The European Journal of Technical and Natural Sciences 2025, No 6
ISSN 2414-2352

PREMIER Publishing
ppublishing.org

DOI:10.29013/EJTNS-25-6-127-133

WATER REGENERATION IN SMART HOME INFRASTRUCTURE

Volodymyr Savenko [1]

[1] Department of Construction Organization and Management (Kyiv National University of Construction and Architecture)

Cite: *Savenko V. (2025). Water Regeneration in Smart Home Infrastructure. European Journal of Technical and Natural Sciences 2025, No 6.* https://doi.org/10.29013/EJTNS-25-6-127-133

Abstract

Water supply represents one of the fundamental components of smart home life-support systems, determining both the technological level and the overall economic efficiency of the smart home infrastructure. This publication summarizes a set of innovative technologies developed by engineer and innovation specialist Bohdan Vitiv, aimed at meeting the core technical requirements for modern smart home water systems. The author emphasizes the importance of these developments for advanced educational programs and professional training in the field of smart home technologies. The article provides an overview of the key technological solutions proposed by Vitiv and outlines their potential for improving the quality and effectiveness of specialist preparation in this rapidly evolving domain.

Keywords: *Water in smart home infrastructure; Electrochemical water regeneration in smart home infrastructure; Chemical-free water regeneration; Comprehensive water recirculation; Compact modules for electrochemical water regeneration; Integrated water supply system within smart home infrastructure and ecosystems; Input control and pre-treatment modules within smart home infrastructure; Used-water storage modules; Separation systems with vortex foam generators; Final control systems without direct contact; Control and processing unit for remote real-time management and monitoring*

Electrochemical regeneration of tap water in smart home infrastructure for recirculation and comprehensive disinfection using real-time online control lines based on electromagnetic resonance spectroscopy principles, operated by artificial intelligence and artificial neural network elements

Integrated Water Supply System within Smart Home Infrastructure

An integrated water supply system within the smart home infrastructure typically includes four groups of modules interconnected by their operating principles and functional interaction:

1. **Input control and pre-treatment modules**, including inlet water tanks and reserve tanks for peak loads. Pre-treatment includes

electrochemical disinfection, aeration, and increasing oxygen concentration to the level of full saturation. Input control modules operate using a non-contact method based on the principles of electromagnetic resonance spectroscopy.

2. **Local modules for electrochemical processing**, installed separately for each residential unit and including water consumption metering units with real-time monitoring sections at the inlet (non-contact, working on the principles of electromagnetic resonance spectroscopy).
3. **Used-water storage modules**, dividing the water into at least two groups: water containing toilet waste and general greywater.
4. **Water regeneration modules**, consisting of at least two sections: one for water with fecal content and one for all other water. These modules include separation systems with vortex foam generators and final non-contact control systems based on the principles of electromagnetic resonance spectroscopy. In addition to the operational modules, the integrated water supply system includes a control and processing unit with artificial intelligence and artificial neural network elements, enabling remote management and real-time monitoring.

Water Consumption Parameters

Water volume is calculated in full accordance with the standards for supplying residential units.

Number of residential units: 100

Estimated number of residents: 150

System Structure Overview

The integrated water supply system includes four groups of interrelated modules:

1. Input control and pre-treatment modules, including inlet water tanks and reserve water tanks for peak loads. Pre-treatment includes electrochemical disinfection, aeration, and increasing oxygen concentration to the level of full saturation. These modules operate via non-contact methods based on electromagnetic resonance spectroscopy.
2. Local electrochemical treatment modules for each residential unit, including inlet water consumption metering blocks with real-time control sections (non-contact, using electromagnetic resonance spectroscopy).
3. Used-water storage modules with separation into at least two groups: water containing toilet waste and general greywater.
4. Water regeneration modules with at least two sections-one for water with fecal particles and one for remaining water. These modules incorporate separation systems with vortex foam generators and final non-contact control systems based on electromagnetic resonance spectroscopy.

The system also includes a central control and processing unit equipped with artificial intelligence and artificial neural network elements, enabling remote control and real-time monitoring.

