UNIVERSITY OF WEST LONDON

Appliance for Water consumption management in showering by using ARduino kit, Energy NExus and SensorS

AWARENESS kit

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19th Computing and Control for the Water Industry Conference 2023

September 2023

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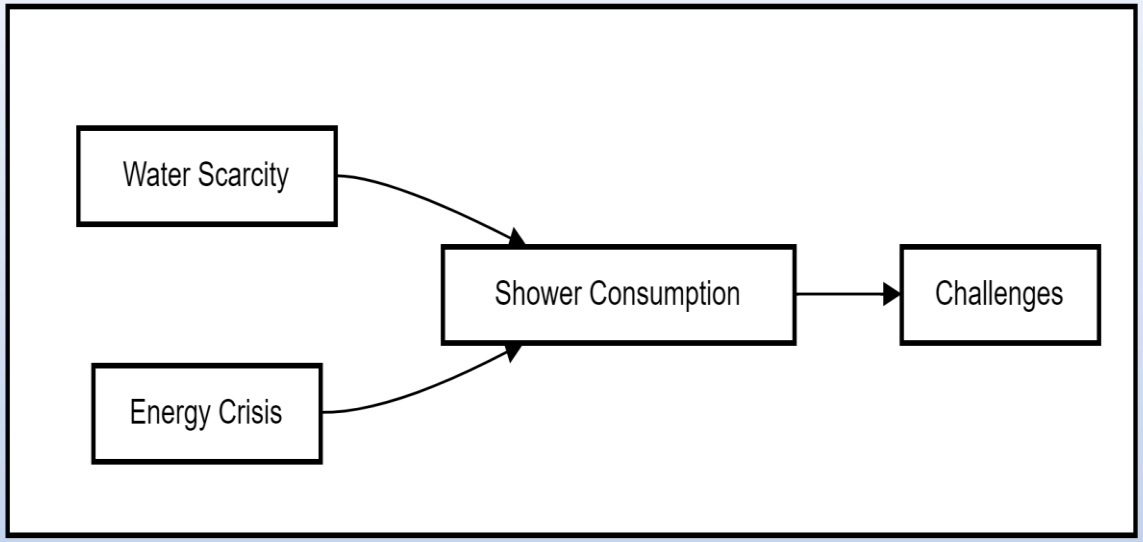
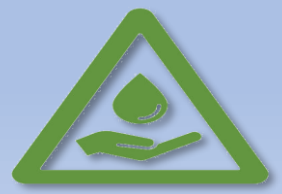
Background



Showering

40% water **30% energy**

Household consumption



Water scarcity

Soaring energy cost

Water scarcity: Many regions of the world are facing water scarcity challenges. In 2020, UN reported that extreme weather events are making water more scarce, more unpredictable, and more polluted.

Energy costs: Even regions with abundant freshwater resources are struggling with energy costs. Europe is facing a serious energy crisis, and the energy price cap in the UK was predicted to rise by 80% last October.

