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Outdoor Regenerative Water Purification and Drinking Water Station Based on Semiconductor Condensation Technology

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Abstract:
In some exhibition sites and outdoor sports venues, there is still a lack of public drinking water resources and hand washing facilities., This topic in view of the existing problems put forward a new scheme, and designed a based on semiconductor condensation technology of outdoor regeneration net drink integration intelligent water station, photovoltaic energy storage technology and air water, realize the self-sufficiency of energy and water, and break the equipment in the regional limitations, make it to meet the needs of people hand clean and healthy drinking water, solve the problem of lack of clean water in specific places. In addition, the device integrates the neural network deep learning algorithm to predict the water consumption, and provides emergency charging and advertising and other functions, which has good social benefits and market prospects.

Keywords: Air water；outdoor water source；photovoltaic energy storage；advertising；neural network

1. Project background and significance

At present, there is still the problem of a lack of outdoor public drinking water resources and hand-washing facilities at the sites of some large-scale gatherings or exhibitions, outdoor sports venues and other places. In addition, in daily life, outdoor sports venues such as school football fields, basketball courts, etc. often also exist in the washroom is far away from the sports area, the end of the exercise can not be timely cleaning problem, and even in the hot summer, due to strenuous exercise led to heatstroke, the crowd may not be able to quickly obtain water nearby lead to the symptom continues to deteriorate. Based on such problems, this project combines professional technology to design a new type of outdoor movable intelligent water station powered by photovoltaic energy storage, able to take water from the air anytime, anywhere, and used for outdoor drinking water and hand washing after high-voltage electrostatic field sterilisation, quadruple filtration and heating. Outdoor water station is not subject to environmental restrictions, non-toxic and harmless, and does not require other disinfection resources to add, to achieve self-sufficiency in resources. The 24-inch screen can be extended through offline outdoor advertising with the help of unique media in different scenes to increase the value of the equipment itself, which has a lot of market and economic growth space.

Figure 1: Outdoor net mobile phone physical display

2. Design scheme

Feasibility analysis

Water vapor condition: usually, the outdoor air humidity is between 30% and 90%. Within the condition range, when the temperature is 30℃, the air of 1m3 contains 30.38g water at most, and the relative humidity is 100%. Whether in the conventional living conditions, or in the relatively bad conditions, the outdoor air has the water vapor conditions to extract water.

Liquefaction conditions: similar to fog or rainfall in nature, the liquefaction of water vapor in the air can be achieved by cooling. This work adopts semiconductor refrigeration technology, using the Peltier effect of semiconductor materials to produce temperature difference to form "hot and cold end", which provides conditions for water vapor liquefaction.

Power supply conditions: the power supply voltage of the refrigeration semiconductor is generally below 12V, and the conventional solar photovoltaic panels can meet the power supply demand. Gas turbine and cooling fans are powered by low-voltage power supply. Photovoltaic power generation and energy storage technology can guarantee the energy supply of the overall system.

Drinking conditions: the air of the water making equipment should be filtered through three layers of air filtration of coarse filter, HEPA cotton and efficient modified molecular sieve. The water formed by filtered air compression and condensation, and then purified by the 4-level filtration water based on RO film, and the drinking water quality produced can reach the national first-level drinking water standard.

Block diagram of the system structure

This system with photovoltaic power generation and energy storage technology, the semiconductor condensate water, and high pressure static field Sanitize, after filtration and high temperature treatment, provide users with direct water and hand cleaning services, and with Shared charging and advertising function, a complete set of equipment through the cloud remote monitoring, ensure the system efficient efficiently. The system structure block diagram is as follows:

