ThermoCatch: Cold Water Recirculation

AN AUTOMATED SYSTEM TO ELIMINATE COLD WATER WASTAGE BEFORE HOT WATER FLOW

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INTRODUCTION

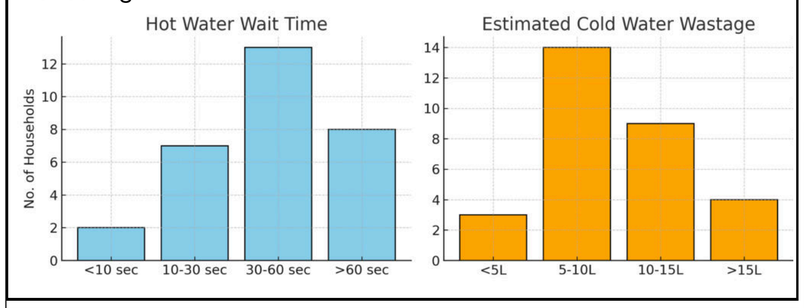
Water scarcity is a pressing global issue, with many regions experiencing reduced freshwater availability due to climate change and unsustainable water use. **Households**, one of the primary consumers of water, often waste significant amounts of clean water without realizing it. The WWF has identified residential hubs such as **Jaipur** and **Bengaluru** to be facing "severe water risk" by 2050. A major yet overlooked source of water wastage occurs when cold water runs down the drain while waiting for hot water in showers and sinks. Since hot water takes time to reach the outlet due to pipeline distance and heat transfer delays, the initially flowing cold water is wasted, leading to substantial water loss over time. A study has shown that, on average, households waste approximately **24 litres** (6.35 gallons) of water per day while waiting for hot water to arrive at the tap. This issue is even more pronounced in colder regions such as Canada or Sweden, where lower ambient temperatures lead to even greater volumes of wasted water while waiting for hot water delivery. In such climates, users may unknowingly waste several liters more per use compared to warmer regions. This project aims to demonstrate how small-scale technological interventions can address overlooked inefficiencies in household water consumption and contribute meaningfully to sustainability goals.

OBJECTIVE

The objective of this research is to develop an automated system **'ThermoCatch'** that detects and redirects cold water back to the main storage tank before it reaches outlets like showerheads and basins. By monitoring the water temperature in real time, the system ensures that only heated water is allowed to flow to the user, while clean cold water is captured for reuse. ThermoCatch aims to offer a simple, practical, and scalable solution to reduce everyday water wastage without requiring any changes to user behavior.

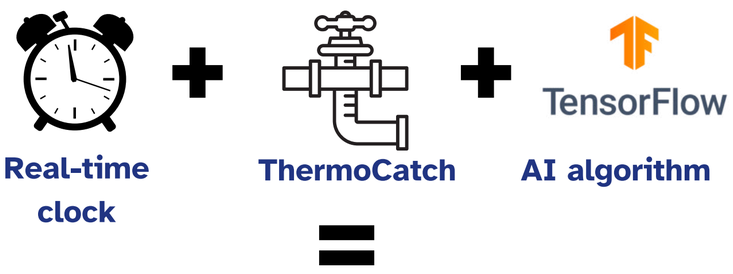
PROBLEM SCOPING

A survey of 30 households across Gujarat and Rajasthan revealed that most users wait 30 to 60 seconds or more for hot water, wasting between 5 to 10 liters of clean water per use. While some reuse the water manually, most let it drain. While a few households manually collect this water for reuse, the majority let it drain due to inconvenience or lack of infrastructure. The extent of this wastage is further influenced by external factors. In colder months, especially during winter, the time taken for hot water to reach the outlet increases significantly, leading to greater volumes of water lost. Geographic and climatic conditions also play a key role — homes in regions with longer plumbing runs or lower ambient temperatures experience higher cold-water discharge. Additionally, the interval between consecutive uses affects efficiency; if long gaps exist between showers or tap use, the water in pipes cools entirely, causing additional wastage during reheating.



