected water for activities such as washing cars, watering plants, flushing the toilet, etc. (FORTLEV, 2020).

Regarding the development of alternatives to avoid wasting water and energy in Brazil, Pasetti (2014) developed a prototype to automate a domestic solar heating unit. The author proposes a hybrid heating system that uses solar and electrical energy as energy sources. The system consists of solar collectors, a storage tank, an electric shower, and the electronic equipment that enables the automation of the system. The system, through tests and simulations, proved to be viable, promoting a reduction in electricity consumption equal to 78% and avoiding waste of water that is accumulated between the boiler and the shower.

Installing devices to prevent water waste, such as the ShowerStart TSV3 valve, which is a thermostatic restriction valve, solves only the problem of behavioural water waste. The installation of recirculation systems, such as the Taco Genie® and Chilipepper CP2011 systems, requires a very high initial investment.

Therefore, this work describes a low-cost automated system that directs cold water in the pipes to another destination, which involves minimal interaction between the system and the user. This automated system can be implemented in an existing plumbing system or in new single-family or multi-family houses. This work deals with the analysis of the automated system only for new projects and only for buildings where there are instantaneous gas heaters as the main heating source. The study was restricted to these systems due to the greater coverage in the southern region of Brazil compared to solar systems and their supplementary systems (ELETROBRAS, 2019).

This work aims to describe the conformation of an automated device integrated into the hot water system of buildings to eliminate the waste of cold water during the first seconds of using hot water fixtures.

2 Material and Methods

The amount of cold water wasted in water fixtures in residential buildings that have instantaneous gas heaters varies depending on the diameter of the pipe from the heater to the water fixtures, the length of the pipe, the water flow, the efficiency of the heater, the time interval between using the fixtures, the pipe material and the insulation, if any.

To prove that most of the cold water wasted in the first seconds of using a hot water fixture is the water that remains at rest in the pipes between the heater and the corresponding fixture, cold water waste measurements were taken. The measurements were taken in a single-family home that has instantaneous gas heater located in the city of São Lourenço do Oeste, southern Brazil.

First, the users were asked if there was hot water consumption in the moments preceding the measurements. To confirm this, the water temperature of the hot water fixture was previously measured. We chose to make measurements of cold water waste considering the heater in the current heating situation, i.e. with the temperature that users were used to and comfortable during the measurement period.

Before starting the temperature measurements, the water flow was checked with the hot water valve turned on; however, with the instantaneous gas heater turned off. Using a graduated container, three samples of water at the highest water flow were collected. A stopwatch was used simultaneously. Lutz (2005), when analysing the waste of cold water during the consumption of hot water, also considered that first, the user turns the device on at the highest water flow to obtain hot water more quickly. The ratio between the amount of water collected and the time characterises the highest water flow rate. The average of the three measurements was performed to get a more reliable figure for the maximum flow.

Then, the gas heater was turned on, and the hot water valve of the fixture to be analysed was opened at its maximum flow. Then, the water was collected in a container and the water temperature was measured right out of the fixture using a waterproof DS18B20 thermometer (accuracy of ± 0.5ºC and measuring range from -55ºC to 125ºC). The thermometer connected to an Arduino UNO and a notebook was programmed to receive and record temperature measurements every second. The temperature measurements were recorded simultaneously with the water collection, and when the thermometer showed a temperature equal to 30ºC, the valve was turned off. The volume of water that would be wasted was obtained by multiplying the water flow rate by the time associated with each measured temperature.

Three measurements were performed for each fixture. The gas valve of the heater was turned off to proceed with new water collection and temperature measurement so that cold water flowed when opening the hot water valve of the fixture to be analysed. This procedure caused the piping and the entire system to cool down so that it was possible to simulate a typical situation of using the fixture again.

The measurements were also used to prove the hypothesis that hot water reaches the water fixtures nearest to the heater more quickly than the water fixtures farthest away. After the measurement of cold water waste from the hot water fixture closest to the heater, which is a tap in the laundry, the measurement of cold water waste from the farthest hot water fixture, which is the common bathroom tap, was carried out. The measurement of cold water waste from the nearest hot water fixture was performed after the measurement of the hot water fixture farthest from the gas heater.

The system operation consists basically of directing water to its appropriate destination according to the amount of cold water inside the pipes between the heater and the fixtures. It can be done with a solenoid valve located at the end of the main pipe of the plumbing system. This valve has the function of directing to its proper destination the amount of cold water that would be wasted through the use of a certain fixture. Through a radio frequency signal sent when a button is turned on near the desired hot water fixture, the system recognises which fixture was turned on and the approximate amount of cold water that must be released through the valve until the arrival of hot water from the heater.

