

# System for Reducing Water Consumption at Home

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**Abstract** - The presented article is aimed at preventing waste of water, which is in great demand all over the world today. For this purpose, the existing methods were analyzed and the most suitable for the system under consideration was selected. A model of the water temperature control system was developed due to the feedback circuit in the combi system, devices for the implementation of the system were selected, the model was assembled on the Arduino UNO and a simulation of the possible result was performed.

**Keywords:** a combi boiler, controller, temperature sensor, valve.

## I. INTRODUCTION

Increasing the number of populations leads to a construction of new buildings and in this type of building, mainly, combi boilers are used as a heater system. In combi boilers, if it is not used for a certain period of time, then, when a hot water is opened, it takes some time duration for heating water temperature inside a combi boiler. As a result of this, within that time interval, a certain amount of water is wasted which is not at desirable temperature. From this point view, by taking into account that all over the world, including our country, the number of renewable water resources per capita is running down from day to day, it is the responsibility of the whole population to obtain more awareness on the elimination of this problem at a big scale by using new technologies. The main aim of preparing this paper is intended in the investigation of all the solutions of this problem and determining the most appropriate one among these solutions.

According to statistical numbers, more than seventy percent of earth surface is still being coated by water; however, only 3% of it can be used for consumption. This number includes both water reservoirs and icebergs which are known as ice caps by placing at the poles. When we do not take icebergs into an account, only 1% of all earth surface covered water is ready to utilize and consume. A culture of utilization and consumption of drinkable and pure water comes from the early human life and living. According to the investigations, in the ancient period of life, especially in the region of the Middle East and Asia, archaeologists found some essential and significant proves that that culture has been preserved in the correct ways. Therefore, approximately, 4000 years ago,

humans get used to build some water pipelines and infrastructure to transport drinkable and usable water across the residence places.

## II. LITERATURE SURVEY

The first implemented action was to pump river water into reservoir in London at the level 37 meter more than the Thames River. However, complicated version of this system which was a pumping station was built in the U.S.A to provide with drinkable water effectively. The first station included 13 cm pump which can be used to raise water up to 21 meters. From 19<sup>th</sup> century, almost 16 cities in the U.S.A had the system for water transportation and storing it. [1]

In order to get more careful utilization of water, some countries in the world follow's this rise in the prices to make people more attentive and responsible. For an example, it must be noted that in the U.S.A, approximately 1.5 billion dollars had been spent to improve water quality and purification by constructing water protection project. The main reason of this construction comes from some analysis that was conducted on water conservation. With regards to those explorations conducted by Mississippi State University Extension Service, it is exactly possible probability that with the help of that type of systems, we can get preservation in water from 30% up to 50%.As a result of this project, people can save their money and use it pragmatically by getting low fees. [2]

**Enlightenment:** With regards to education, on this method, it has already been mentioned in the previous sections. It is called foundation of water conservation. Therefore, it is clear that in any person's life, everything almost starts from the school years, from learning alphabet up to having all good and kind human characteristics.

**Home appliances:** From the water usage statistics, it is obviously clear that the most used water is recorded in the houses. This is the proof that the most effort should be spent in the water conservation at homes. For this aspect, we implement some methods. Firstly, the easiest method

**Low flow faucet aerator:** This gadget works with high efficiency but at low flow rates which help users to save their water and money. Generally, faucets use approximately 10-15% of the house consumption overall. This type of faucets economizes more 75% of water in the comparison with

convenient type of faucets. In the calculation, this preservation amount equals almost equals to more than 55000 liters on an annual basis is to check al joints of pipes.

