Electronic Supplementary Material (ESI) for Energy & Environmental Science.

Supporting Information

Contents

S1. Supporting Notes

S1.1. The specification of the S-PAM hydrogels at the cold side

The first one (marked as SP_1) consists of 3 hydrogels (length: 4 cm, width: 0.5 cm, and height: 2 cm) with 1.25 cm spacing between each other. The second (marked as SP_2) is made up of 4 hydrogels (length: 4 cm, width: 0.5 cm, and height: 0.5 cm) with ~0.67 cm spacing between each other. The third (marked as SP_3) consists of 9 hydrogels (length: 0.5 cm, width: 0.5 cm, and height: 4 cm) with 1.25 cm spacing between each other.

S1.2. Measurements of vapor and electricity generations

A hollow support was designed and made to evaluate the performance of evaporation and electricity. The co-generator was placed on the support and irradiated by the solar simulator (Solar-500, NBet, AM 1.5 G, China). The mass changes of the co-generator were reflected on an electronic balance (ATX 224, SHIMADZU Co., Japan, accuracy: 0.0001 g) and real-timely recorded by a personal computer connected with the balance. The electricity produced by co-generator was traced by a nanovoltmeter and recorded by personal computer connected with it (As shown in Figure S13).

Evaporation voltage measurement: After the co-generator was illuminated by the simulative sunlight (without spray), the voltage would gradually approach to a certain value, which is recorded as the “Evaporation voltage”.

Spraying voltage measurement: During spraying the voltage of the hybrid model was raised to steady state, and then reverted when spray turned off. Then the process was repeated and cycled. All steady voltage values were recorded and averaged excepting a maximum and a minimum to get “Spraying voltage”.

S1.3. Simulated sunlight purifying water

The evaporation test was implemented at an independent room. Before experiment, the air conditioning and dehumidifier in closed room are put on for 6 hours to stabilize test environment. The temperature and humidity in room were remained at 28 ^{o}C and 55% ± 3%, respectively. In the desalination experiment, the hydrogel is previously soaked into 10 wt% NaCl solution for 5 hours to substitute inherent DI water to accurately evaluate evaporation and electricity performance of salt water.

S1.4. The establishment of automatic spraying device

A solenoid valve was used to block the water tap. The spraying time and interval could be controlled by STM32F103 programed. The spraying rate could be adjusted by the knob on the shower head.

S1.5. Modeling for temperature distribution and output voltage

We modeled 3D geometric model with 1:1 size to the real hybrid cogenerator using COMSOL Multiphysics software. Modeling is done on a thermoelectric module with 128-np-pair TE legs and different hydrogel arrays at the cold side. The input parameters of the model are the same as those of the real experimental system, including the size, spacing, substrate, copper layer, and packaging materials.

S2. Supporting Figures

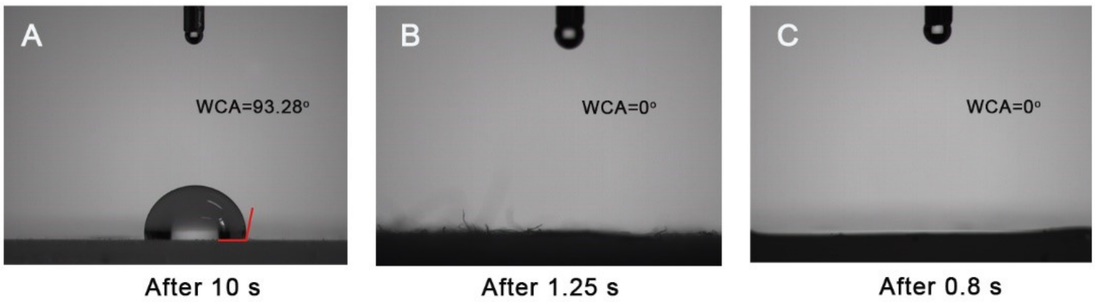

Figure S1. The water contact angle of different materials.
(A) The water contact angle of alumina after 10 s.
(B) The water contact angle of air-laid paper after 1.25 s.
(C) The water contact angle of starch-polyacrylamide hydrogel after 0.8 s.