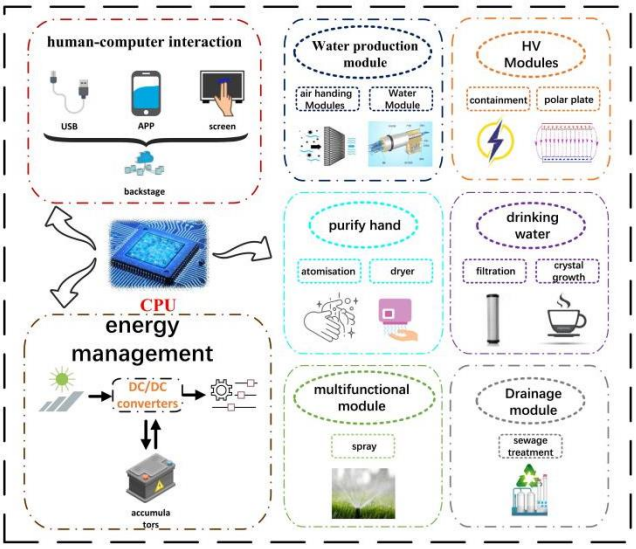


Figure 2: System Architecture Block Diagram

Model design and principle

Equipment peripherals. The hand washing drying table and wash basin in this work are designed based on ergonomic principles. The final height of the table is 75cm, and the height of the drinking water receiving table is 95cm. There is a 24-inch touch screen embedded on this. In addition to showing the operation guidance of the device, public welfare or commercial advertisements can also be placed. The front infrared detection function of the device can open the screen on the device and automatically enter the dormant state after not receiving the signal for a long time to reduce energy consumption. On the left side of the screen is a USB shared charging interface and mobile phone storage box, which expands the content of human-computer interaction.

Internal module composition. Considering the environmental factors of the equipment, the team designed the battery, communication module,high voltage power supply and all levels of circuits on the top layer of the equipment and conducts moisture-proof treatment. The middle layer is the semiconductor condensing water device, ultrafiltration water purification device, drinking water heating and storage device. Through the optimization of structure, the intake of air water is effectively increased. The lower layer is mainly water disinfection storage box, sewage disinfection storage box and net hand water storage box. The high voltage static field is used to Sanitize the water tank to ensure the water quality, reduce the product center of gravity and facilitate the sewage collection and discharge.

Figure 3: Design drawing of washing mobile phone model

3. Working principle

a. Condensing water unit

Semiconductor refrigeration technology uses semiconductor Peltier effect: direct current through the formation of thermocouple pair, the two ends of the electric couple heat transfer, produce temperature difference to form cold and cold ends, to achieve the purpose of refrigeration, to provide liquefaction conditions for water vapor.The upper and lower sides of the water making unit are provided with air inlet and outlet respectively, and said air inlet and outlet are provided with suction and extractor to improve the efficiency of condensation water making. The air filter is located on one side of the suction machine. Air through the suction machine through the HEPA cotton based three-stage filter, can filter out most of the harmful particles in the air. Condensation water unit through the control centre regulates the fan and semiconductor condenser work, control the operation of the whole set of water unit, has the advantages of integration, intelligence, energy saving and practicality.

b.High-voltage static electricity field Sanitize the water purification unit

The high voltage static field generator is driven by the inverter circuit and controlled by PID closed-loop to achieve stable and adjustable DC high voltage output up to 3kV. The high voltage electrostatic water treatment device consists of stainless steel plate Yin and anode, and the coat has teFE plate to ensure good insulation. The high voltage DC power supply between the Yin and Yang poles produces high voltage electrostatic field. Under the action of electrostatic field, the excitation or ionization of superoxide anion free radicals in water can destroy the biological structure of bacteria, leading to cell death and play a bactericidal role.

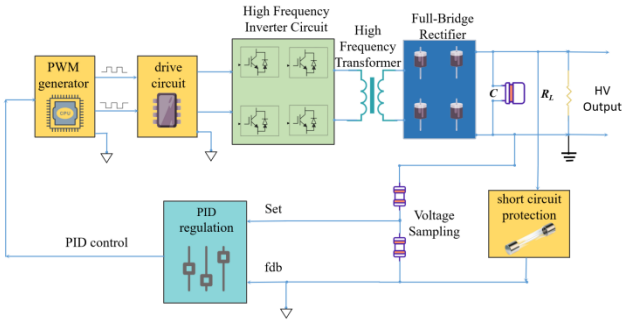
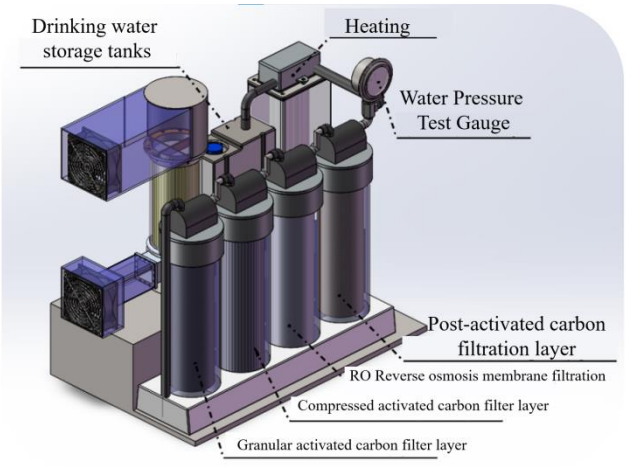


Figure 4: High voltage generator circuit topology

c. Ultra filter water purification unit

The ultrafiltration water purification device adopts four-level precision filtration to purify the water after sterilization. After granular activated carbon, compressed activated carbon, RO reverse osmosis membrane, rear activated carbon four-level filtration, can effectively filter the parasites, bacteria, sediment, heavy metals and other harmful substances killed in the water. Efficient sterilization, water purification, improve the taste. After the elimination of the high-pressure static electricity field, it fully meets the drinking water standards. At the same time, equipped with a voltage test table, real-time monitoring of voltage, safe and reliable.