**Low flow shower heads:** For shower heads, according to the calculations, while in use of convenient type of this gadget, it consumes 7.5 liters of water during a minute. Installation of this is very simple, by just unscrewing an old one and replacing it with the new one. After installation, it saves water up to 3.5 liter per minute by consuming 3 liters. As a result of this, it is feasible to save 7570 liter of water yearly. This type of heads has two types: aerating shower heads and streamline shower heads. [2]

**Soaker hoses:** In order to develop agriculture productivity and making it more economic and environmentally friendly, this type of hoses is used. It also includes an irrigation system with drip method. This method refers to a technique which when the main water tap is opened, system starts to work and the roots of plants are watered gradually and slowly by means of drops. This avoids waste of a huge amount of water. As well as, water is interacted directly with the root, so, it increases productivity. [2]

**Shutoff devices:** This device is a device which is in connection with irrigation system. Inside of it, there is a sensing element which analyzes moisture and humidity in the air and on the ground. Therefore, if it senses humidity in the environment is higher than the desired or initialized value, it automatically takes some corresponding actions by turning off all irrigation system to economize water. An initial cost of this type of systems is low-cost, however, in the installation part, it takes to much effort. The inital cost varies between 25 to 100 dollars. With the help of this cheap gadget, we can cut water fee down by 2 times. [2]

**Sensored water taps:** In the modern world where a technological revolution has been following a dramatical progress, new solutions appear ith thanks to the science and engineering. Therefore, new water taps have been used in the last years. This type of water taps is supplied with proximity sensor which prevents waste of water. The main working principle is that when the object gets closer to the sensor working area, it detects an object and sends signal to actuator and opens the tube. Also, when an object disappears in its sensing area, it closes the tube. Currently, more improved versions of this tap are available in today’s technology.

**Recycle:** From the origin of life, recycling of some matters which can be depleted somehow has been the crucial issue for all the humanity. Almost, in all areas of living, recycle is used and done correctly. As well as, in the water consumption and for water conservation is one of the most vital points for the whole society. In this point of view, recycling of water has a

deniable and great impact on the state of the number of water reservoirs.

Firstly, one of the commonly used recycle method is to use grey water. This method contains reuse of utilized water. For an illustration, after washing hands or clothes, used water is used for anything else, such as cleaning a car. In the recent years, this method has got an extreme popularity. The main work principle of this technique is based on the classification of used water. So, there are two types of grey water. One of them is black water and the other one is grey water. Black water is made of by washing machine, bath or anything which is done with chemical substance, such as, detergent. Grey water comes from kitchen sinks or hand washes which does not contain chemicals. So, reuse of black water is not recommended because of the chemical ingredients. However, it is possible to use grey water for laundry, irrigation and etc. easily. [2]

After recycling water, high proportion of water used once can be utilized again to save it. From an experiment, it is possible to see the result on the picture below:

After applying water conservation techniques, some hopeful results were obtained on water consumption statistics. It is provided below (figure 1):

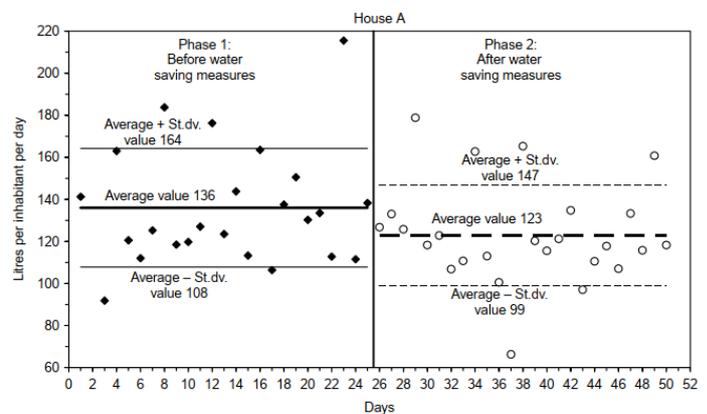


Figure 1: Water Statistics after implementing Water Conservation Techniques

### III. PROBLEM DEFINITION

In the previous sections, much more detailed information was provided on water statistics and water conservation methods and techniques. Also, some illustrations related to after using water saving techniques were attached to express the essence of water conservation. In all ways of water conservation, the main purpose is the same. However, in terms of to economize and becoming more pragmatic, among all the techniques, recycle of utilized water is the best option to

implement. With this solution, we not only save waste of water but also, we save extra water fee.