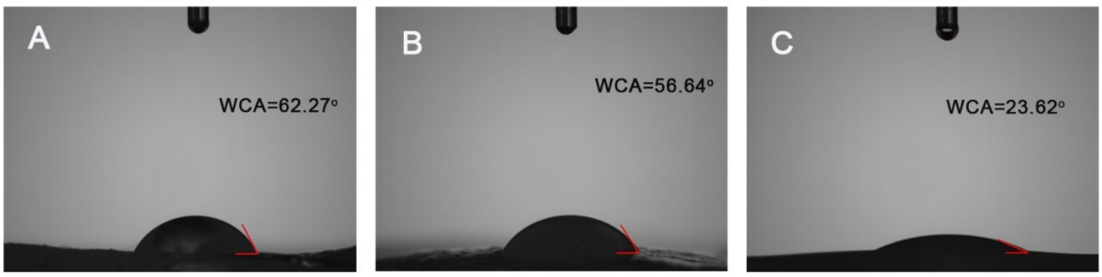

Figure S2. The water contact angles of different hydrogels after 0.8 s (A) polyvinyl alcohol, (B) gelatin, and (C) polyacrylic acid.

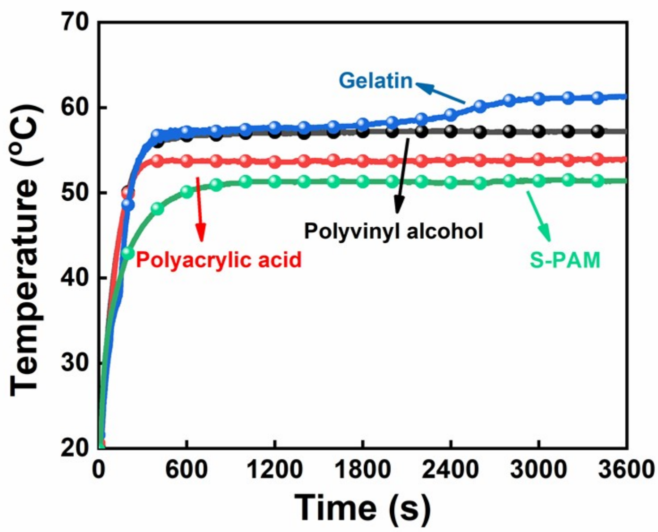

Figure S3. The cooling effect of different hydrogels.

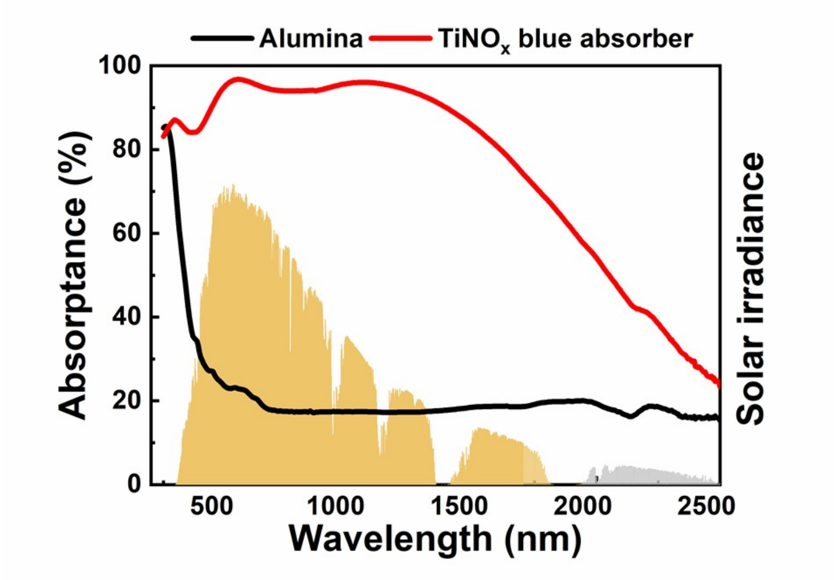

Figure S4. The absorptance of pristine thermoelectricity module (Alumina) and $TiNO_x$ blue absorbing membrane.