Carbon–Carbon Composite Fabric

A carbon–carbon composite fabric has the following functions:

(When you provide the functions, I will translate and format this section in the same style.)

Carbon-Carbon Composite Fabric: Functional Application

In the anode block of a water desalination unit, the functions of this fabric consist in significantly increasing the contact surface between the anode (the fabric itself) and the stream of saline water. As the saline water passes through the openings in the fabric-anode, it receives the maximum possible amount of positive electrical charge.

In an electrochemical cell for disinfection (an electrochemical reactor of any type), this fabric (not connected to the power supply) is positioned as a spacer between the electrodes – the anode and the cathode. This spacer equalizes and stabilizes the flow of liquid, which, in the electric field between the electrodes, migrates and separates: the positively charged liquid contacts the cathode, while the negatively charged liquid contacts the anode.

After passing through the inter-electrode zone, the charged liquid exits in an upward flow: on the cathode side, the liquid carries a negative charge (a flow with an acidic background), and on the anode side, the liquid carries a positive charge (a flow with an alkaline background).

Innovations Opening a New Scientific and Technical Service Direction

Augmented reality in consumer and personal optics is still in its early development, yet it is expected to have significant future potential. Such headsets remain expensive, and continuous daily use is not yet convenient. Nevertheless, several high-quality devices are already available on the market or at the final stages of development. This review aims to provide an analytical overview of these products.

More than ten years have passed since the release of the first successful augmented reality headset, Oculus Rift. These glasses produced an immediate "wow effect," but after some time, once users were sufficiently familiar with the novelty, interest decreased. The key issue is that developers have not yet succeeded in transforming augmented reality glasses into a device as commonplace as a smartphone, game console, or smartwatch.

According to the author of this publication, one of the reasons for this situation lies in the state of service technologies, which are not yet sufficiently developed to support such complex devices in conditions of mass production and, consequently, mass consumption.

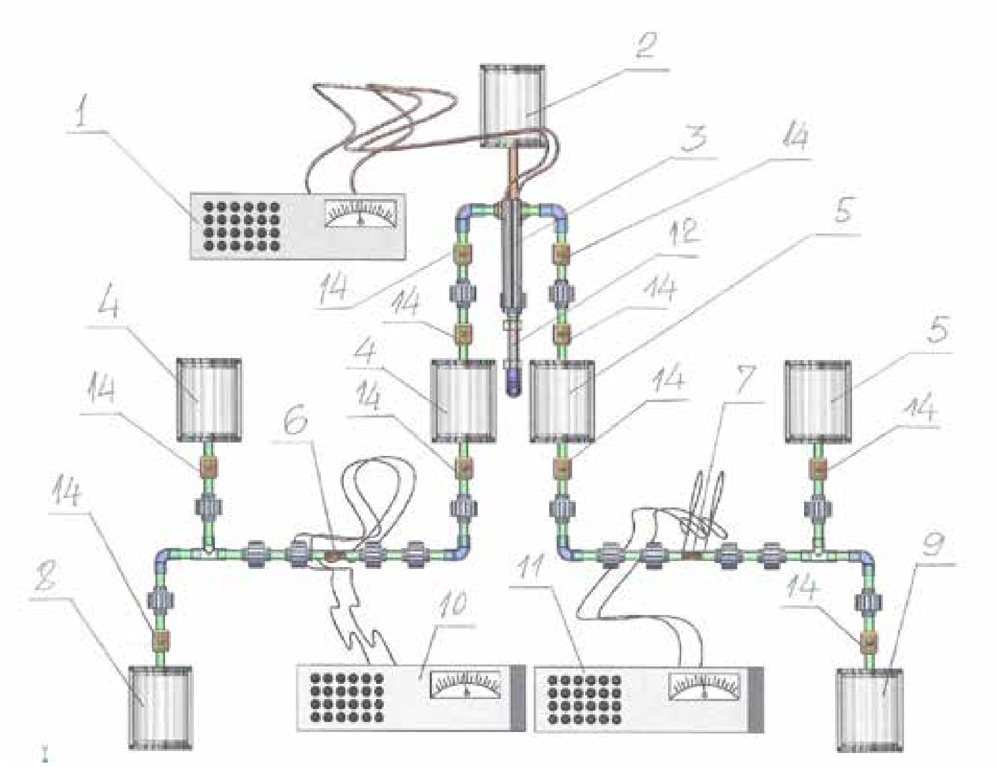
The state of patent protection for these new technologies also raises numerous questions.