The main purpose of this graduation work is to provide more clarifying information on implementation of a new system for water recycle at homes by mainly focusing on a house appliance, combi boiler. When hot water tap is opened in combi boiler, during some time interval, in the pipe there is only cold water. Until boiler heats water, cold water continues to flow. It takes some time for boiler to make temperature of water at some predefined desired value.

In this paper, we will try to analyze and find a new solution to prevent water loss in combi boiler system. The main methodology and devices, as well as results will be discussed in the following chapters and sections.

In the previous chapter, it was mentioned that this graduation work is mainly focused on water recycle in combi boiler. Thus, when the hot water tap is opened, in some time duration interval when temperature of hot water output of combi boiler is less than desirable temperature. As a result of this, until temperature reaches wanted point, the amount of water which the temperature is less than desirable value is wasted. In order to avoid this waste, in this chapter, more explaining methodology will be evaluated and given. Also, the main technique which is used to conserve water in combi boiler will be presented. In addition, some mechanical devices which are the main components of this conservation system will be provided with their technical properties and capabilities.

As it was mentioned, in some time duration when water reaches the set point, from the water tap, cold water is released. In order to prevent this loss, there is not any convenient system inside the combi boiler.

In order to prevent this lack, we should build a new system which is integrated with the combi boiler to save water. In order to do that we need control the overall system output.

#### IV. METHODOLOGY

Generally, each system consists of some parameters and devices. Also, control system consists of some parameters and devices. Parameter means the value of any variable and with the help of these parameters; mechanical devices take some corresponding actions to keep system's productivity at high level or in the desirable condition. The main purpose of the control theory is to evaluate the process and in terms of this system, it should be built the closed-loop control system. Evaluation of the process is to determine the overall characteristics and behavior of the system. [7]

From the overall meaning of feedback notion, it related some things or some desirable parameters in real life. In order to take into account that, in this graduation work, it is mainly engaged in combi boiler system and control process of that unit to save water and reduce consumption of it. From this point of view, feedback is interconnection of any process. There are some important facts on application of feedback. First of all, in order to implement feedback, it must be mentioned that existence of dynamic content of process is essential and important. Generally, feedback system has two types: open loop and closed loop systems.

On the above, illustration for closed-loop system is added. It can be easily seen from the picture that output of the second system is connected to the the first system (figure 2). This means that our second system feeds the first system. Thus, some parameters from the second system may be needed for the the first system. It can be done through several processes or systems.

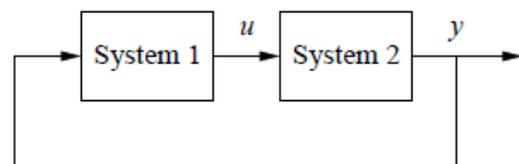


Figure 2: Closed-loop System

With regards to the implementation of feedback system to water conservation system, as it has already been mentioned in the previos chapters and sections, we need to regulate water flow of the system in the corresponding temperature measurement to prevent waste of water. In the previous sections, it was mentioned that inside of combi boilers, there is not any convenient system to regulate water at outlet flow. That is why when hot water tap is opened at home, within some time interval, cold water is supplied and if user requires hot water by opening tap, he or she is not going to utilize water with does not meet his or her requirement. In order to prevent water loss, we offer a system which will be elaborated and evaluated in the further parts. [6]

#### Control System

From the control side of this project, closed-loop feedback system would be well matched because of some reasoning factors. Firstly, in the process, there is a dependent parameter and that affects process behaviour. That parameter is temperature of water.

Prior to the main part, it must be noted that it should be distinguished that when combi boiler is started, user sets temperature for water. This temperature identifies the temperature of boiler heater which is mainly done inside of

boiler. In the output of the boiler, system does not remain that temperature and due to that, although on the boiler screen, instant water temperature is shown high, real output water temperature is much less than shown. Another reason is that when water tap is opened, boiler starts heating process and as that process continues, water at outlet which has not got enough heat continues flowing. Finally, this leads to waste of a huge amount of water.

