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Executive Summary

Water is the most fundamental necessity for our survival, yet we still do not have water security across the globe. Therefore, we need to find a solution that can provide water anywhere in the world with convenience.

Water that exists in the air as water vapor is rarely used as a source to provide clean water. Machines that generate water from the air, which are known as atmospheric water generators, already exist in the market, but as larger units. Thus, we are proposing, *The Bottle*, an atmospheric water generator that is sized down to the typical water bottle size and runs on energy collected by a solar panel, as our solution to this problem.

Our current target market is backpackers who travel to places that do not have reliable access to a source of water. As soon as production prices decrease, we can make this bottle more accessible for everyone and help those with water insecurity.

All current atmospheric water generators are built to be large scale, immobile products. Our product will be portable and much smaller, but we use these as a reference for price points and distribution because there are no existing smaller scale air to water generators. Since our product is unique compared to existing products, we will not be competing with them directly since we will have a separate target audience. We will sell *The Bottle* on our own website and at Home Depot for a retail chain.

To use *The Bottle*, customers have to turn on the solar panel and put it in sunlight to start generating power. The cap of *The Bottle* also needs to be exposed to air which will create the water. When the user wants to drink water, they can use it like any other water bottle: untwist the cap and drink. They will need to clean and replace the components of the air water generator every 2 months or when needed.

The current market for this bottle is nature enthusiasts, climbers, and hikers, so *The Bottle* will be exposed to very unique and unforgiving environments that it must withstand. We chose materials and will run tests on *The Bottle* based on this fact to ensure its quality and safety.

Overall, *The Bottle* is designed to give access to drinking water anywhere making it the solution to the lack of water security. It generates drinking water by drawing in and condensing water vapor in the air, while being portable, convenient, and uses a renewable source of energy.

Problem and Inspiration

Water is the most fundamental necessity for our survival, yet we still do not have water security across the globe. Access to clean drinking water has been a problem and will be a problem for the next few decades. Over 1.1 billion people do not have access to fresh water and 2.4 billion people lack access to clean, uncontaminated water. Contaminated water causes cholera, typhoid fever, and many illnesses that kill millions of (mostly children) every year (Water Scarcity).

Water that exists in the air as water vapor is rarely used as a source to provide clean water. Machines that generate water from the air, which are known as atmospheric water generators, already exist in the market as larger units. They are not easily accessible by the general public and are not easy to use anywhere because of their size and requirements to operate. Therefore, we need to find a solution that can provide water anywhere in the world with convenience.

Solution

The Bottle is our solution. It is an atmospheric water generator that is sized to the typical water bottle size (Hydro Flask) and runs on energy collected by a solar panel. There will be air and water filters to turn the water created from water vapor into safe drinking water anywhere you are.

MARKET RESEARCH

Customers

Our current target market is backpackers who travel to places that do not have reliable access to a source of water. Backpackers travel over long periods of time with all their gear on their back, so they can only pack what they can carry (Outdoorsy, n.d.). Because it is not efficient and sometimes impossible to carry all the water needed for the entire trip that can last weeks or even months, they need to plan their trip around sources of water, which limits the places they can travel to.

This portable atmospheric water generator will open up possibilities of backpacking destinations that are currently impossible due to the limitations of water. With *The Bottle*, they will not need to worry about finding water and they can put full focus into enjoying their trip.

Backpackers want their gear to be as lightweight and small as possible because it allows them to have room to pack even more gear to make their trip easier and safer (BackpackersPantry, 2019). They want their gear to be durable because it would go through a lot of wear and if it were to break during a trip, it would be dangerous since they are relying on its use. The gear would have to be put inside or attached onto the backpack in some way to keep their hands free for balance

or navigation. For backpackers, it is recommended they drink 2 liters of water for every hour of hiking so they will carry at least 2 liters of water at a time or none at all and rely only on drinking at the sources (Cage, n.d.). If they do not have access to water, they will not have access to a power outlet, and thus, their gear can not rely on one.