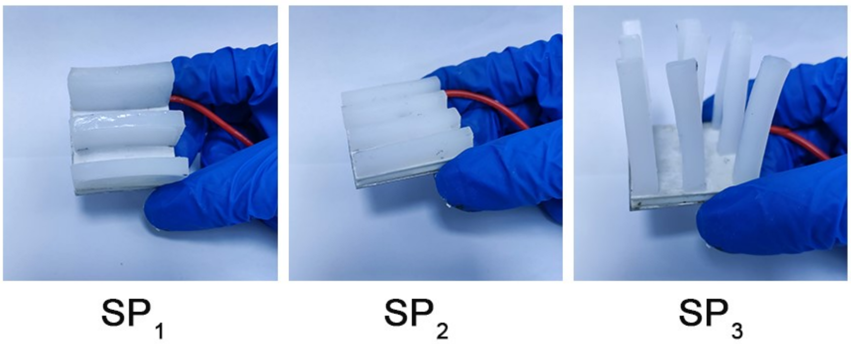

Figure S5. The optical photographs of different hybrid models based on various geometry arrays of S-PAM hydrogels at the cold side of TEG.

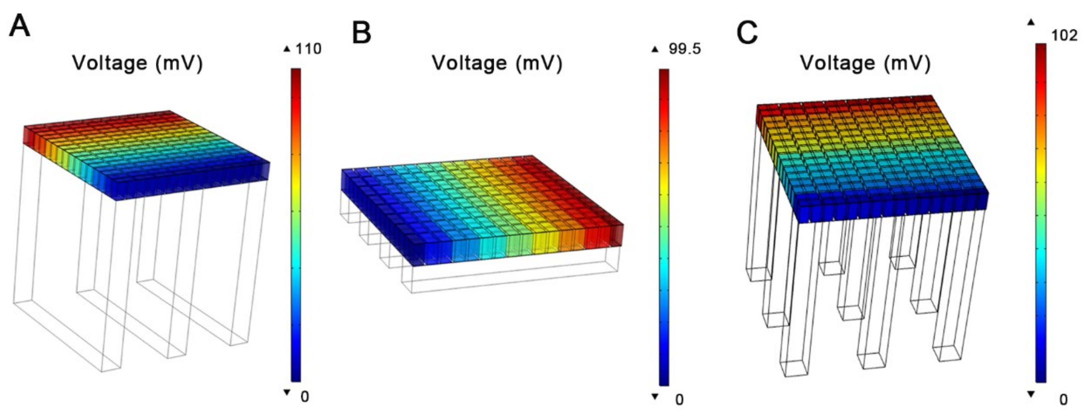

Figure S6. The evaporation voltage simulation of different types co-generators. (A) SP_1-type and (B) SP_2-type (C) SP_3-type.

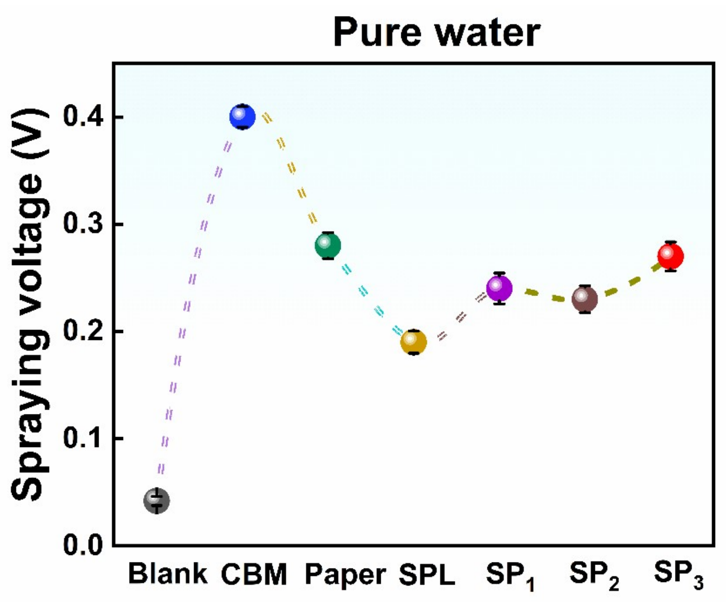

Figure S7. The spraying voltage of different co-generators for pure water of 18 °C.