Here, there is another contradictory part that for the corresponding temperature, flow of water must be directed. Therefore, my suggestion is to redirect output water of boiler which does not meet requirement of enough heating. For the direction, it would be much preferable that redirected water should flow towards cold water input of the boiler.

At the outlet of the combi boiler, control unit is mounted which help us to derive high level water conservation. For this concept, it is offered two various schemes. One of them is the model which is located above. Another model suggests that control unit can be installed by manufacture of combi boiler. It would be the best and convenient choice because of some reasons. Therefore, from the point view of customer, buying an extra unit for water conservation may be seen like waste of money. As well as, installation of that unit cost some amount of money. However, if that unit is installed by the manufacturer company. It would be minor factor for customer. And even, with the installation of this unit in the manufacture line, companies can attract more customer on behalf of water conservation. Generally, application of this unit in any way can bring a lot of advantages from water conservation up to a significant rise in combi boiler trade.

As it has already been mentioned in the previous stages, at outlet of combi boiler, control unit which is the most crucial part of this project is mounted (figure 3).

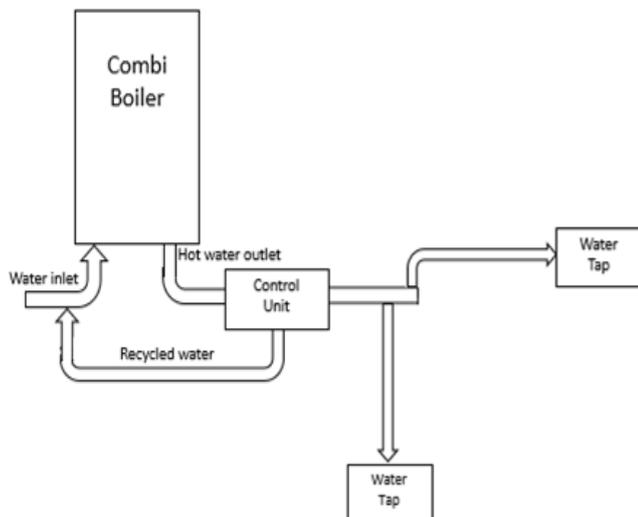


Figure 3: Structure of given solution

This control unit includes some hardware and mechanical devices which control the process itself. Process control in this manner means identifying temperature of water at outlet. After that stage, according to the temperature, it takes some corresponding actions to flow water direction to achieve the targeted aim. In order to accomplish that goal, we need some mechanical devices. It consists of temperature sensor, 2 electric solenoid valve and a controller.

**Control Unit**

Before moving to inside of control unit, methodology of this unit is provided. As it was mentioned, in order to make this project, it is recommended to use closed-loop feedback system. The main purpose is to flow water to save it.

Control diagram of the overall system is given in the figure 4.

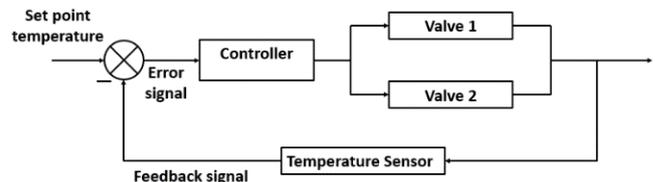


Figure 4: Closed-loop feedback control of the solution

It can be easily seen that this is very simple process but effective and worth to do it. From diagram, it is easily understood that at the beginning, in the installation process, we define such a temperature that it is desirable and if user opens hot water tap, it means that user need hot water and he or she is not going to utilize cold or undesirable water under the specific temperature. Sensor measures water temperature whenever pipe is filled with water. And, with that reading, corresponding error signal is generated by the controller by comparing measured variable with the predefined or desirable value. In the following stage, controller takes corresponding actions due to the program which is coded inside of the controller. It means that, when the temperature is less than desirable value, it allows water to flow towards water tap by opening the first valve and closing the second valve which directs cold water to combi cold water input. Whenever temperature of the water decreases below the predefined, it turns off the first valve and opens another. [6]

**A Choice of Components**

In the above sections, it was provided detailed information on the essence of thermowells. From this side, the most important factor is to pay attention to the material of installation place. In our case, it is a plastic water pipe. Here, the installation of threaded thermowell is needed and should be mounted for some reasons. Firstly, it is evident that an

installation technique of other types is different, by being with welding machine. In addition to this, flanged type thermowells are mounted on the surface with a large area.