Figure 1 shows the floor plan of a usual plumbing system in a flat, and Figure 2 shows a vertical schematic of the plumbing system of the bathrooms in the same flat. In multi-family buildings with instantaneous gas heaters (with no boiler), the water fixtures are usually supplied by a cold water pipe connected to the building's main water tank, and another hot water pipe connected to the heater.

Butterfly valves are required in the pipes to interrupt the water flow in case of eventual repairs and also pressure valves for fine adjustment of the flow of cold water and hot water. Finally, the water circulates through the mixer, where cold water and hot water mix and flow to the shower or the tap.

For the automated system proposed, some modifications in the layout of the hot water pipes are necessary. To increase the efficiency of the automated system proposed herein, the main hot water pipe must be as close as possible to the hot water fixtures.

The activation buttons that send the radio frequency signal must be installed close to the hot water pressure valves. Besides, the system must have a solenoid valve close to the hot water fixture farthest from the heater and also, in the case of multi-family homes, a water flow meter. Finally, there must be a system to collect the water from the fixtures. First, there must be a pipe to collect the water that flows through the solenoid valve. Then this pipe is connected to a vertical pipe, responsible for collecting water from all flat units and directing it to the potable water tank in the building.

The diameters of the pipes that direct the water to the water tank depend on the number of hot water fixtures in the building. Such diameters can be determined using the method that is addressed in NBR 5626 (ABNT, 1998). All other recommendations made by NBR 5626 for the correct functioning of the system must be followed for the installation of the water collection system of the automated system proposed.

Therefore, to facilitate installations, it is possible to have more than one vertical pipe that collects water from the different parts of the building. Such vertical pipes can be installed in the same shafts where there are pipes for hot water, cold water, and sewage.

Finally, these vertical pipes connect to the pipes with larger diameters on the ground floor and allow the water to flow to the underground potable water tank in the building.