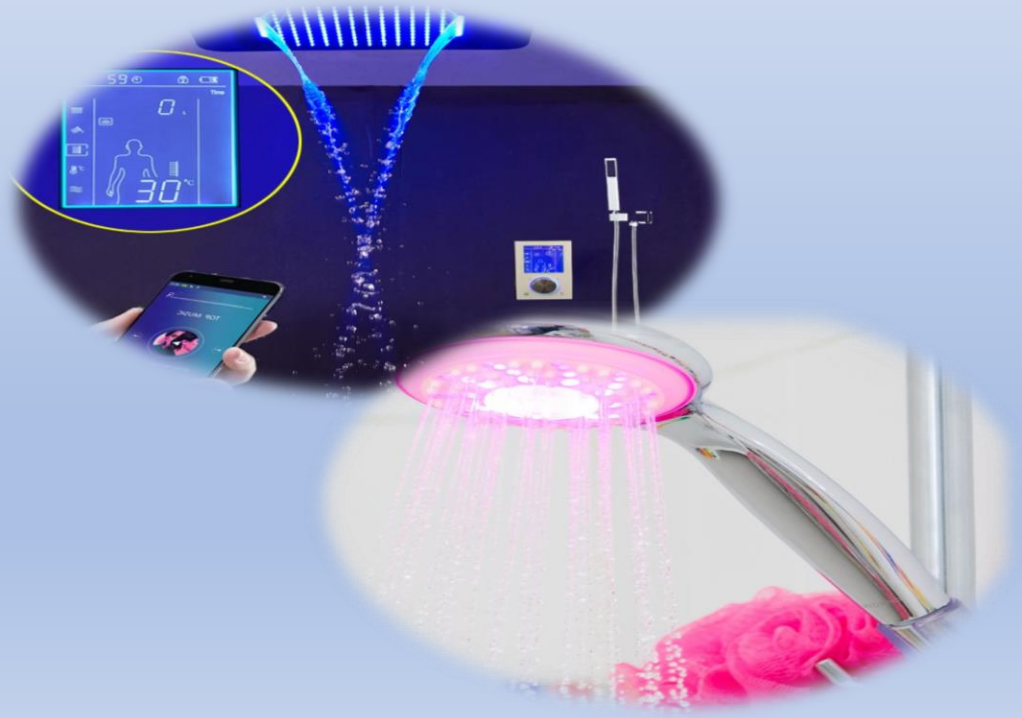
Shower consumption impact: Alone, accounts for around 40% water, and 30% energy, of household consumption. Monitoring water and energy usage while showering has become imperative, requiring better tools or gadgets.

Previous research

- Innovative water-saving gadgets are proposed, including smart shower remote controls, smart showerheads and IoT showerhead devices, to address the issue.
- A study states that smart shower systems connected via the cloud and mobile devices may be low-cost solution to manage shower consumption (Reis 2022)
- HydroSense, a wireless device that monitors water consumption during hotel showers, promote water conservation (Hawrylak et. al. 2015).
- An interactive shower panel, that provides water consumption statistics, to alert users have been proposed (Czajkowski et. al. 2021).
- A study found out that a visual display monitor that alerts users in showers can reduce water usage, saving up to 27% of water (Willis et. al. 2010).
- According to another study, a simple display (the show-me device), showing water consumption while showering led to water usage reduction by users however, when the device was removed old habits of users returned (Kappel et. al. 2009).
- These gadgets could be effective, combining with education or incentives, to boost behavioural change (Stewart et. al. 2013).
- Within this context, further research is required for a more comprehensive solution.

Gaps & goals

Water-saving gadgets using smart and IoT technologies can provide accurate data on water temperature and consumption however, they face several limitations.

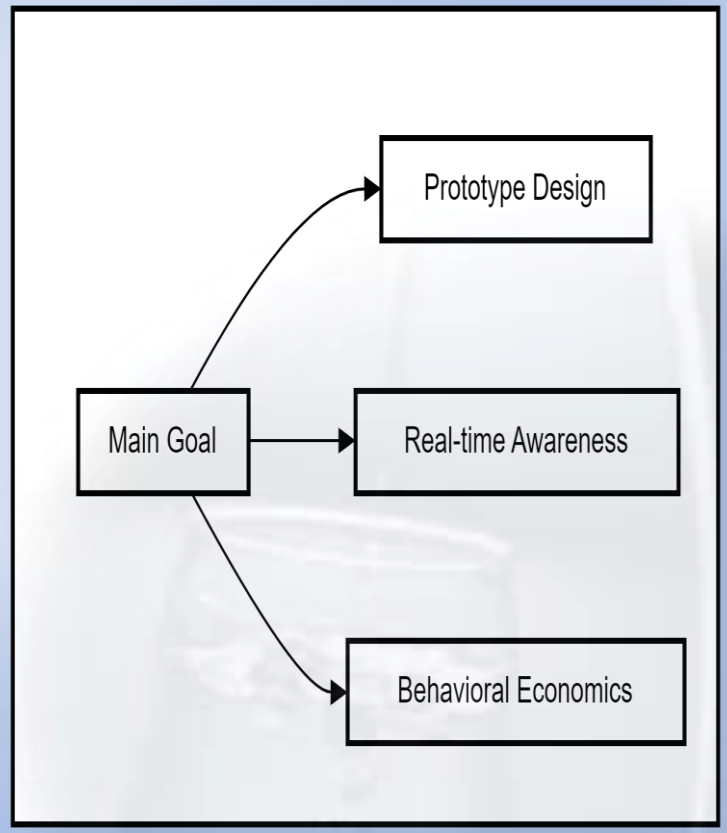


- High purchasing costs and installation.
- High cost of maintenance and calibration.
- Inability to adapt to existing and outdated bathing systems.
- Inability to react actively in real time and, lacking education or incentives to encourage behavioural change.
- Provide technical information and large data that most users are unable to comprehend and follow.