Table 1: Price Range of Backpacking Gear

Gear	**REI**		**Dick's Sporting Goods**	
	low	high	low	high
Backpack	$120	$550	$70	$100
Tent	$120	$1200	$25	$650
Sleeping bag	$80	$930	$50	$80
Hiking shoes	$220	$280	$70	$380
GPS	$300	$600	$100	$600
Total	$840	$3560	$315	$1810

Backpacking is a versatile activity because the amount someone wants to spend is up to them. Therefore, the income range of people who backpacker is wide. Because of the wide distribution of incomes of our customers, we rely on the current market prices of backpacking gear, which is displayed in Table 1, to get a sense of how much people are willing to spend. We found highs and lows of essential gear items (McIntosh-Tolle, n.d.) needed for backpacking on the market and added them up to get an estimated budget range. The range we found goes from as low as $315 to over $3500 which shows we have a wide range of customers because they get to decide for themselves how much they want to spend.

We will have to start with targeting backpackers with higher incomes because of how expensive it costs to make the bottles with the current technology. As soon as production prices decrease, we can make this bottle more accessible for everyone and help those with water insecurity.

Competition

Our idea is to focus on turning this into a product that can be convenient to use and is easily accessible to the general public. Some of the companies that currently sell products that create water from air include Watergen, Akvo, Atmospheric Water Solutions, and Innovaqua Water Solutions. We have outlined the main companies that sell products similar to our product, *The Bottle*, below along with their features, price points, and distribution methods.

All of these products are atmospheric water generators that are built to be large scale, immobile products. Our product will be portable and much smaller, but use these as a reference for price points and distribution because there are no existing smaller scale air to water generators.

Watergen:

Watergen is selling the Genny, Gen-M, Gen-L, Gen-M Erv, and automotive solutions. All five of these products are made for different situations.

The Genny is designed for use in a home or office. This is the only small scale product that Watergen sells, however it is still not small enough to be portable. It needs to stay where it has been installed (Creating Drinking Water from Air).

Table 2: Genny

Product	Features [1]	Price Points [2]	Distribution [1]
Genny 	• 8 gallons of water per day • Can dispense hot and cold water • 176 pounds • Water purification technology based on UV treatment, mineralization and carbon filter • Maintenance required once every six months by user	• Starting at $18,000	• Installation within 2 weeks • Worldwide distributors • The company also sells their products directly from their website.

Sources:

[1]Creating Drinking Water from Air. (n.d.). Retrieved February 7, 2020, from https://us.watergen.com/

[2] Hamilton, A. (2014, April 24). Turn Air Into Water with Water-Gen's Atmospheric Water Generator. Retrieved February 8, 2020, from https://time.com/75612/atmospheric-water- generator-watergen/

The Gen-M model is designed for use in areas without easy access to clean drinking water with large groups of people as well as commercial, municipal, and sports events. This model is significantly larger than the previous model at 1720 pounds, therefore making it stationary. Once this product has been installed, its location most likely will not be changed. However, for

medium to large size groups, this`is useful because of its price and rate of water production. Gen-M has a similar price scale as the Genny, but it produces more water, making it more useful for groups larger than a home or office (Creating Drinking Water from Air).

Table 3: Gen-M

Product	Features [1]	Price Points [2]	Distribution [1]
Gen-M 	• Medium-Scale Atmospheric Water Generator • Generates up to 211 gallons of clean water every day • Dispenses cold and room temperature water • 1720 pounds	• Starting at $18,000	• Installation within 2 weeks • Worldwide distributors • The company also sells their products directly from their website

Sources:

[1]Creating Drinking Water from Air. (n.d.). Retrieved February 7, 2020, from https://us.watergen.com/

[2] Hamilton, A. (2014, April 24). Turn Air Into Water with Water-Gen's Atmospheric Water Generator. Retrieved February 8, 2020, from https://time.com/75612/atmospheric-water- generator-watergen/

Gen-L is the largest scale air to water generator that Watergen sells. It is built for municipal and commercial use as well as areas low in clean water in developing countries. Unlike the previous medium scale product, Gen-L is large and can generate up to 51,300 gallons of water in each 24 hour cycle. This model is most definitely meant for use with large groups of people (Creating Drinking Water from Air).

Table 4: Gen-L

Product	Features [1]	Price Points [2]	Distribution [1]
Gen-L 	• Generates up to 51,300 gallons of clean water per day • 5,791 pounds	• Starting at $30,000 • Cost per liter: 2-4 cents	• Installation within 2 weeks • Worldwide distributors • The company also sells their products directly from their

			website

Sources:
[1]Creating Drinking Water from Air. (n.d.). Retrieved February 7, 2020, from https://us.watergen.com/
[2] Hamilton, A. (2014, April 24). Turn Air Into Water with Water-Gen's Atmospheric Water Generator. Retrieved February 8, 2020, from https://time.com/75612/atmospheric-water- generator-watergen/

The Gen-M Erv model has a slightly different purpose compared to the other models. It can transport 211 gallons of water and then continue to generate more once people start to use the stored water. Another big plus is that this product does not require any power to generate the water. This is ideal for emergencies because the truck is able to drive through any terrain (Creating Drinking Water from Air).