Figure 1 – Floor plan of a usual plumbing system in a flat

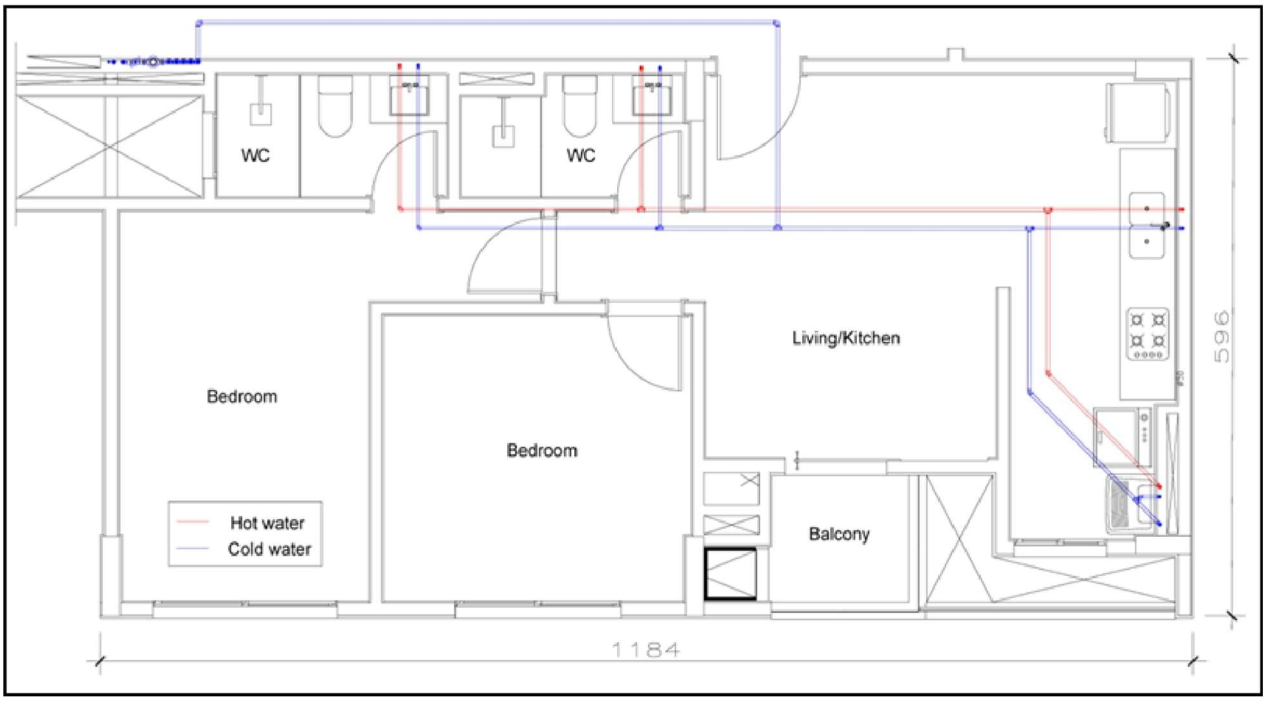
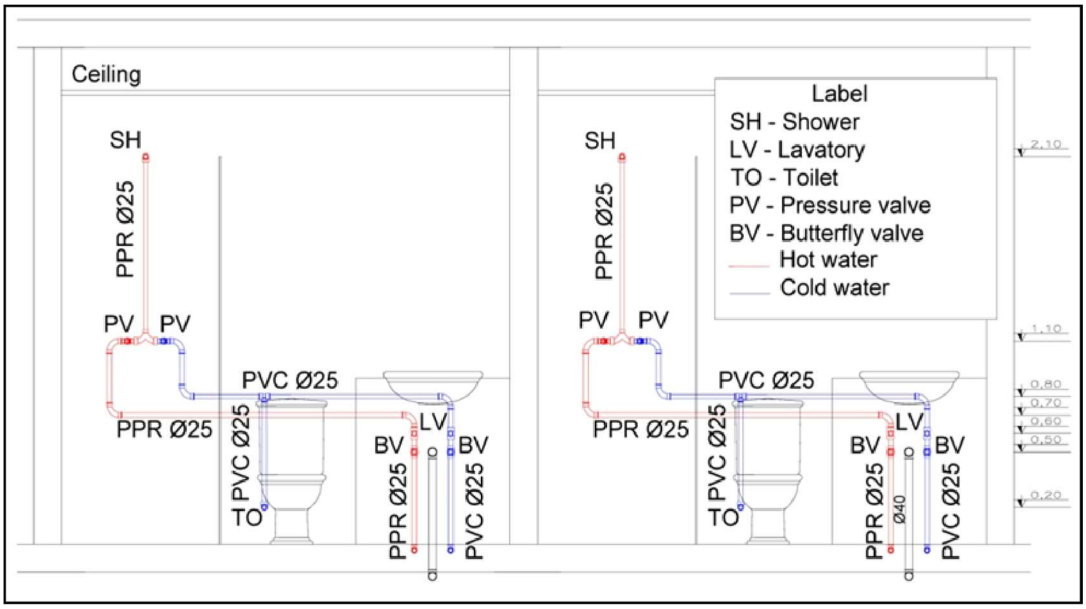
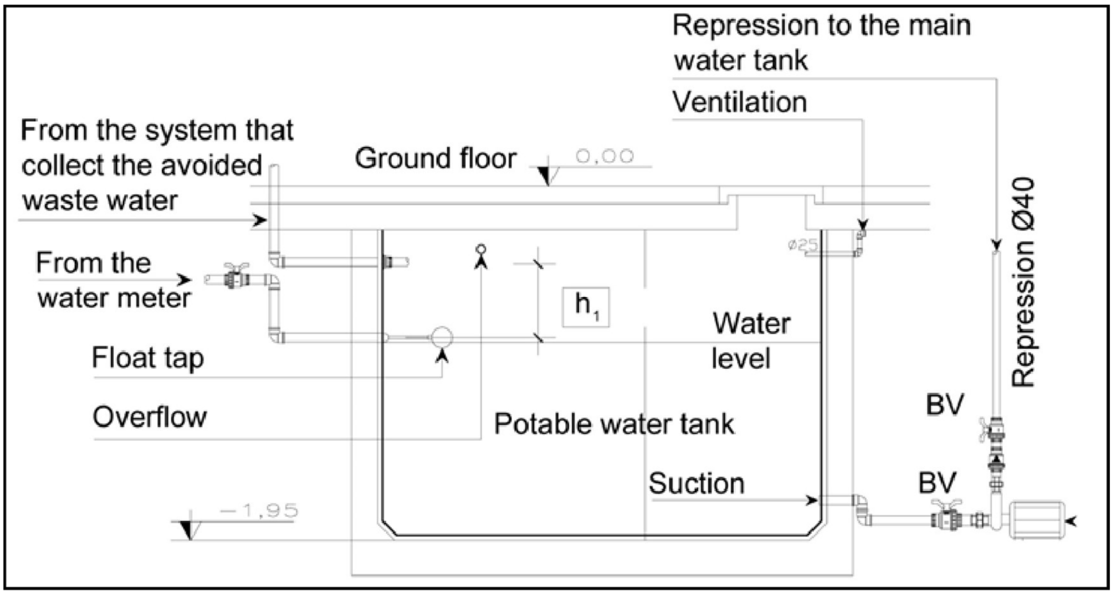


Figure 2 – Vertical schematic of a usual plumbing system



The connection of these pipes to the potable water tank must occur at a height h_1 above the water inlet, as shown in Figure 3. This height varies according to the maximum volume of water that will be collected, that is, the simultaneous use of all hot water fixtures in a building. This volume is, therefore, the total amount of water that is at rest in all hot water pipes in the building.