It is noteworthy that, despite expectations of rapid market growth for augmented reality visualization projects and technologies, the dynamics of patent filings remain slow and inactive.

A patent search conducted by the author using key terms in the United States Patent Office database identified only 133 patent applications and no patent grants related to this topic.

An initial analysis of the published patent applications revealed that all such applications are exploratory in nature and do not focus on the construction or systems of augmented reality glasses as finalized products. In addition, the examples provided in these applications refer to devices at the final stages of development.

Figure 1. *Model of a system for bidirectional correction of acidity and alkalinity in deionized water*



1 – power supply unit for the electrochemical reactor

2 – tank with deionized water for feeding into the electrochemical reactor

3 – electrochemical reactor with an interelectrode space in which processing is carried out in two parallel upward flows

4 – collector of water with a reduced acidity level

5 – collector of water with an increased alkalinity level

6 – sensor module for measuring the reduced acidity level

7 – sensor module for measuring the increased alkalinity level

8 – reservoir for water with a reduced acidity level

9 – reservoir for water with an increased alkalinity level

10 – pulse generator for the impedance-resonance sensor

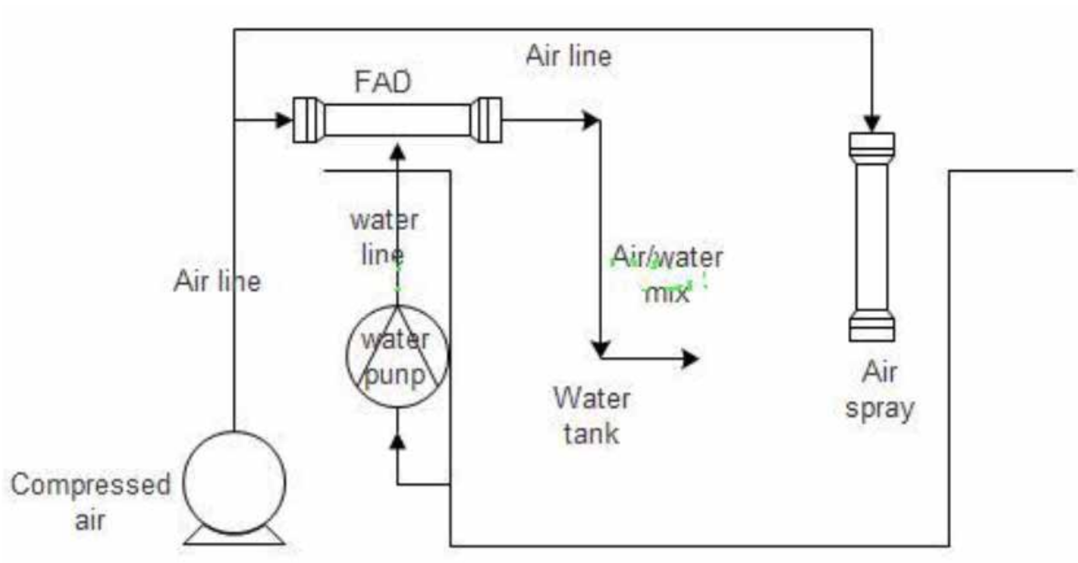
11 – pulse generator for the impedance-resonance sensor

Since the author of this series of articles is engaged in the practical implementation of such devices for a specific market, it is noted that a significant number of technical solutions are currently lacking-both for the devices themselves and for the accompanying tools and products necessary for their everyday use. One of the primary needs is the development of technical solutions and products designed to support augmented reality glasses in daily operation, including cleaning the lenses from inevitable contamination of both organic and inorganic origin.