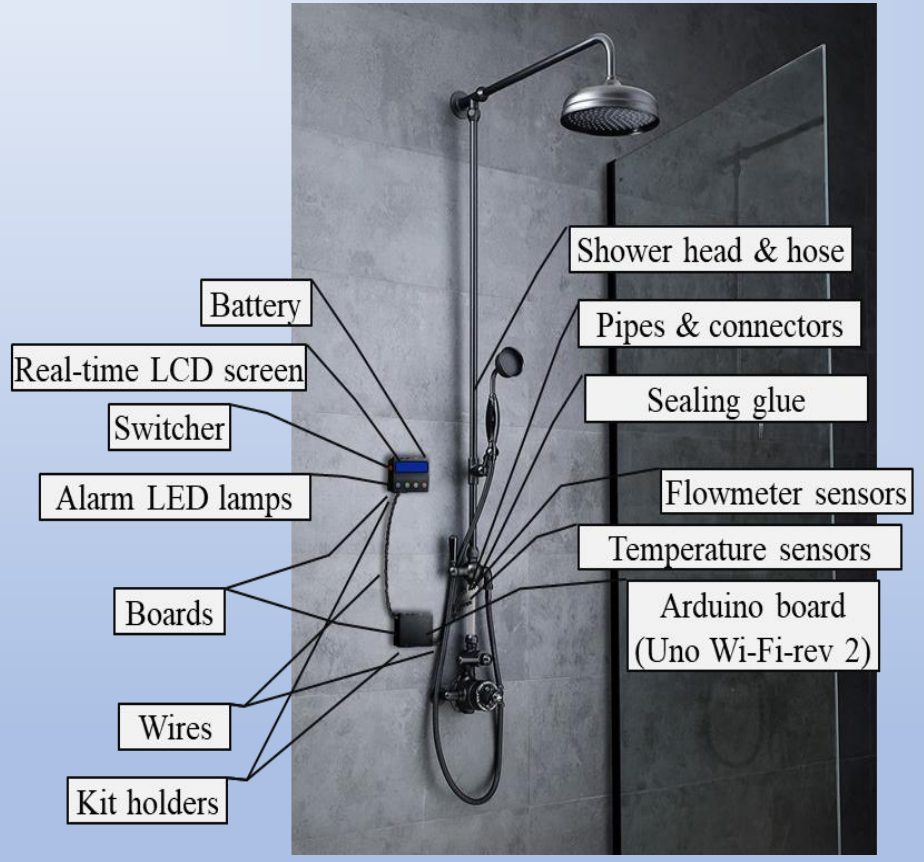
Gaps & Goals Cont.

To develop an Internet-of-things-based shower gadget, encouraging behavioural changes, to save water and energy.

- Create a prototype appliance that is inexpensive, simple to assemble, and easy to replace while also offering a wide range of applications.
- To provide a real-time user awareness system that monitors water and energy usage. That is to offer a real-time user awareness system for monitoring water usage, providing quick access to information via LCD screens and LED alerts, thereby increasing awareness and control over water and energy consumption.
- To employ behavioural economics concepts to provide user-friendly, engaging systems that connect data to behaviours, and encouraging responsible consumption in shared occupation households.