Figure 3 – Suggestion for the connection of the pipe that collects cold water from the hot water fixtures with the lower potable water tank



The volume of water inside the hot water pipes of a flat was calculated using Equation 1. It is emphasised that the length of the pipe must be measured between the heater and the farthest hot water fixture that is fed by the heater.

$$V_1 = \frac{\pi}{4}\left(D_1^2 c_1 + D_2^2 c_2 + D_3^2 c_3 + \ldots + D_n^2 c_n\right) \qquad (1)$$

Where: V_1 is the volume of water inside the hot water pipe (m^3), D_n is the internal diameter of the pipe (m), c_n is the length of the pipe between the heater and the farthest hot water fixture, where the solenoid valve is located, *n* is the number of pipe diameters between the heater and the solenoid valve.

The height in the water tank that must be available to store the volume of water collected from the flats was obtained using Equation 2.

$$h_1 = \frac{V_2}{A_b} \qquad (2)$$

Where: h_1 is the height in the water tank that must be available to store the volume of water collected from the flats (m), V_2 is the water tank capacity to store the water that comes from the flats (m^3), A_b is the floor-plan area of the tank water (m^2).

For situations in which the volume of water collected from all flats is very large, for example, in tall buildings, to the point of preventing the compatibility proposed in Figure 3, an additional water tank connected to the main water tank must be provided.

For a single-family building where the installation of an underground water tank is not foreseen, the suggestion for installing the system would be to use a supplementary water tank. This supplementary water tank would be at a level lower than the main water tank. The cold water coming from the main water tank, which flows through the heater and then through the pipes, must have enough static pressure to return to the supplementary water tank. The rest of the conformation for a single-family house would be the same as for a multi-family building.

The operation of the automated system is limited to the pressing of a button to direct a specific amount of cold water from each water fixture, supplied with hot water, to its proper destination. The solenoid valve installed at the end of the hot water pipe is a normally closed type, that is, its opening will only occur when receiving an electrical signal.

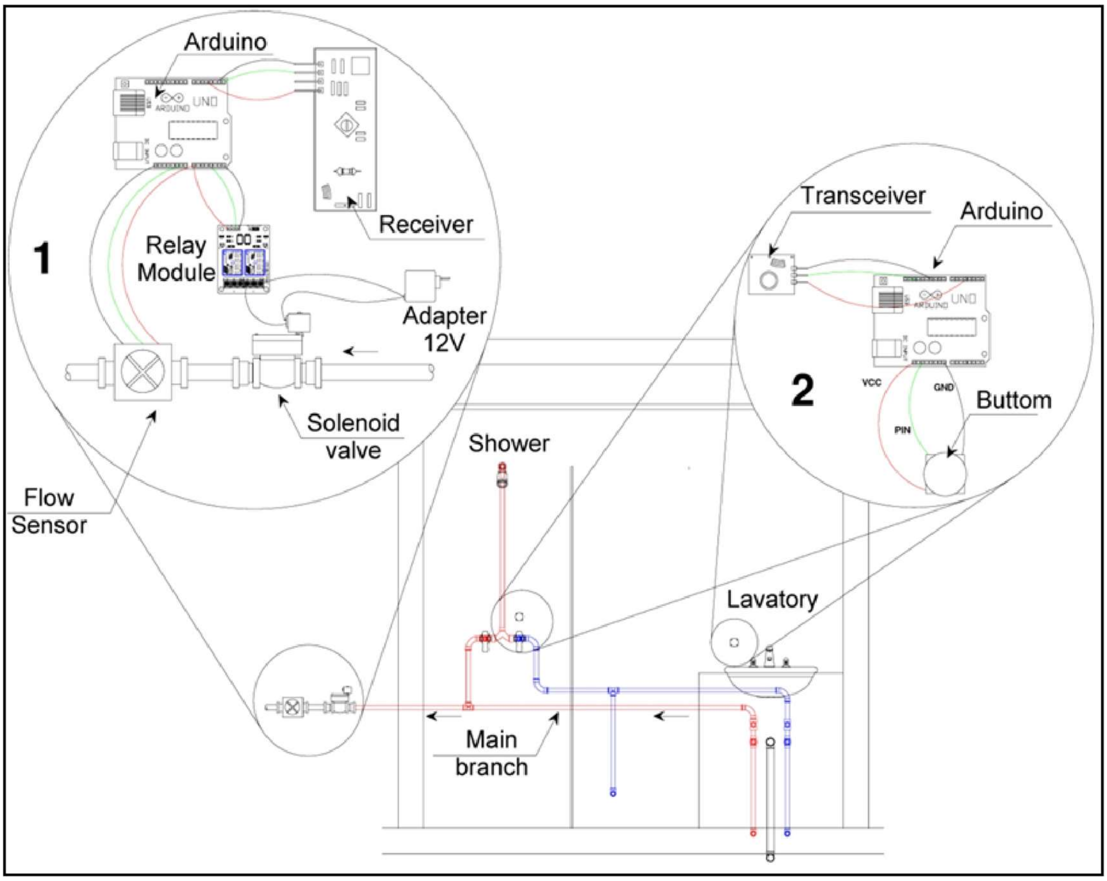
Therefore, for each hot water fixture, the volume of water in the pipes has to be calculated. Based on the solenoid valve water flow, it is possible to identify the time needed to eliminate the amount of cold water that remains in the pipeline. Each water fixture will be associated with the time necessary to eliminate the cold water from the hot water pipe. The particular time for each fixture will be programmed individually for each button next to the fixture. When pressing this button, the system will identify the time that the solenoid valve at the end of the main pipe needs to remain open so that the hot water reaches the fixture.