Table 5: Gen-M Erv

Product	Features [1]	Price Points [2]	Distribution [1]
Gen-M Erv 	• Can bring clean, fresh water to sites of major emergencies and natural disasters • Heavy duty truck can transport 211 gallons of water through any terrain • Energy efficient, doesn't rely on an electric grid • 17,720 pounds	• Starting at $30,000	• Installation within 2 weeks • Worldwide distributors • The company also sells their products directly from their website

Sources:
[1]Creating Drinking Water from Air. (n.d.). Retrieved February 7, 2020, from https://us.watergen.com/
[2] Hamilton, A. (2014, April 24). Turn Air Into Water with Water-Gen's Atmospheric Water Generator. Retrieved February 8, 2020, from https://time.com/75612/atmospheric-water- generator-watergen/

The newest model the Watergen has released is the Automotive solutions which is meant to install into vehicles and the small generator makes water. This is the closest any existing company has gotten to creating a portable air to water generator, however no price point has been determined because they are not selling yet (Creating Drinking Water from Air).

Table 6: Automotive Solutions

Product	Features [1]	Price Points [2]	Distribution [1]
Automotive Solutions 	• Tailored for in vehicle use • Dispenses hot and cold water • Applications include an add on drinking system on any vehicle • Reduced carbon footprint	• No price point determined yet	• Installation within 2 weeks • Worldwide distributors • The company also sells their products directly from their website.

Sources:

[1]Creating Drinking Water from Air. (n.d.). Retrieved February 7, 2020, from https://us.watergen.com/

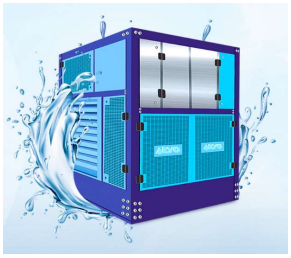
[2] Hamilton, A. (2014, April 24). Turn Air Into Water with Water-Gen's Atmospheric Water Generator. Retrieved February 8, 2020, from https://time.com/75612/atmospheric-water- generator-watergen/

Akvo Water Systems:

This company sells five different products, some for an indoor setting and others for a larger, more outdoor setting. The 36K and 55K models serve better in homes or offices because of their smaller size and amount of water produced. In addition, those two models are also significantly more affordable than the 110K, 180K, and 365K models that AKVO makes. Those three models are geared towards an outdoor setting for large groups of people because they produce more water and are heavier. They are also more expensive, so they are not ideal for homes or offices (Avko Products).

Table 7: Akvo Water Systems Air-to Water Generators

Products	Features [1]	Price Points [2]	Distribution
36K 	• 26.4 gallons per day produced • 309 pounds • Can produce cool or warm water • Built in nanocarbon filter • Designed for use in the home or office • Voltage: 220	• Starting at $490	• Unknown

55K 	• Produces 40 gallons of water per day • 353 pounds • Generates cold and hot water • Designed for use in the home or office • Voltage: 220	• Starting at $490	• Unknown
110K 	• Produces 79 gallons of clean water per day • 772 pounds • Designed for outdoor use, large machine • Voltage: 220	• Starting at $12,585	• Unknown
180K 	• 132 gallons of water per day • 992 pounds • Uses 5 micron sediment, nano carbon filter and UV to filter the water • Voltage: 220	• Starting at $12,585	• Unknown
365K 	• 264 gallons of water per day • 1323 pounds • Uses 5 micron sediment, nano carbon filter and UV to filter the water • Built for outdoor use, not in a home or office setting • Voltage: 220	• Starting at $12,585	• Unknown

Sources:

[1]Akvo Products. (n.d.). Retrieved February 7, 2020, from https://akvosphere.com/akvo-atmospheric-water-generators/

[2] Borgohain, A. (2017, December 19). Converting air to water: Small companies make great strides in water generation. Retrieved February 8, 2020, from https://economictimes.indiatimes.com/small-biz/sme-sector/converting-air-to-water-small-companies-make-great-strides-in-water-generation/articleshow/62131689.cms