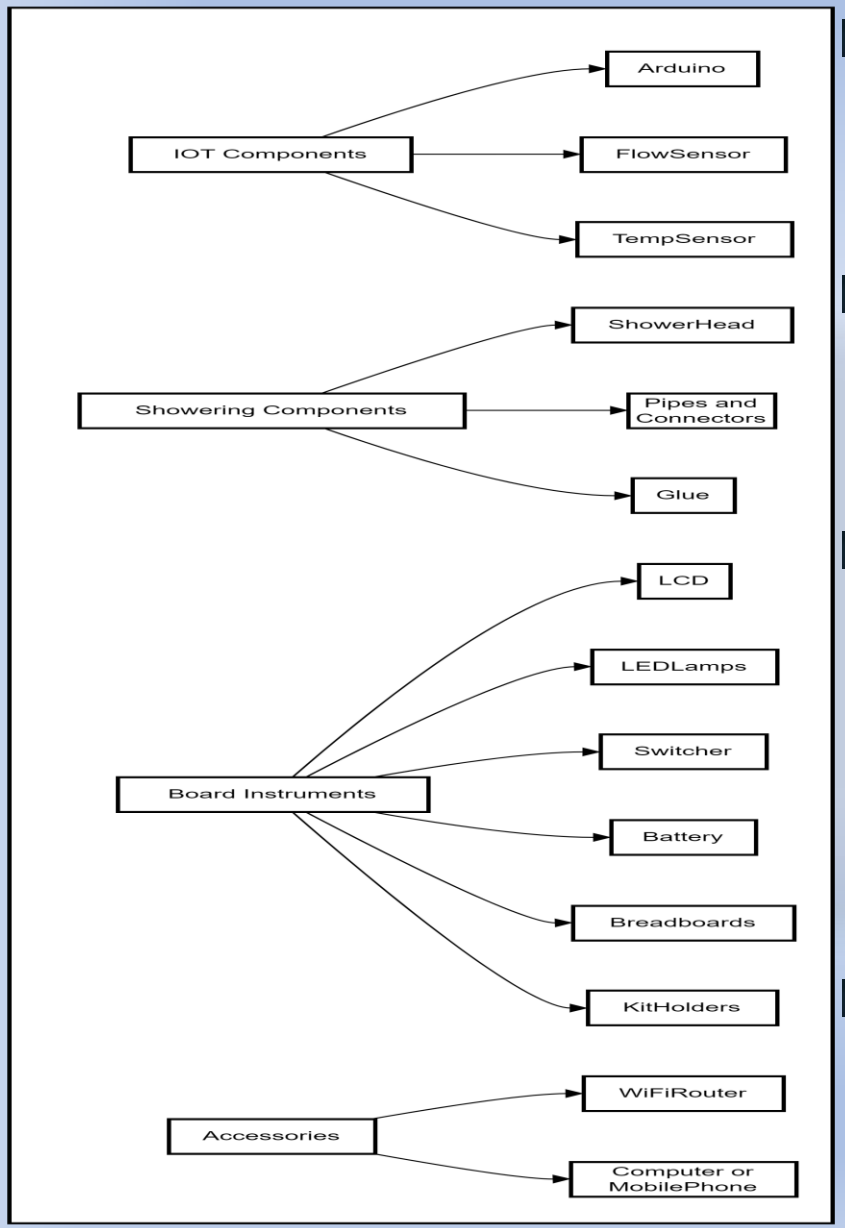


Materials & Method



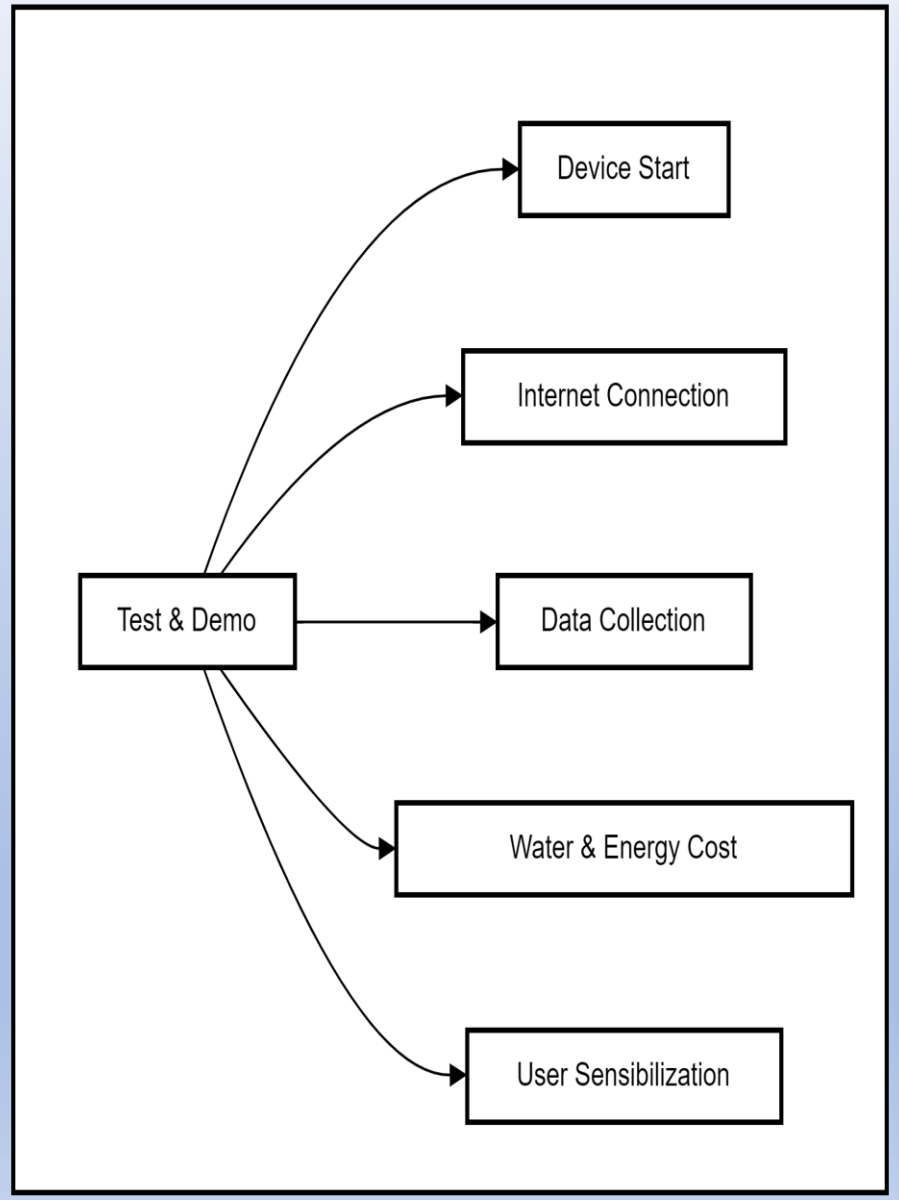
- IoT components
- Showering components
- Board instruments
- Accessories