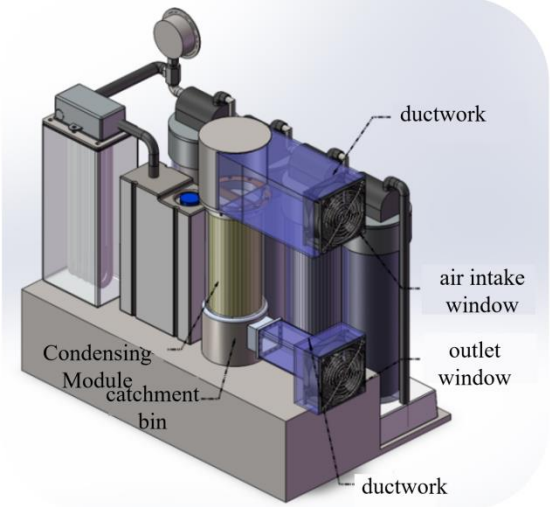


Figure 5: Ultra-filtration water purification unit (top) condensed water production unit (bottom) structure

4. Theoretical design and calculation

Energy storage management

The power of the single crystal photovoltaic panels used in this system can reach 300W, the power generation efficiency reaches 23%, and the power generation in sunny days can reach 1.5kW·h, which can fully meet the power supply demand of each module and realize self-sufficiency. The specific calculation data of each power consumption module are as follows:

Table 1: Estimated power consumption statistics for each module

power consumption module	*Power consumption (W)*	*Usage time (h)*	*Power consumption (kW·h)*
Hand washing and	250	0.2	0.05
High-pressure	50	8	0.40
Semiconductor	110	5	0.55
Circuits at all levels	10	24	0.24
Drinking water	2000	0.03	0.06
Total power consumption	--	--	1.30

Calculation of water production quantity

When the room temperature is controlled at 20℃, the water content in saturated air per unit volume is A=17.3, and the air humidity is fixed at 67%, and different inlet air flow rates are recorded separately as follows:

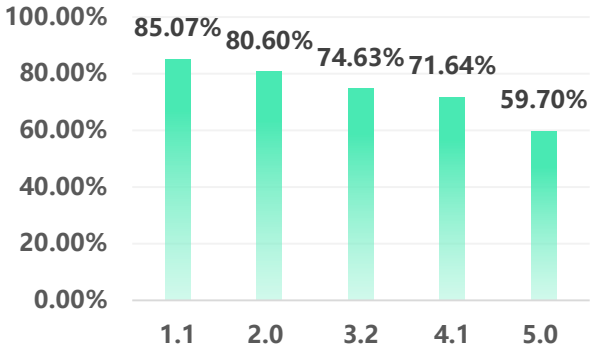


Figure 6: Plot of air flow rate versus moisture absorption rate

It can be seen that when the flow rate is slow, the hygroscopic rate is higher, but the total amount of fluid flowing through per unit time is small. When the flow rate is large, the moisture absorption rate is low, and the total amount of air flowing through the corresponding unit of time is large. The total amount of water vapor liquefaction can be expressed as the product of the total amount of flowing air and the amount of moisture absorption per unit volume:

$$\boldsymbol{Total\ condensate = Svt \cdot A \cdot \delta \cdot 67\%} \quad \textbf{(4-1)}$$

cross-sectional area of the ventilation opening;air flow rate; water content per unit volume of saturated air;moisture absorption rate

The cooling capacity Qc and the power consumption W of a semiconductor cooling chip can be calculated using the following equations :

$$\mathbf{Q_c = (a_p = a_N)IT_c + k(T_c - T_B) - \frac{1}{2}I^2R} \quad \textbf{(4-2)}$$

$$W = I^2R + (\alpha_P - \alpha_N)(T_n - T_c) \quad \textbf{(4-3)}$$

This scheme estimates that the air liquefaction efficiency can be relatively large when the flow rate is at 5 m/s. According to the test moisture absorption rate, the estimate given by this section can be calculated: the vent cross-sectional area of the device is 100, can in 67% air relative humidity, optimal temperature 20℃, work 5 hours a day water about 6L, considering the error loss caused by temperature and air humidity, the actual 5.2L is expected to produce 5 hours a day.