FUTURE SCOPE

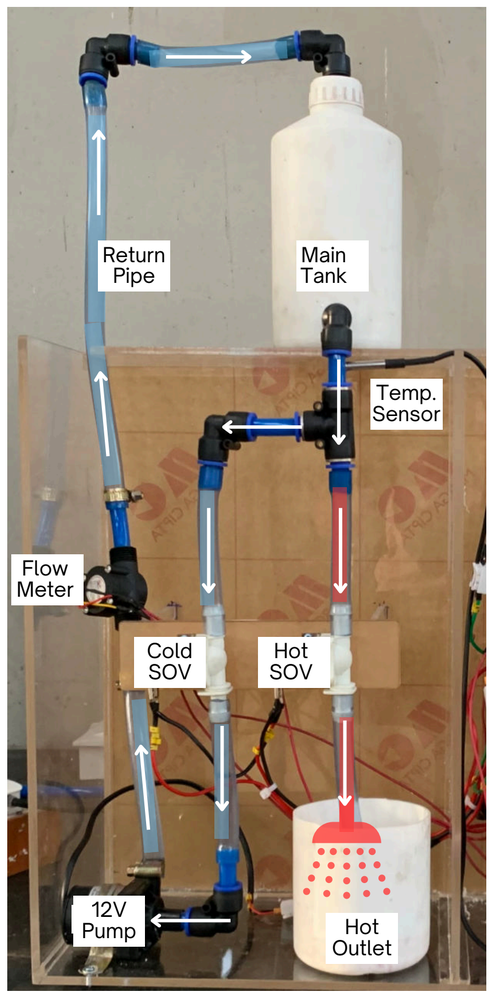
- AI-Driven Usage Prediction: By analyzing user behavior and household routines, the system can **anticipate hot water demand and activate proactively, minimizing wait time and increasing efficiency.**
- Smart Power and Connectivity: Integrating solar power and cloud-based analytics will reduce energy dependence and allow users to monitor savings, receive alerts, and access performance data remotely.
- Enhanced Sensing Capabilities: Future versions can include water quality sensors to ensure safe reuse and detect leaks or system faults automatically, improving reliability and sustainability.
- Connect the water meter to an online central website or real-time monitoring and quantification of water recycled and saved.



Reduced waiting time ensures seamless integration into daily routines without disrupting user habits

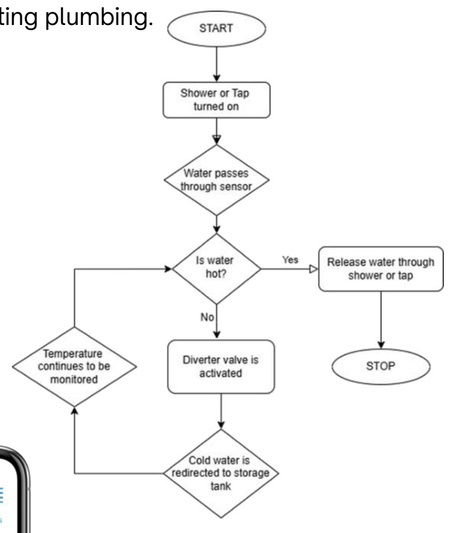
PROTOTYPING

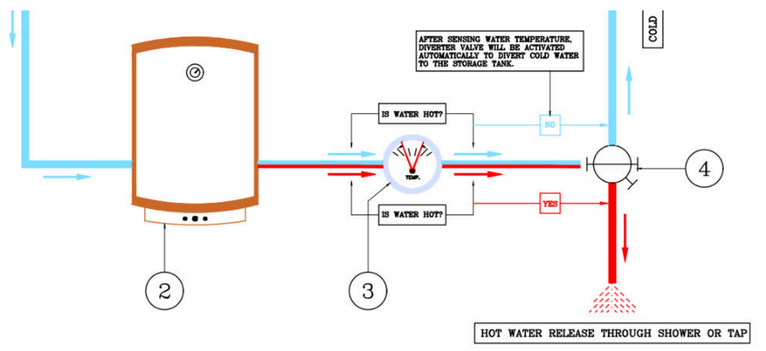
The ThermoCatch prototype was designed to intelligently divert cold water before it reaches taps or showers. A three-way water diversion system was built using two solenoid valves mounted on a T-connector: one directing flow to the tap, the other returning water to the main tank. At system start-up, the temperature sensor (DS18B20) continuously monitors the water flowing through the pipe. If the temperature is below the preset threshold, the Arduino UNO signals the return valve to open and the outlet valve to remain closed, diverting the cold water for reuse, which then flows through a Hall Effect Flow Sensor to measure the volume and flow of water being diverted. When the water reaches the desired temperature, the logic switches: the return path closes, and hot water flows normally to the user. An LCD connected at the side displays vital information. Since the solenoids, pump, and microcontroller operate at different voltages, a complete electrical circuit was designed using two relays and an SMPS (Switched Mode Power Supply) to safely and efficiently manage power distribution across the system. This compact, modular setup ensures accurate temperature-based water diversion while remaining low-cost, reliable, and easy to integrate into existing plumbing.