With regards to temperature sensor, it has already been given that it has mainly two types. The comparison between them with both positive and negative sides has been provided. As a result of the final evaluation, it can be claimed that application of appropriate sensors in this area is very important. At the same time, it should be noted that after analyzing the normal operating conditions of this system, it is evident that it is not going to be used a sensor with high specs. So, it will mainly engage in water and a small amount of error in this area is not considerable and significant. From this point of view, after looking through all sensor types, it would be pragmatic to use thermocouple instead of RTDs. Therefore, our measurement range is significantly small by being maximum 80-90°C and accuracy is not so important for us.

From this point of view, K-type thermocouple MCP 9600 is the best suited one for this project. Below, it is added specification of this sensor:

- Measurement range: up to 85°C
- Input voltage: 5V
- Accuracy: ±1.5°C

### Solenoid Valve

From solenoid valve side, with the corresponding to our system, one of the valves must be always in open mode while not working. Because when water tap is opened, combi boiler should detect the pressure drop in the pipe and according to that drop, it opens output and starts water flow towards to that water tap. For this reason, the first valve which is directed to the water taps must be always open, in industry; it is called Normally Open (NO). On the other hand, another valve should be selected Normally Close (NC). Therefore, if it is chosen as Normally Open, then combi boiler will detect pressure drop always and flows water.

With regards to solenoid valve side, it would be the best choice to use 12V solenoid valve. The main point is to be compatible with the most of controllers including Arduino type controllers. On below, the specification of the chosen valve is given and provided detailed.

### Controller

The most crucial and vital part of this process is implementation of the appropriate controller. From this point of view, if we have a look on the overall process, we face that generally, we need only, to create an error signal and giving corresponding commands. Here, in order to make system

simple, we can use just ON-OFF type controller which is very simple and handy. However, in order to make it compatible with other mechanical devices, it is feasible to face with some issues. For preventing this type of problems, it is highly recommended to use simple logic boards, such as Arduino. The type of Arduino does not matter. However, to make system cheap and simple, use of UNO type would be the best option.

We will need:

- 1 analog input for temperature sensor
- 2 digital outputs for solenoid valves
- Supply voltage and ground

It was mentioned that solenoid valve works with 12 V. However, this type of controller supports 3.3 and 5 V only. In order to power solenoid valve, it is recommended to use 5 to 12 V converter.

### System Diagram

This is the system diagram and inside of control unit (figure 5). It is possible to find physical location of mechanical devices from this illustration. When water temperature exceeds predetermined limit, controller will send signal. As a result of it, valve 1 will be opened and valve 2 will be closed. If water temperature falls below the desirable value, valve will be closed and unused cold water which is not going to be used will be redirected to the combi cold water input.

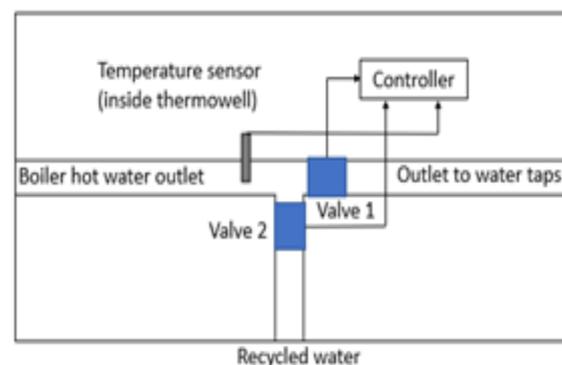


Figure 5: System diagram of the solution

### Simulation

In order to make the overall system check, it is desirable to create an online model of this project and simulate it. Tinkercad is a website which helps users to generate online models and simulate them. However, there is only one limitation that due to absence of solenoid valve in simulator, we have added simple lamps for showing simulation and

checking function of written program inside controller (figure 6).