5. Performance test and analysis

Average daily supply-neural network prediction model

According to the data set collected by the intelligent water station, the data set is divided into training set, verification set and test set according to 65%, 15% and 20%. BP neural network is used to learn and train the model. Finally, BP neural network based on machine learning and GM (1,1) water demand prediction model suitable for small sample data sets are constructed.

$$\text{Accuracy} = \frac{TP+TN}{TP+FN+FP+FN} \quad (5\text{-}1)$$

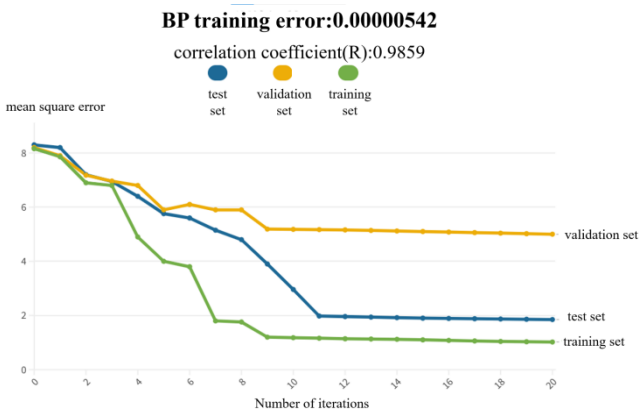


Figure 7: BP neural network model learning training graph

The trained BP neural network is used to predict the water demand of the simulated and actual water demand is 0.16%~1.15%, and the average relative error is 0.46%. The simulation accuracy is high, and the prediction

results have high confidence. Wash hands with atomization water, water pump provides 4kg pressure and water spray flow is 0.10 l / min. According to the frequency of 60 people washing hands every day, the average of each person washing hands for 20s, a total of 2L of water consumption, can accept a large flow of water. About 3.2L of remaining water can be drunk by passers-by every day. Through data pooling, each person drinks about 150ml of water at each time, and about 20 people can drink water every day. The water data is considerable.

High-voltage sterilization

Under normal temperature conditions, the water body was subjected to 8h high voltage static field treatment, adjusted the operating voltage, and detected the survival rate of bacteria in the water under different high voltage static field strengths. The experimental results are obtained as follows:

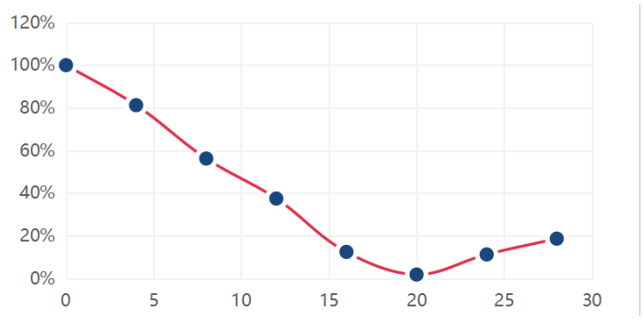


Figure 8: Sterilisation effect of high voltage electrostatic field

The high voltage static field generator of the system can stably output 3kV voltage, the two plate interval is 0.15m, forming a high voltage of about 20kV / m static field, and the water sterilization rate can reach more than 95%

Cloud remote monitoring

The air temperature and humidity of the equipment environment, the water storage and high voltage output of the equipment are transmitted to the Internet cloud platform through the 5G module, and the dynamic data of each equipment is captured through the Internet platform to realize real-time monitoring of the system and provide data guarantee for the safe operation of the equipment. In addition, the platform can also compare and calculate the fault according to the comparison of the water quantity and water consumption of the monitoring machine at the interface of the water management platform. It can also make overall calculation of the devices within a certain range, constantly trial and error, adjust the water production, and adjust the position of the large data of human detection flow.

Figure 9: Smart Water Platform Management Interface

Figure 10: Operations Service Management Interface

6. Economic benefit analysis

Cost analysis

Based on the design concept of low cost and high return, the all-in-one machine is itself by generating 36 degrees per month and about 66 liters per month, without other consumable energy inputs; the equipment is unattended, without personnel maintenance cost. The device only needs the initial investment of RMB 3200 per equipment cost, and can obtain a monthly profit of about RMB 800 yuan through advertising revenue. It is expected that the product will enter the pure profit stage in four months, and can obtain a huge market share and profit space.