Atmospheric Water Solutions:

Table 8: Aquaboy II Pro

Products	Features	Price Points	Distribution
Aquaboy II Pro 	• Produces 2-5 gallons of water per day • Stores up to 4.6 gallons of water • Can produce cold (44°) or hot (180°) water • No installation or plumbing needed • 2 year limited warranty • Designed for residential use	• $1,849.00 for one unit • For one year, filter replacement costs only $215, and it has free shipping	• They use their website to sell the Aquaboys online. • The product is also sold through HomeDepot, Walmart, and OfficeDepot.

Source: AquaBoy Pro II. (n.d.). Retrieved February 8, 2020, from https://www.atmosphericwatersolutions.com/store/p- 1/AquaBoy_Pro_II.html

The same company also sells commercial units of air to water technology. Since this will not be our competition for our target audience and have already outlined the details for other commercial sized products, refer to Akvo's products for a similar, general idea. Additionally, refer to the company's website for further details.

Innovaqua Water Solutions:

This company has three main products that they sell and advertise: the NUBE SS30, NUBE SS150, and NUBE refill stations. The NUBE SS30 and SS150 are made more for indoor settings because they are smaller in size and produce 30 and 40 gallons of water respectively. In addition, they both have easy installation and maintenance as well as low electricity consumption (Innovaqua Water Solutions).

Table 9: Innovaqua Water Solutions

Products	Features	Price Points	Distribution
NUBE SS30 	• Generates up to 30 liters per day • Electricity consumption per liter produced: 250 - 350 Watts • Maintenance: must change 3 cartridges every 6-12 months that cost $65, but it has free shipping (installation is less than 5 minutes) • 5 year warranty	• $1865.36 • Cost per liter: about 5 cents	• They sell through Amazon. • The company also sells their products directly from their website.
NUBE SS150 	• Produces up to 40 gallons of water per day • Electricity consumption per liter produced: 250 - 300 Watts • Maintenance: must change 3 cartridges every 6-12 months that cost $150, but it has free shipping (installation is less than 5 minutes)	• From $7,994.40 to $8,272.55 • Cost per liter: 1 to 2.6 cents	• They sell through Amazon. • The company also sells their products directly from their website.
NUBE refill stations 	• Can produce up to 264 gallons of water per day	• From $26,115.04 to $27,074.37	• They sell through Amazon. • The company also sells their products directly from their website.

Source: Innovaqua Water Solutions. (n.d.). Retrieved February 7, 2020, from https://innovaqua.shop/

Intellectual Property

The main brand names that we would be competing with include Watergen, Akvo, Atmospheric Water Solutions, and Innovaqua Water Solutions. However, since our product is unique compared to these products we will not be competing with them directly since we will have a separate target audience. None of the existing companies or products have control of a name that is synonymous with the product. This is mostly because the air to water generators have not become an extremely popular product to use. There is one company, Watergen, that has a patent on a part of the air to water generator that they invented. It is for their new and improved model, GEN-M. The patented GENius allows the water generator to create more water efficiently while minimizing electricity consumption. GENius includes a unique heat exchanger, making it more affordable and significantly more efficient to run compared to the older atmospheric water generator solutions that are based on an old, inefficient air conditioning technology (Gen-M).

We have decided to name our air to water generator *The Bottle*, for its portable water bottle size.

Figure 1: Logo

Pricing

The current atmospheric water generators on the market are to be used to supply water for set ups with multiple people such as a home or office and they are not built to be portable by manpower.

The price falls around $2000 for a unit to produce up to 8 gallons of water in a day which is 30 liters. For a backpacker, we want to have the same water production power but on a smaller

scale. The targeted size of the bottle is to carry two liters of water. There also needs to be space to contain the mechanism to turn air to water. In comparison to the size of atmospheric water generators built for homes, we want a bottle that is an eighth of that size. That would mean the bottle requires less materials but the technology advancement needed to shrink everything down and still keep the same power will be costly.

Since the goal is to keep the amount of water produced the same, but with a machine that is at a portable size, the general price goal would be the same as those already existing on the market. However, considering backpacking is supposed to be kept inexpensive, the price goal has to be set to something lower. To target backpackers, we have to set our goal to be around $1000. In order to reach that goal, we will start off at a price that is higher than $1000 to generate funding to further research and improve technology to make the materials and manufacturing process cheaper.

