Extracting Water and Energy from the Air: A Quantitative Study

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Introduction

Condensation is a method of extracting water from the air which involves pressure or temperature changes to the air which causes water vapor to stick to a surface. As the temperature and/or pressure of the air increases, the likelihood that water will condense on a surface increases. This physical phenomena can be exploited by developing a system which either increases the temperature or pressure of the air. In this case, a box with a transparent roof that will allow the sun to heat the inside (Fig. 1). A lot of charge is contained within this water, and this project aims to tap into that (Fig. 2).

	Temperature	26.7	°C
	Absolute Humidity (Saturated)	22.2223	g/kg
Assume:			
	Relative Humidity	60	%
	Absolute Humidity (Actual)	13.33338	g/kg
	Density of Air	1.225	kg/m³
	Approximate Volume	2160	ft³
		61.16	m³
	Amount of Air	74.93	kg
	Amount of Water	999.022	g
	Molar Mass of Water	18.02	g/mol
	Moles of Water	55.4	mol
	Moles of Hydrogen	37.0	mol
	Moles of Electrons	37.0	mol
	Coulombs	3566060.4	C
	Total Current:	0.48	A
	Could Power for:	7429292.6	s
		2.83	Months

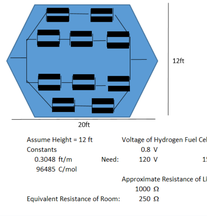


Figure 2 – Calculation to see how long you can power lights of average room with condensation

Project Goal

The main goal of the study is to design, prototype, and test an effective water collection system that will condense humidity in the atmosphere and convert it into liquid water. This has dual benefits. The stored water can be used for drinking or other purposes especially in water-poor regions or in developing countries. Another potential benefit which will be tested and quantified is that the stored water could be turned into electricity in combination with a fuel cell, therefore using all or part of the collected water to generate electricity (Fig. 3).

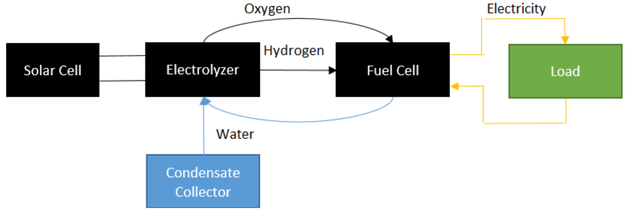


Figure 3 – System for collecting condensation and converting that water into electricity.

Results

A prototype condensate collector was successfully built and tested under many different conditions to provoke condensation. This prototype was engineered to ensure efficient air circulation and plentiful sun exposure to the inside (Fig. 1). As of yet, it has been determined that over an 8 hour period during the course of the night, this prototype can collect 2.8 g/ft^2 of water. Figure 4 shows the prototype at night after it has collected some condensation. The hydrogen in this water contains a little over 3 times the amount of charge held in an iPhone 6 battery (Fig. 5). After experimenting with the fuel cell to figure out properties such as its hydrogen production rate and output current, it was calculated that using this water could power a 60W light bulb for about 2hrs using the water collected. These calculations are shown in Figure 6.

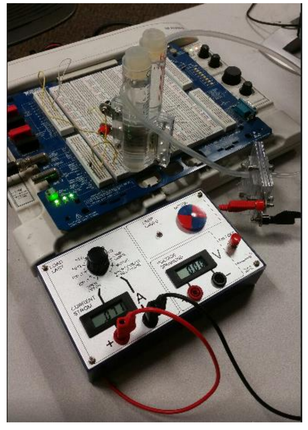


Figure 3 – Lab set up to test out the hydrogen fuel cell and electrolyzer.

Figure 1 – Prototype condensate collector

Figure 4 – Prototype condensate collector with condensation

Amount of Water	5.976	g
Molar Mass of Water	18.02	g/mol
Moles of Water	0.33	mol
Moles of Hydrogen	0.22	mol
Moles of Electrons	0.22	mol
Coulombs	21331.64	C
Number of Times more Charge:	3.27	

Mass of Cup	4.954	g
Mass of Cup + Water	10.93	g

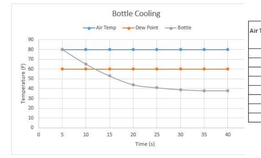
Battery in iPhone 6	
1810	mAh
1.81	Ah
6516	As
6516	C

Figure 5 – This is data of water collected by the condensate collector after 8 hours overnight. The calculation shows the total amount of charge stored in the hydrogen from that water.

Conclusions

This prototype was successful in its purpose of a proof of concept. If this were to be commercialized, it would need to be much bigger and made out of different material. More surface area means more condensation, and more insulating materials would mean even higher temperatures and therefore more likelihood of condensation.

Air Temperature (°F)	Dew Point (°F)	Bottle Temperature (°F)	Time (s)
80	60	80	5
80	60	65	10
80	60	53	15
80	60	44	20
80	60	41	25
80	60	39	30
80	60	38	35
80	60	38	40



Air Temperature (°F)	Dew Point (°F)	Bottle Temperature (°F)	Time (s)
80	60	80	5
95	75	80	10
107	87	80	15
116	96	80	20
120	100	80	25
122	102	80	30
123	103	80	35
123	103	80	40

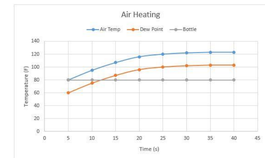


Figure 8 – Graphs which show the basis of the design of the prototype.

Future Work

Further studying of the prototype is necessary to come up with an optimal system for the collection of condensation. Future tests could include:

- Use of an adsorbent material to trap more water,
- Using stones or concrete as a source of heat for the night
- Finding an easily reversible endothermic reaction to continuously cool down the acrylic panels
- More frequent water collection to find the maximum amount of condensation this prototype can collect

Oxygen production Rate:	1	mL/hr
Hydrogen Production Rate:	2	mL/hr

Would run for:			2669.9	hours
			9611719.0	seconds
			111.24675	
R	10	ohms		
I	72	mA		
P	0.05184	W		

System delivers:	498271.5	J

Can power 60W light bulb for ~2hrs

5.976	g	Water collected
18.01528	g/mol	molar mass of water
0.331718	mol	water
0.221146	mol	hydrogen
24.14628	L/mol	
5.34	L	hydrogen
5339.8	mL	hydrogen

V/n = RT/P		
R	0.082057	L atm/(mol K)
T	294.261	K
P	1	atm
V/n	24.14628	L/mol

Figure 6 – Calculations and data based on the output of the hydrogen fuel cell. With the water collected, we could power a 60W light bulb for about 2 hours.