Figure 4 shows a non-scale schematic of the electronic circuits that would be embedded in the wall. The button next to the hot water fixture is connected to an Arduino microcontroller that connects to a radio frequency module transmitter. The transmitter sends the solenoid valve opening time information to the receiver that is connected to another Arduino microcontroller that is also connected to the solenoid valve. The receiver receives the information from the transmitter, transfers the information to the Arduino, which commands the opening of the solenoid valve.

To show the user that the opening of the hot water valve must be started, the Arduino will activate a red LED lamp that will indicate that all cold water has been drained from the pipe. Another option would be to install a button that returns to its initial state once the solenoid valve closes.

The operation of the system in a single-family house is similar to a multi-family house. The difference consists in finding an adequate way to place additional appliances, such as pipes and water tanks. Unlike the system applied to multi-family houses, the system for a single-family house may be more feasible in terms of savings in piping costs and to direct the cold water, that would be wasted, to a specific pipe to supply only one fixture, such as a toilet. It is unlikely that a single-family home will have a lower water tank, located at a level lower than the water fixtures level. Therefore, a specific study must be carried out for each house to identify the most convenient and feasible installation of the system.

Figure 4 – Electronic circuit of the system proposed herein



3 Results and Discussion

In a house located in the city of São Lourenço do Oeste, State of Santa Catarina, it was possible to measure the amount of water that would be wasted in a tap in the laundry room and also in a tap in the bathroom. The tap in the laundry is the hot water fixture nearest to the heater. Figures 5 and 6 show the results.

In Figure 5, it is possible to see, through the dashed line, that the waste of cold water in the bathroom tap, which is the farthest point from the water heater, decreases in case the tap in the laundry room, which is the hot water fixture closest to the heater, has been used previously. When using the bathroom tap immediately after using hot water in the tap in the laundry room, there is a cold water waste decrease of approximately 34% compared to the average waste without prior use of the laundry tap.

Figure 6 shows the same trend, but there is less waste of cold water if there is hot water consumption in a hot water fixture farther away from the heater immediately before the use of a hot water fixture closer to the heater. In this example, temperature measurements are taken from the tap in the laundry room after using the bathroom tap, which is the hot water fixture farthest from the gas heater. It appears that for water to show positive variations in temperature, there is a waste of only 1.25 litres of cold water, that is, 78% less than the average waste found without prior use of a water fixture farther away from the heater. There is a waste of 5.00 litres of cold water to reach a temperature of 30ºC. That is, 43% less than the waste found on average, 8.8 litres.