Distribution and Sales

We will sell the product on our own website and at home depot for a retail chain. After research about our competitors' distribution of the product, we discovered that all of their products were sold on their own websites. Figure 2 depicts the importance of online sales as to retail sales, showing how online shopping is becoming increasingly popular and the main reason why we are selling our product mainly online.

Figure 2: E-commerce vs In-store Sales Growth Rates

Setting up our website

In order to have a website to sell our product on, we need to purchase a baby plan of a cloud hosting on hostgator, we will be provided with a free SSL certificate for purchases, a free domain, 4 core CPU and 4GB memory for $6.57 a month. An SSL certificate is needed to

encrypt the important information for purchases and make the information available for use only to the intended recipient.

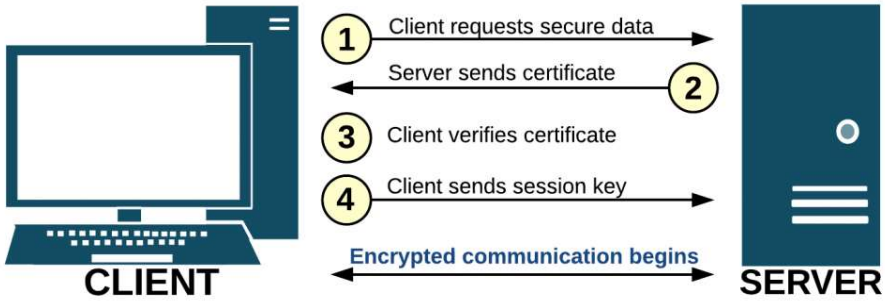


Figure 3: How a SSL certificate

Afterwards, we need to buy a website hosting provider for $3.84 a month on website builder. We would need to pick and register the domain name, design the website, and set up a merchant account to allow online payments to be processed. As we start selling our products, it would need advertising online in order to be known to the people.

Search Engine Optimization

The picture below demonstrates how 85% people rely on Google to find product information before making a purpose. It implies how our company should use Google to increase our product name through search engine optimization.

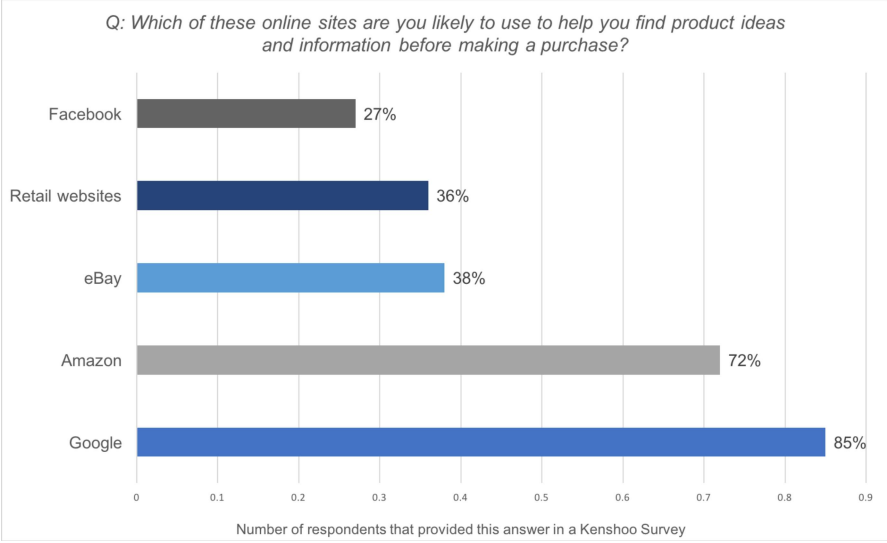


Figure 4: sites in which online shoppers rely on to find product information before making a purchase

Search engine optimization, or SEO, is the usage of good keywords, tags, server speeds to allow bots to pull up your page on google and other search engines when potential customers search online. When people search up wanting to purchase something online, they would prefer to choose an option that Google has on their page instead of ads that pop up. Google determines if your page is relevant to the search by looking for keywords, ranking the pages by the amount of people that stay on your site, the site's loading speed, and the amount of unique content on the site. Another important aspect is the number and the quality of the sites that refer to your site on their web page. By implementing SEO, it would boost our product's reputation.