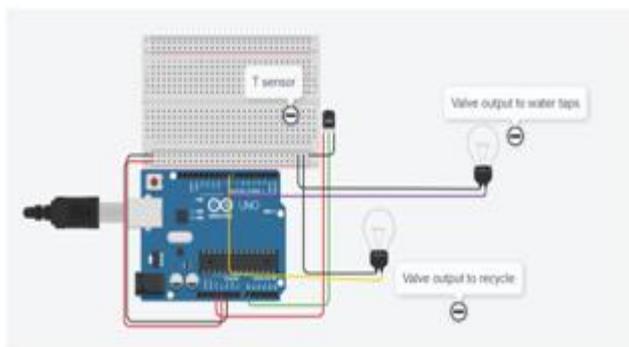


Figure 6: Simulation

When temperature is less than  $36^{\circ}\text{C}$ , it closes the first valve and opens the second one to save water (figure 7).

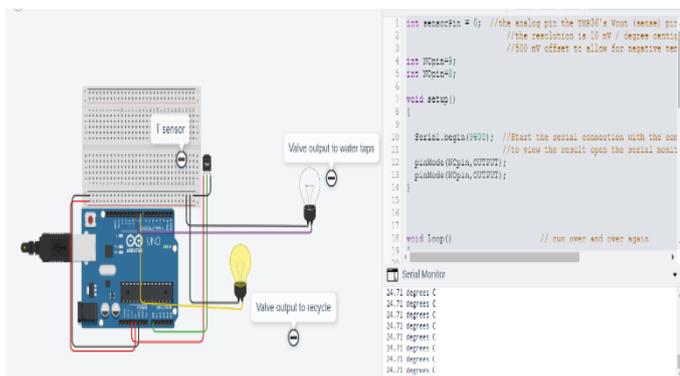


Figure 7: Simulation at less than  $36^{\circ}\text{C}$

When temperature exceeds  $36^{\circ}\text{C}$ , it opens the first valve and closes the second one. As a result of this, water goes to water taps (figure 8).

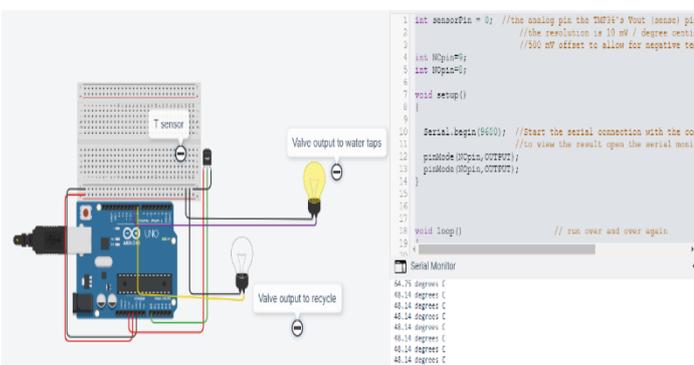


Figure 8: Simulation at higher than  $36^{\circ}\text{C}$

## V. CONCLUSION

Firstly, it was investigated all feasible water conservation systems and generated a general overview among all techniques. In the next procedure, it must be considered choosing the right way to save water at home appliances by

evaluating other methods, also. After that, the main goal was to generate the control system and creating the system diagram to identify physical location of the mechanical devices. In the following stage, choice of mechanical devices which meet requirements of this project is done. The next stage includes an installation of the mechanical devices. Finally, it was ended up making the final amendments and getting the results.

## VI. FUTURE SCOPE

For the following progress of this project, there may be a possible enhancement in modeling a various infrastructure of this project. Mainly, this developed model would be mounted inside the combi boiler itself which gets a huge effect in the initial cost by decreasing the amount. In order to obtain better measurement and higher operational efficiency, sensors and actuators can be replaced by improved ones which are going increase project reliability.

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#### Citation of this Article:

Mustafa Aghayev, Kamala Pashayeva, "System for Reducing Water Consumption at Home" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 7, pp 91-97, July 2021. Article DOI <https://doi.org/10.47001/IRJIET/2021.507015>

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