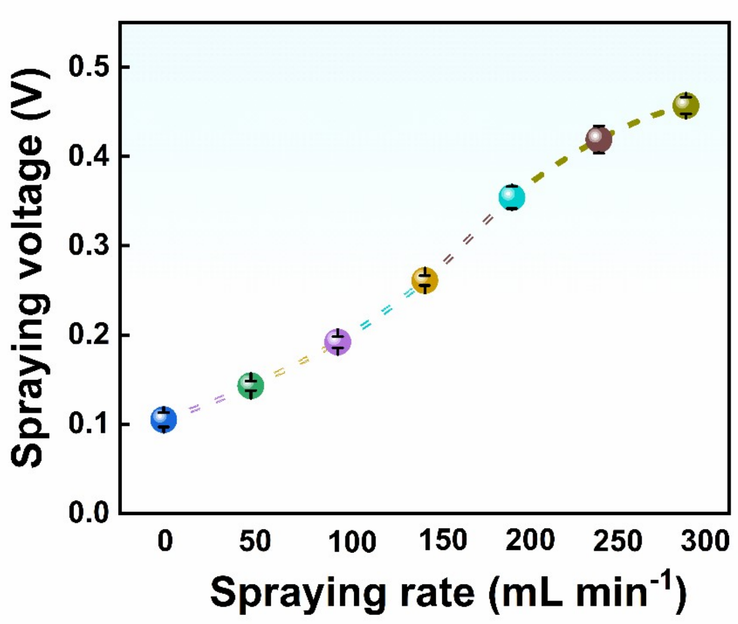

Figure S8. The spraying voltages of SP_3 hybrid model at different spraying rates.

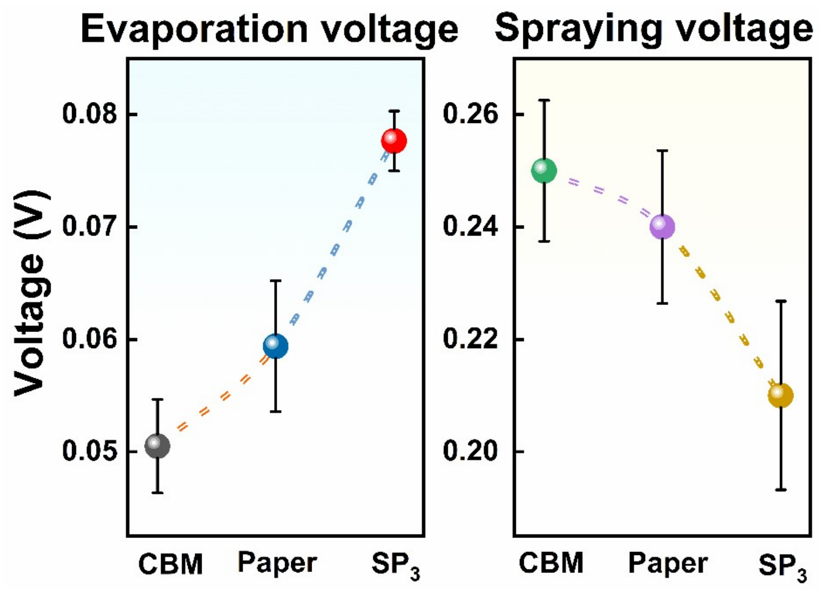

Figure S9. The evaporation voltages and spraying voltages for different types co-generators with 100 Ω loaded.