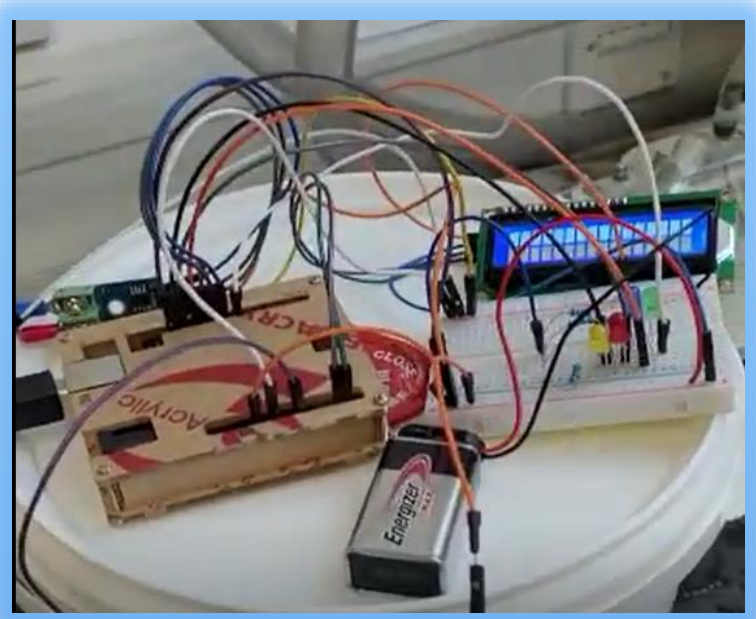
Applied devices

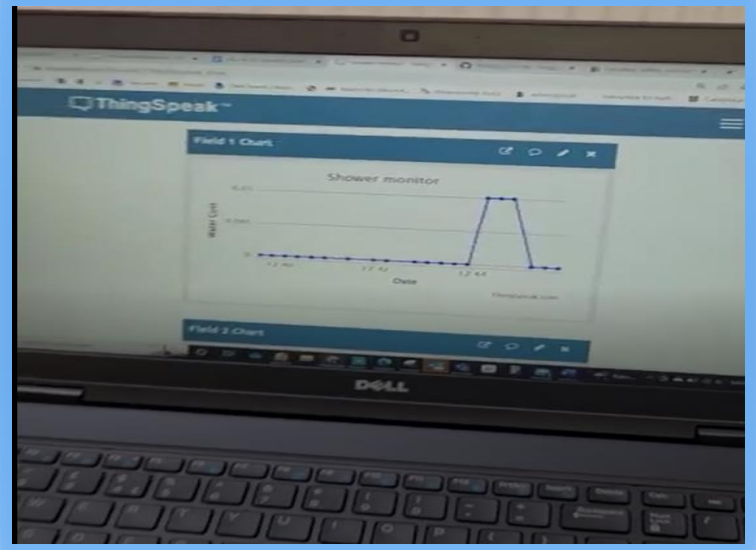


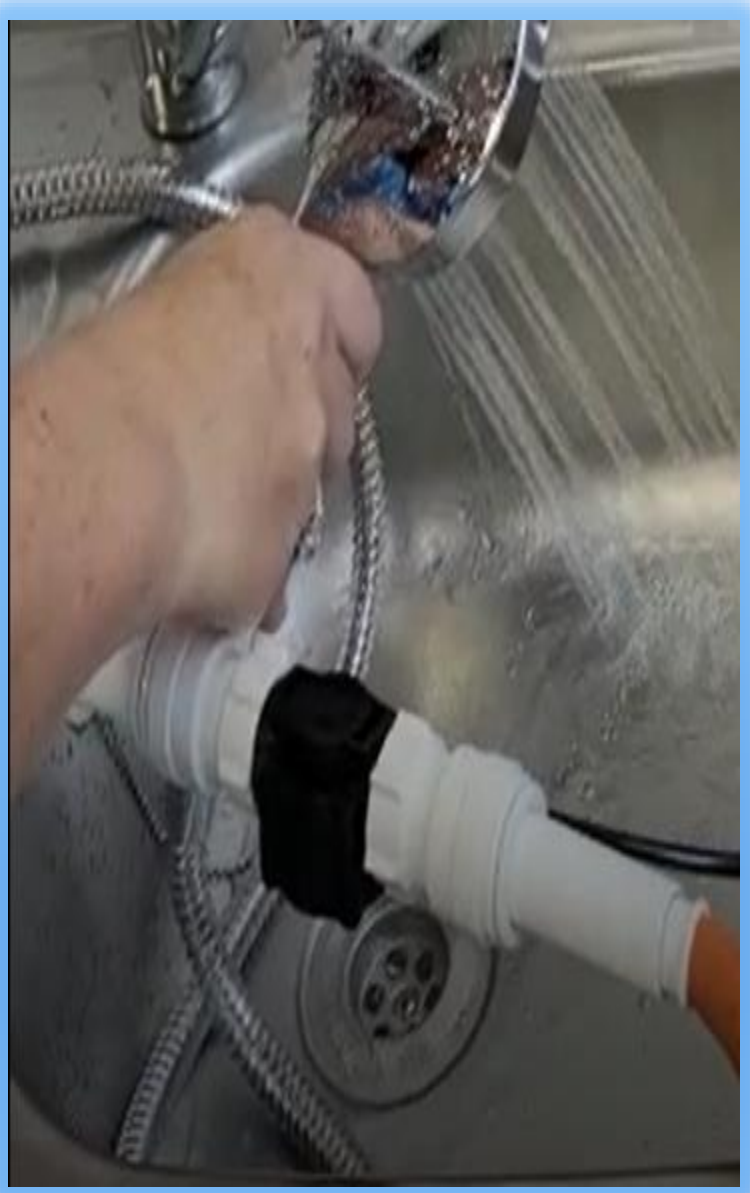
- IOT components:
  - (1) Uno wifi-rev2
  - (2) Measuring real-time water flow
  - (3) Measuring real-time water temperature
- Showering components:
  - (1) Any type and brand but not buried in the wall
  - (2) For connecting the sensors to the showering system
  - (3) Waterproofing all openings and wires
- Board instruments:
  - (1)Showing real-time water and energy consumption
  - (2)Alerting cross lines
  - (2) Switcher and Wires
  - (3) Rechargeable preferably, or use for at least 100 showering times
  - (4) To assemble all components
  - (5) Using 3D printer
- Accessories:
  - (1) Transfer captured real-time data
  - (2) Access platform and retrieve raw data in graphs or tables of records