Table 2: Product Economic Benefit Outlook

Economic analysis parameters	Analyse data
Equipment production costs	3200RMB/unit
Advertising budget revenue	800RMB/Mont
Air water intake	66 L/month
Solar power generation	36

Advertising market analysis

Outdoor advertising online traffic growth of the Internet in the second half of the value highlighted. The compound annual growth rate of outdoor advertising market scale was 18.2%, and the scale reached 45.61 billion yuan. Therefore, the value of outdoor advertising communication has not been exhausted under the transformation of The Times and demand, but enduring.

7. Innovation significance and application prospect

Innovative significance

Photovoltaic power generation and energy storage technology are combined with high voltage electrostatic field elimination to ensure the stability of power supply of the system and achieve high-efficiency intelligent elimination.

Compared with refrigerants such as Freon-12, the semiconductor condensing water technology is simple to operate, safe and reliable, and the water intake meets the daily water demand. There is no need to add water resources after the device is put into use.

High voltage electrostatic field stimulates or ionizes superoxide anion free radicals, destroying the biological structure of bacteria and kills cells. This method has the advantages of significant sterilization and algae control, wide range of water quality and low operation cost.

Provide free USB service, with a 24-inch large screen in the equipment, which can provide public service advertisements, commercial propaganda videos, etc., to open a new way of advertising investment, and improve the sense of service while bringing long-term economic benefits.

The system can remotely monitor the parameters of the whole device through the cloud, or it can remotely observe the changes of relevant indicators under the device in real time through the cloud monitoring interface, and obtain the fault information of the device in the first time for timely maintenance.

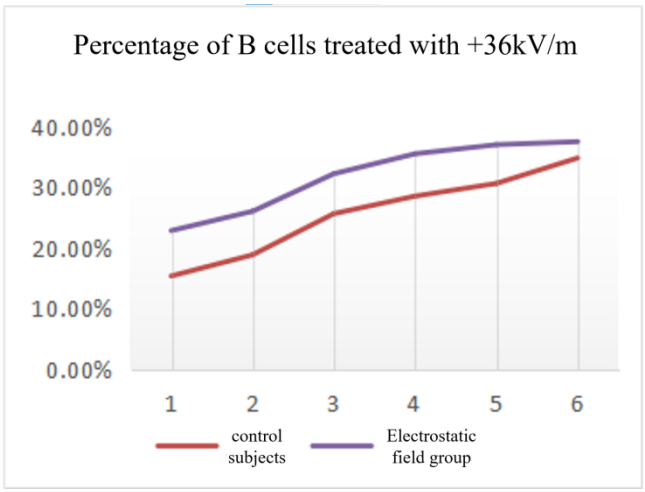


Figure 11: Comparison of B cells after electrostatic field treatment

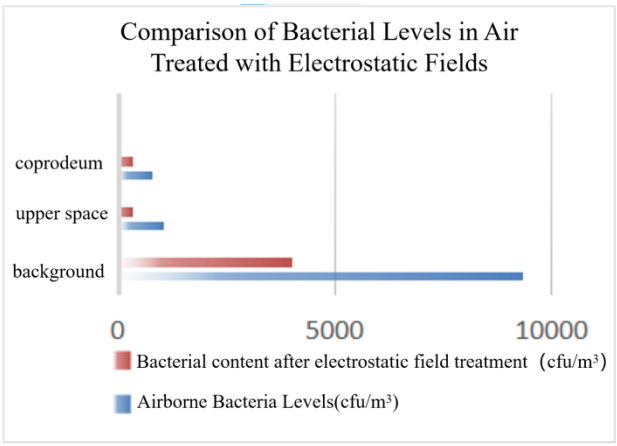


Figure 12: Comparison of airborne bacteria levels after electrostatic field treatment

Application prospect

The effective combination of semiconductor condensing water technology and photovoltaic and energy storage technology provides a new idea for the sustainable utilization of resources. The whole system of outdoor clean mobile phone only needs a one-time investment of resources, and the water and electricity resources are self-sufficient. On the one hand, while ensuring the health of water resources and water quality, it can greatly reduce energy consumption and economic input. On the other hand, the outdoor hand washing device can effectively prevent the infection of many diseases. It can be put in stadiums, large gatherings, playgrounds and other outdoor places to provide including but not limited to clean drinking water, hand cleaning, emergency charging and other services for people in this area, which has a wide range of application scenarios.

Figure 13: Outdoor net mobile phone application scenario diagram

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