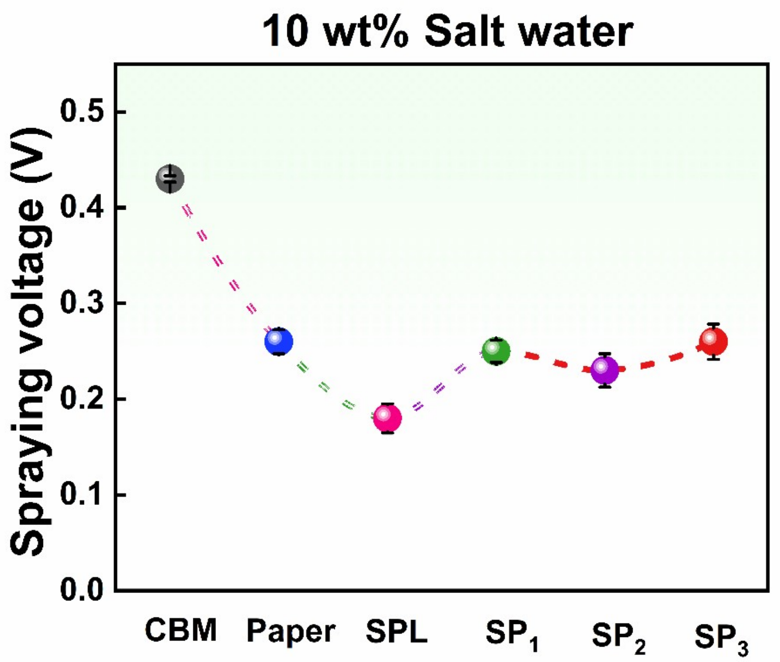

Figure S10. The spraying voltages of different co-generators for 10 wt% salt water of 18 ºC.

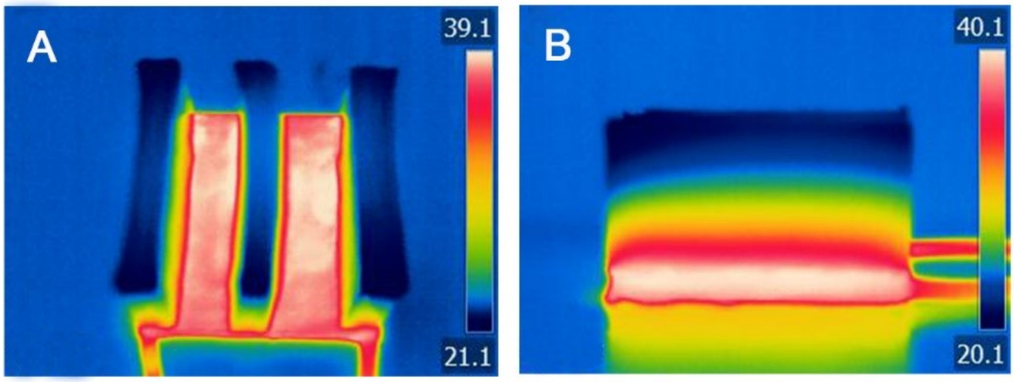

Figure S11. The bottom and side temperatures of SP_1-type co-generator under 1 kW m^{-2} illumination.