As the lenses of augmented reality glasses become dirty just as easily as those of standard glasses, the first practical requirement is the creation of an integrated technology for producing a cleaning and disinfecting liquid from water that does not contain high concentrations of salts, including hardness salts.

However, this proved insufficient. As required by practical conditions, the liquid used for rinsing must be an insulator in order to eliminate any possible local current impulses. An analysis of potential water sources for processing within the system led to manufacturing complexes of photolithography, where deionized water is used. This water demonstrates properties closely matching the characteristics considered most necessary and suitable for servicing the optical lenses of augmented reality glasses.

Figure 2. *Model of a system for bidirectional correction of acidity and alkalinity in deionized water*



12 – inlet pipeline to the electrochemical reactor

14 – regulating and control valves

15, 16 – flow meters

17 – current-carrying cables

For comparison, variants using distilled water and deeply purified water were also examined and analyzed. Nevertheless, the properties and performance characteristics of deionized water proved superior. Special attention was given to the possibility of using deionized water in the future, both after treatment in an electrochemical reactor and before treatment, for preparing various emulsions intended for subsequent service operations on augmented reality glasses.

Experimental evaluations confirmed the feasibility of producing high-quality emulsions both with deionized water before treatment and with water after modification of its neutral acidity or alkalinity level.

Figure 3. *Model of an electrochemical reactor with a power supply*

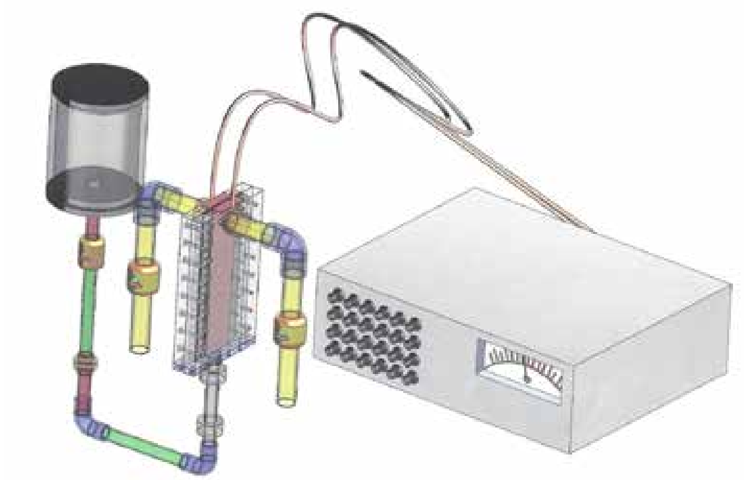
Since this technology was recommended for use for the first time, it became necessary to produce a basic prototype to verify, under real operating conditions, the feasibility of implementing several innovative technologies, the first of which was the technique and technology of the electrochemical reactor.

In the described reactor, the electrode cells have working zones separated by a neutral membrane positioned symmetrically between two electrodes. One of the important operating principles in the electrode cells is that the processing of deionized water takes place in an intensified upward flow. The distance between the active surfaces of the electrodes is only 3 millimetres, of which the membrane thickness accounts for 1 millimetre. Thus, the thickness of the liquid stream in such an electrode cell is only 1 millimetre.

This small stream thickness made it possible to sharply increase the current density to 100 amperes per square decimetre, which in turn enabled the electrochemical correction of acidity and alkalinity in water that is very similar in its parameters and properties to a dielectric liquid. Because the processed liquid forms two separate outlet streams, it becomes possible to use either the highly alkaline water or the highly acidic water for treating the optics of augmented-reality glasses.