Test & demonstration









Test & demonstration cont.

- For 8 seconds, a message explaining the product and the text "welcome to your saving programme" is displayed on the LCD screen, creating a warm and encouraging atmosphere.

- In the meantime, the gadget is configuring the internet connection and communication with the cloud platform. We utilised MATLAB's "ThingSpeak" platform because it is free and open to the public.

- When the shower is turned on, the two sensors along the showerhead hose measure the water flow rate and temperature every second, and the gadget begins to record and monitor the consumption.

- The data is sent to the Arduino board, where it is processed and delivered to the cloud platform over Wi-Fi.

- The Arduino's internal programme compares the consumed water to the total volume required to fill a hot tube. When the amount of water consumed exceeds the specified limit, the blue LED alert goes off. This volume is equal to 50 litres according to UK standards.

- To reach a larger audience, we turned water use into the equivalent of 50 large water bottles, which may be more understandable and impactful to consumers.

Test & demonstration cont.

- The water temperature threshold was set at 15 degrees Celsius, which is standard for cold water, and higher temperatures necessitate the usage of appliances such as boilers that use electricity and gas. In addition, the cost of water and wastewater services charged by water corporations considered. Each second, distinct LED colours independently display the total costs on the screen.

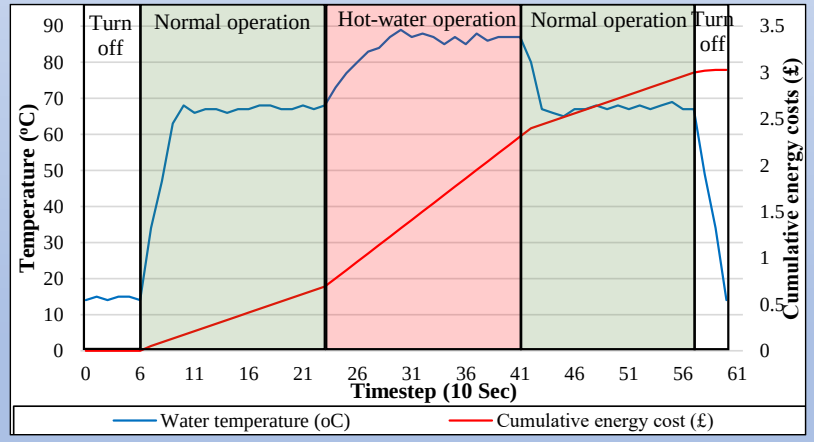
- When the cost hits £1, the yellow alert LED lamp will switch on, followed by the red lamp when it reaches £5.

- Finally, the weight of environmental impact is considered. When the water pressure surpasses 0.2 l/s or the temperature rises over 35^{o}C, the green lamp illuminates. In tree units, this means that the CO_2 produced, is equivalent to volume captured by 200 mature trees.