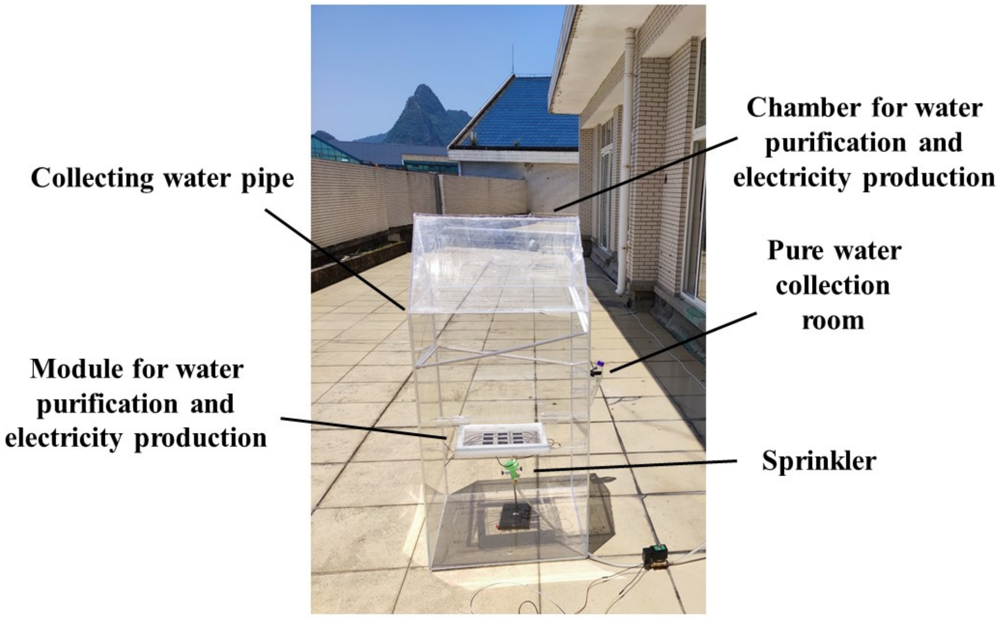

Figure S12. The digital photo of real self-configured setup.

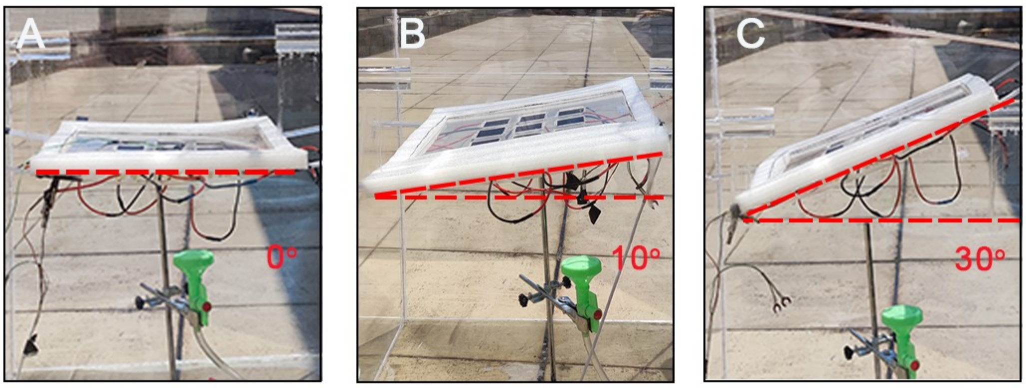

Figure S13. The digital photo of angle demodulator (A) 0^o (B) 10^o (C) 30^o in real home-made setup.

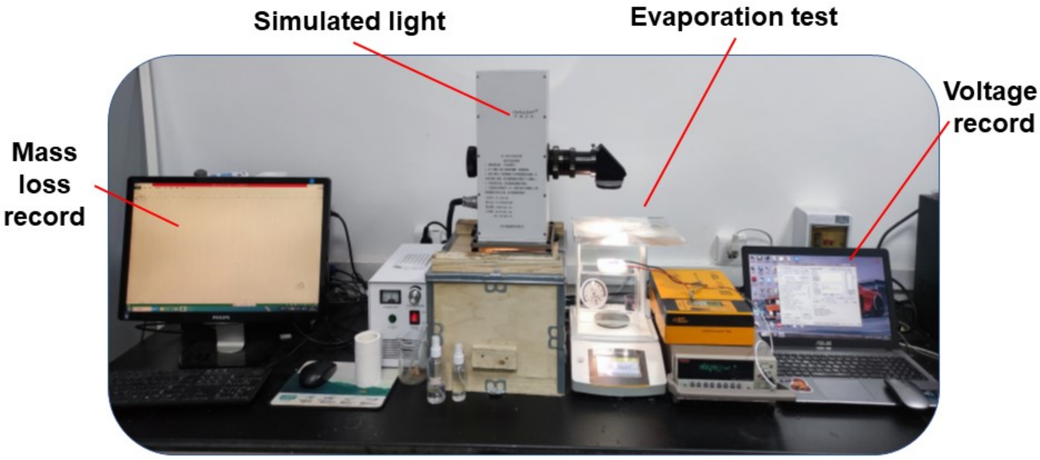

Figure S14. The digital photo of water-electricity co-generator indoors.

S3. Supporting Tables

Table S1. The relationship between exposed cold side area and spraying voltage facing spray water of 18 °C.

Different hybrid cogenerators	Exposed area (cm^2)	Spraying voltage (V)
SPL	0	0.19
SP_1	10	0.24
SP_2	8	0.23
SP_3	13.75	0.27