Figure 5 – Volume of water wasted until the water comes out from the bathroom tap at a certain temperature

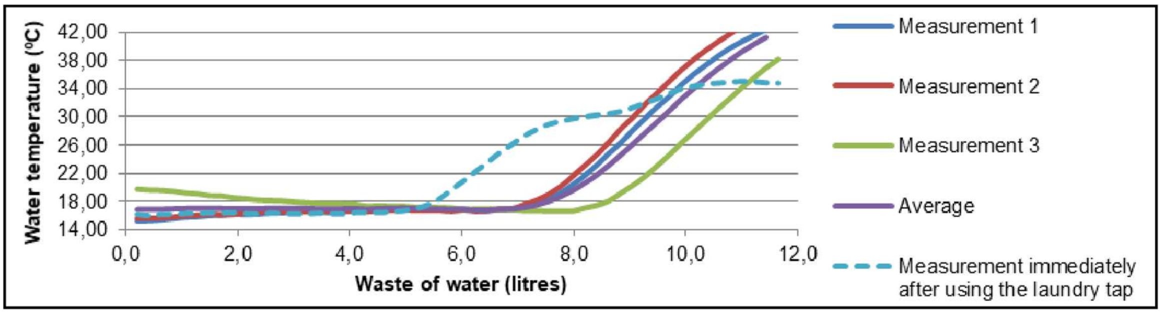
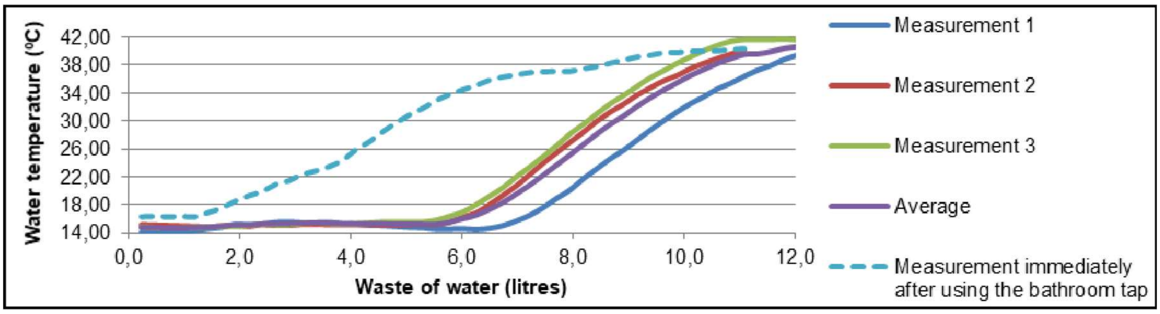


Figure 6 – Volume of water wasted until the water comes out from the tap in the laundry room at a certain temperature



Based on this analysis, it is possible to conclude that, even without checking the plumbing design, the hot water fixture in the laundry room is the closest one to the heater. Thus, the premise of installing a system that releases cold water contained in the pipeline is accepted, according to the idea proposed.

As described in the method, for better efficiency, the configuration of the automated system in houses must be carried out so that the hot water pipes are placed as close as possible to the water fixtures. Figure 7 shows how the plumbing design floor plan of the flat shown previously should be. Figure 8 shows a suggestion for the plumbing system vertical schematic for the bathrooms. In this example, it would be possible to install the solenoid valve and the flow meter close to the hot water fixture farthest from the heater, as there is a lighting and ventilation shaft nearby. Such a shaft could be used to place the vertical pipes to convey the cold water, which would be wasted, to the water tank in the building.

Figure 7 – Plumbing system floor plan for the automated system

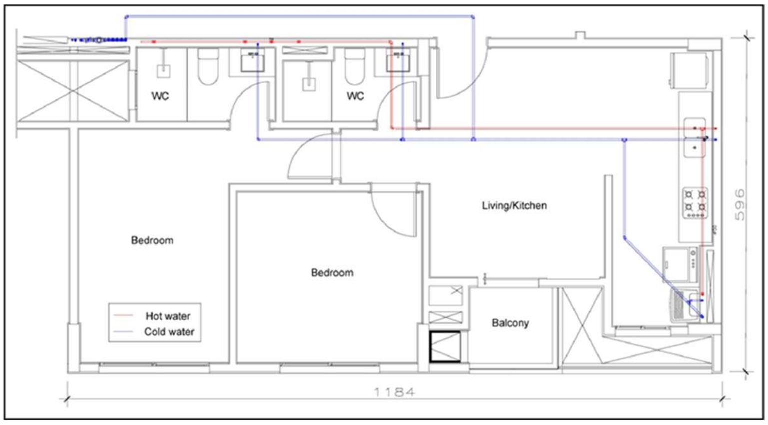
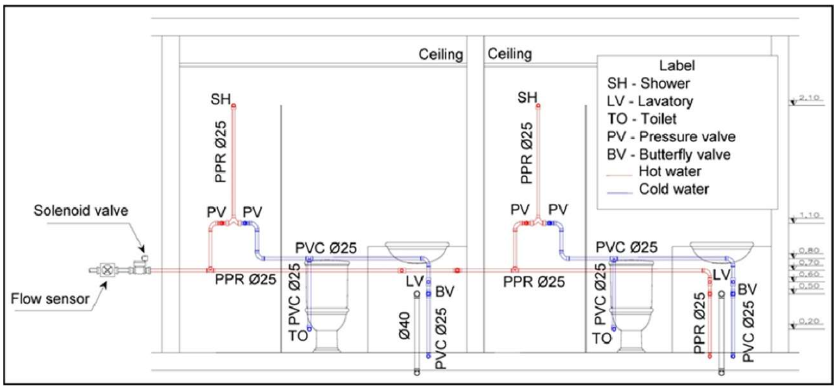