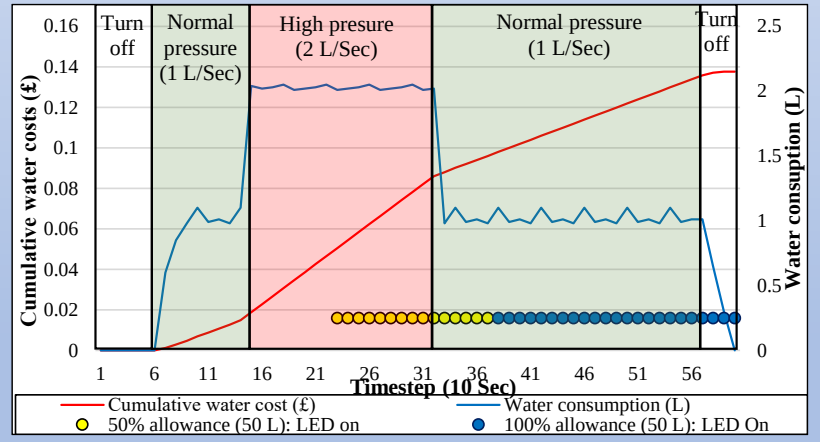
- Attempting to educate the end-user, on the money spent, water consumption, water bottles used, and grown trees cut down.

Results

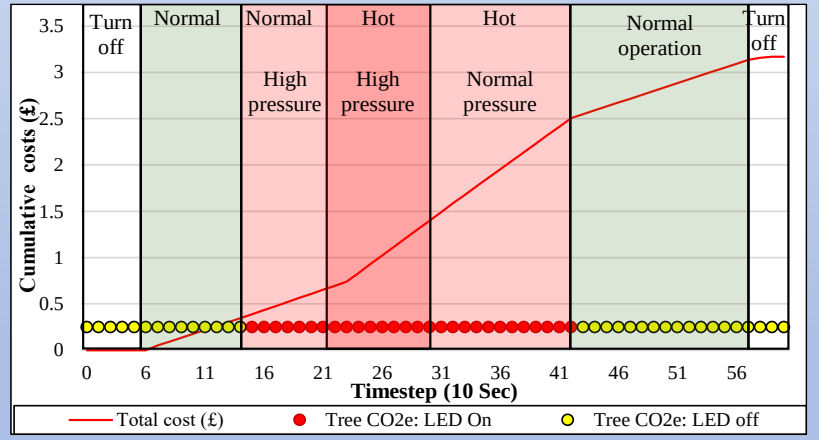
The Arduino board, which is used to connect to a Wi-Fi Protected Access (WPA) network, processes the data collected from the temperature and flow rate sensors to generate live readings of four variables: water cost (£), energy costs (£), water consumption (number of water bottles), and equivalent of one tree ability to absorb CO_2. The readings are instantly transferred to the shower room's LCD display and online to an IoT platform, which automatically generates one graph for each variable, shown in the figures below, and from which a table of the records may be downloaded as needed.



(a)



(b)



(c)

Results of simulated 10-min showering operation: (a) energy-related measurements, (b) water-related measurements, (c) total cost

Future potential

App-based application

- Real-time cloud-stored data can be analysed to promote sustainable water practices, such as reducing shower temperatures or encouraging off-peak usage, based on peak-time rates, water volumes, and energy consumption.

Multi-accounting

- Reports on water consumption, energy cost, CO_2 capture, and bottle usage can be generated through online access or full reports of the four measured variables. This information will be crucial for households and commercial units that use heated water in their operations, like hotels, government properties, and gyms.

Commercial benefit

- This modular appliance allows easy connection of various water and wastewater sensors, measuring water hardness and wastewater turbidity, which indicate the quality and concentration of chemicals in the water.

Current limitation

- Fixed Utility Rates: Currently, water and electricity rates are fixed, but there is potential for future enhancements through remote uploading, which can be addressed through further research or accessory development.

- Battery Maintenance: The existing system requires regular battery changes. Implementing a rechargeable system could eliminate this inconvenience.

- Design Enhancement: To ensure safety and robustness, it is essential to work on design improvements for the final product. This will help create a more durable and user-friendly solution.

Conclusions and perspectives

- An IoT-based showering appliance that reduce water and energy consumption in household showering, by providing end-users, real-time awareness and economic-behaviour of nudges.
- The data stored in cloud-based sources for subsequent analysis can be analysed, to encourage lowering showering temperatures, by a few degrees or off-peaking usage. Reports covering various data combinations can be useful for individuals in a shared accommodation, hotels, council properties, and gym.
- The appliance can easily allow connection to various water and wastewater sensors, such as water hardness and wastewater turbidity.

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Thank you for your time