This approach made it possible to disinfect the surface of optical lenses from microorganisms and bacteria using the acidic stream, and to remove fatty contaminants using the alkaline stream. It must also be emphasized that because the system for preparing and treating deionized water is structurally simple and uses the most widely available engineering materials and components, it can be installed in any small retail enterprise that sells optical instruments and glasses, including augmented-reality glasses-both current and future models. Another important factor relates not only to the specific requirements of augmented-reality glasses, but to optical devices in general. This concerns the anti-allergenic effect. Since the electrode cell of the electrochemical reactor is powered from a single power source, and the electrodes have identical active surface areas, the correction of liquid parameters in two opposite directions proceeds proportionally. As a result, the acidic stream and the alkaline stream do not cause any allergic reactions when used simultaneously. This phenomenon fundamentally changes the consumer properties of the system, not only for augmented-reality glasses but also for any other optical devices. As in any system for dynamic electrochemical treatment of liquids-especially liquids with a low level of electrical conductivity-the design of the electrode cell becomes critically important. All structural features of the cell must be considered: the materials used for electrode fabrication, the materials and design of the neutral membrane, and the materials and design of the cell housing. It was found that a particularly high efficiency potential is associated with the use of electrodes made of carbon–carbon composite materials (the phenomenon associated with these materials will be described in subsequent publications).

Figure 4. *Model of the electrode cell of the electrochemical reactor. Photograph of the system for real-time correction of acidity and alkalinity in deionized water*



Photographs of the actual prototype system demonstrate the intentionally designed structural simplicity and, as a result, the low cost combined with sufficiently convenient operation. Such a system can be installed and operated in virtually any retail facility without significant expenses, and through the products generated by this system, it becomes possible to raise the level of servicing such devices to the standard of technological refinement required for all current and future optical instruments. To present the broader situation within the technological field-which, in addition to traditional optical technologies and materials, includes a wide range of processes, technological groups, and materials-the author intends to provide, in subsequent publications, an analysis of the overall state of innovation development in this area. The search for an open and unoccupied niche within this technological field continues with exceptional intensity. However, the actual degree of this intensity remains unclear, as the level of patent protection for these solutions does not correspond to the publicly stated degree of development of these projects, nor to the declared breadth of efforts aimed at identifying new technical solutions.

References

Appendix 1. Johnson, L. E., et al. *Smart Glasses Having Interfering Light Filtering*. United States Patent Application US 2018/0031836 A1, February 1, 2018.

Appendix 2. Kawamura, T. *Head Mounted Apparatus and Gripping Apparatus*. United States Patent Application US 2017/0307787 A1, October 26, 2017.

Appendix 3. Kuehne, M., et al. *Method for Operating Virtual Reality Glasses and Systems with Virtual Reality Glasses*. United States Patent Application US 2015/0378155 A1, December 31, 2015.

Appendix 4. Joo, G.-h. *Wearable Glasses and Method of Providing Content Using the Same*. United States Patent Application US 2016/0034042 A1, February 4, 2016.

Appendix 5. Park, J., et al. *Glasses-Type Mobile Terminal and Method of Operating the Same*. United States Patent Application US 2018/0005421 A1, January 4, 2018.

Appendix 6. Sevostianov, P. V. *Method and System for Displaying Three-Dimensional Objects*. United States Patent Application US 2017/0366805 A1, December 21, 2017.

Appendix 7. Liao, C. *Wearable Smart Glasses*. United States Patent Application US 2017/0371164 A1, December 28, 2017.

Appendix 8. Park, S. W. *Wearable Glasses, Control Method Thereof, and Vehicle Control System*. United States Patent Application US 2016/0173865 A1, June 16, 2016.

Technical Report. TEI Company. *Technical Report – Water Aeration: Increasing the Oxygen Concentration in Water*. Test installation conducted at the Dor Chemicals maintenance site, including a 1000-liter tank system with two FAD devices, a circulation pump, and compressed air supply (7–8 bar). Experimental results demonstrated an increase of water saturation level from 40% to 96% after 10–15 minutes of operation.

Technical Report. TEI Company. *Technical Report - Water Aeration: Increasing the Oxygen Concentration in Water*. Test installation conducted at the Dor Chemicals maintenance site, including a 1000-liter tank system with two FAD devices, a circulation pump, and compressed air supply (7-8 bar). Experimental results demonstrated an increase of water saturation level from 40% to 96% after 10–15 minutes of operation

submitted 09.11.2025;
accepted for publication 23.11.2025;
published 30.12.2025

Contact: sedova.alina7810@gmail.com