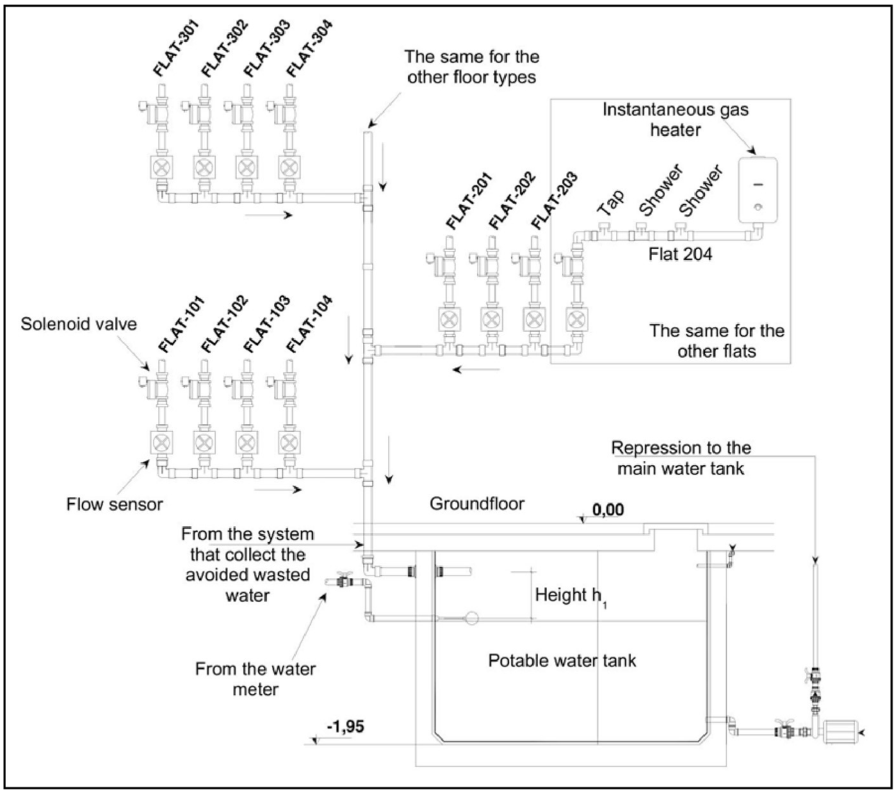
Figure 8 – Plumbing system vertical schematic for the automated system



The water tank to be part of the system proposed herein can be, for example, a rainwater tank planned during the design stage. Some cities foresee in their construction codes the possibility of using a rainwater storage tank for areas where the permeability rate is lower than the pre-established limits, such as in the city of Joinville (SC) (JOINVILLE, 2018). Cold water from the system proposed herein could be directed to such tanks and used for flushing toilets, for example. Other water tanks possible to be adapted to the system proposed herein are the water tanks of multi-family buildings located in points of the municipalities where the water supply is of low pressure. For the upper tank to be filled, an underground tank connected to a pump is required. This configuration, for example, is mandatory in the construction codes of some cities in southern Brazil (FLORIANÓPOLIS, 2000; GASPAR, 1988; PORTO ALEGRE, 1992; SÃO JOAQUIM, 1987).