IOT AND AUTOMATION

ThermoCatch operates fully autonomously, but for data tracking and performance insights, an Android application was developed using MIT App Inventor. The app connects to the system via Bluetooth and displays key parameters such as live temperature readings, daily water saved, and total flow diverted. Although the system runs independently without needing user input, the app adds value by visualizing conservation efforts and enabling future possibilities such as remote diagnostics or cloud-based data logging.





IMPACT ASSESSMENT: PROJECTED WATER, COST AND ENERGY SAVINGS

A single 4 person household can save 61 L daily or 22,447 L annually

With 250 million households, full adoption saves over 5.6 trillion liters annually

YEARLY IMPACT FIGURES

National Water Savings
~$3.3 BILLION

National Energy Efficiency Savings
~$6 BILLION

Energy saved nationally in kWH/yr
~35 BILLION

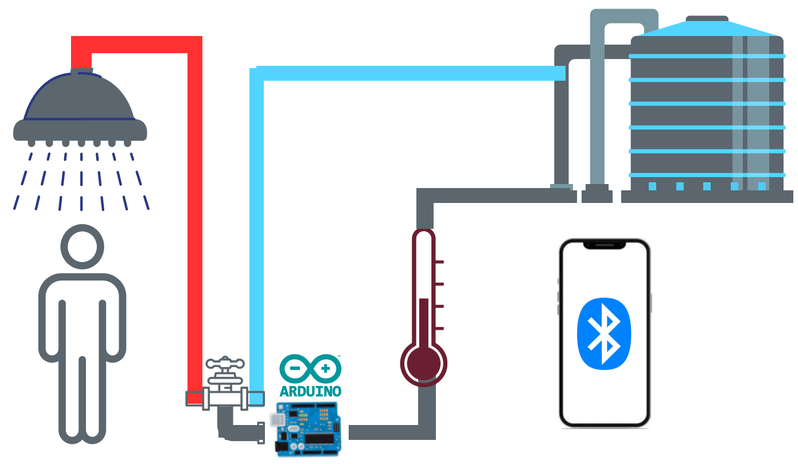
~25-30 million tons of CO2 emissions from heat generation avoided

Offsets the water demand of 150+ Tier 1 Cities

5.6 Trillions Liters could provide drinking water to all Indians for 13+ years

AT A GLANCE

- **Easy Integration**
  Simple installation in residential and commercial properties
- **IOT and Automation**
  App control, data sharing and AI-enabled potential
- **Resource Conservation**
  Reduces water, heat & power consumption, lowering bills
- **Hidden Design**
  Non-visible system design without changing user behavior



RESULTS AND DISCUSSIONS

- ThermoCatch was tested in a household of two people over a period of **15 days.**
- The system diverted all cold water before hot water reached the outlet during every use.
- Saved an average of **7.69 liters per use**, resulting in **464 liters** of water saved over the test period.
- Operated fully automatically, requiring no change in user behavior or manual input.
- Temperature detection achieved **97.31% accuracy**, with average valve switching in **13.31 seconds.**
- The system effectively demonstrated that meaningful water conservation can be achieved without inconvenience to the user.

15-DAY EXPERIMENTAL STUDY

Installed ThermoCatch in a 2-person household in Vadodara, Gujarat. With an average of 4.1 showers per day, ThermoCatch recorded the following results:

7.69l saved per usage

464l saved over testing period

97.31% temp sensor accuracy

13.31s avg system response time

ThermoCatch offers a practical, automated solution to household water wastage, combining innovation, efficiency, and sustainability to make everyday conservation effortless.

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