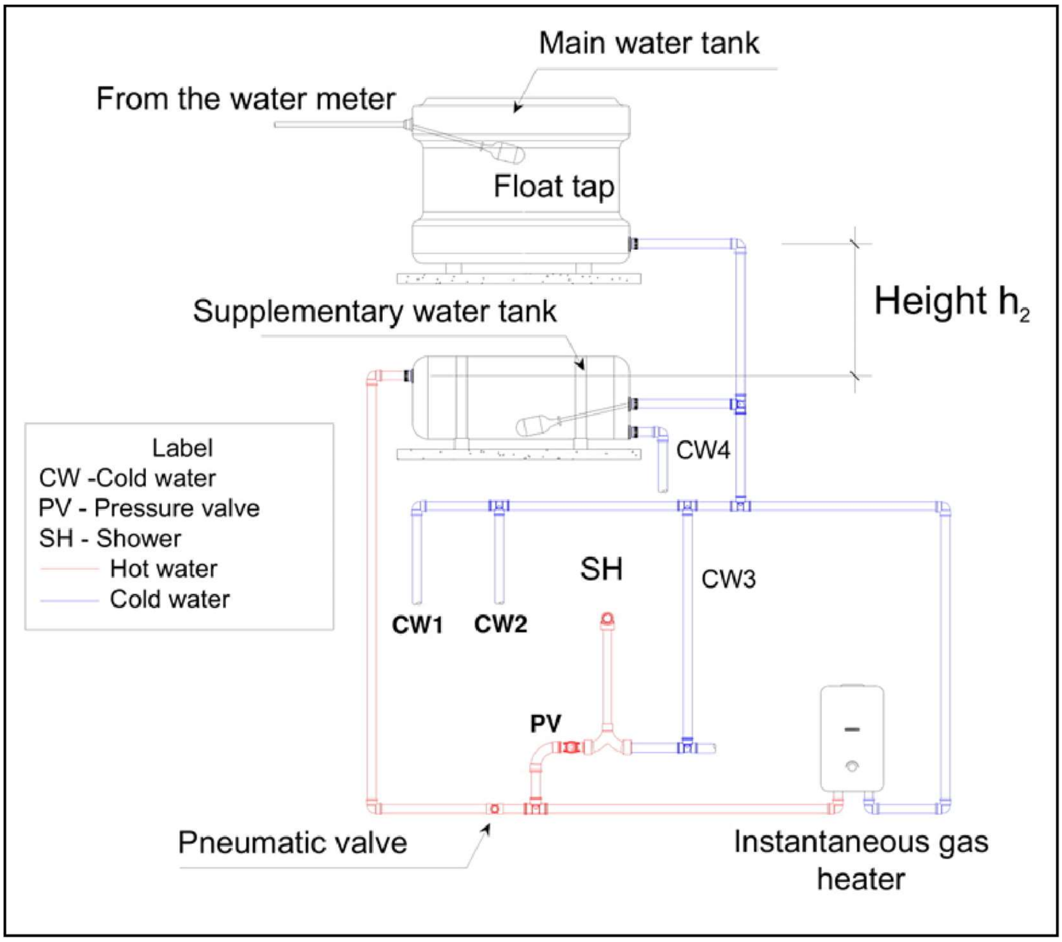
Figure 9 shows a schematic of what the building installation would be like, i.e. from the collection of water from the hot water fixtures of all flats to the underground potable water tank in the building.

Figure 9 – Vertical schematic of the building installation of the automated system



For the automated system to work in a single-family building, it is necessary to have a tank of adequate size to collect the cold water that would be wasted. Unlike the system applied to a multi-family building, the amount of water directed to the water tank would be much smaller. Therefore, what is proposed herein is the installation of a supplementary water tank smaller than the main water tank. This supplementary water tank must be close to the main water tank and connected to it, as shown in Figure 10.

Figure 10 – Installation of the automated system for a single-family home without an underground water tank



The operation of the system for a shower in a single-family house, for example, could be performed by turning on a pneumatic valve. The device would work during a period of time to drain the amount of cold water in the pipe between the heater and the fixture. This pneumatic valve, to facilitate the use of the system, would be installed close to the shower pressure valve, as shown in Figure 10. The water that returns to the supplementary water tank could then be used for one or more toilets supplied by a specific pipe, indicated in Figure 10 as CW4 (a cold water pipe). So that the water capacity of the supplementary water tank is not only dependent on the water coming from the system, a floating tap can be installed on a level below the inlet of structural wastewater allowing the filling of part of the supplementary water tank through the main tank. For this, the height h_2, indicated in Figure 10, must be the maximum height for the water to be able to return considering all the pressure losses due to connections and pipes.

4 Conclusions

Through this work, it was possible to present the conformation and operation of an automated system that avoids the waste of water during the consumption of hot water in water fixtures in a building. By measuring the waste of cold water at two hot water fixtures in a home, it was possible to conclude that hot water takes longer to reach fixtures farthest from the water heater. Therefore, this causes greater waste of cold water. Proposing a system designed so that the hot water pipes are installed close to the water fixtures, and with a solenoid valve and the other necessary equipment at the end of the main pipe, it is possible to convey the water that would be wasted to another water tank. This work is of great importance to guide the planning of the system for different buildings. As the installation and design depend mainly on the layout of the building, each project must have its own technical and even economic feasibility analysis.

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