Retail Options

Home Depot is our target retail store and where most of our competitors sell their products. For small business participants, it must be certified by the Small Business Administration (SBA). After determining which type of business participant to identify as, we need to submit our application. Our information will be forwarded to the appropriate Buyer for consideration as a potential partner. If an opportunity exists, you may be asked to submit more specific information about your business, product or service.

Before being able to be listed as a supplier, we need to submit our product for approval by submitting an online form that includes a description and picture of the product, the pricing information, patents, and website and contact information. Our goal is to convince Home Depot how they will benefit from having our product on their shelves, also showing how highly we view our relations with Home Depot.

After that, we would need to transact important business details through the process, Electronic Data Interchange (EDI). It is important for us to meet the requirements in order to increase our chances of being chosen to stock their shelves with our product.

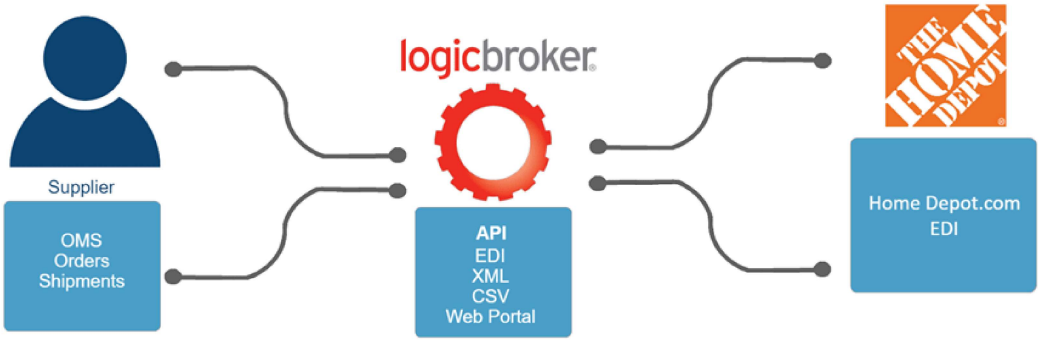


Figure 5: Process of EDI

Legal Requirements and Approvals

The Safe Drinking Water Act of 1974 was passed by the federal government to ensure safe public drinking water. Through this act, the EPA set standards for what is legally drinkable water: https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf (What is safe drinking water). This is a comprehensive description of the amount of certain chemicals, metals, and organic matter that can safely be in drinking water. These regulations are different than those to sell bottled water, which is controlled by the FDA. But our product doesn't need to follow these regulations. For requirements for the filter apparatus of the bottle, the filtered water must pass the epa's guidelines of safe drinking water.

The main legal concern in selling the bottle itself is that it must be BPA (bisphenol A) free. BPA is legally banned in most states from bottles that babies could use. BPA has been connected to cancer, childhood obesity, autism, and early puberty (State Laws on BPA).

Overall, since there are no products like this on the market, there are no clear guidelines on the legal requirements for this product, just for the individual components. We will have to inquire more about this when a prototype of the product has been created.

DESIGN

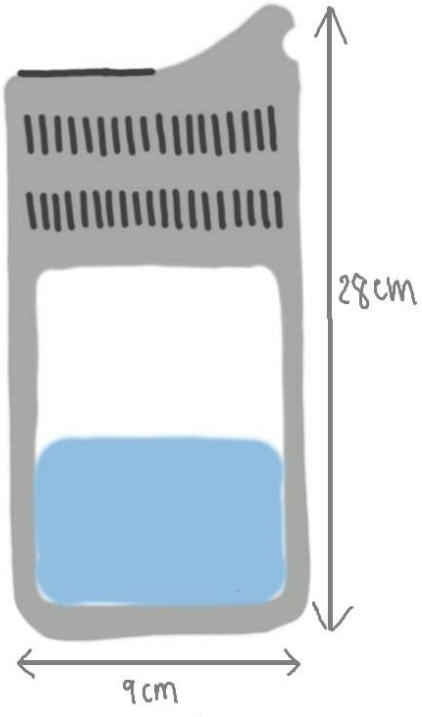


Figure 6: The Bottle with dimensions

The Bottle will be composed of two main parts: the body and the cap. The entire bottle will have a diameter of 9 centimeters and a height of 28 centimeters as shown in Figure 6.

Body

Figure 7: The Bottle's body with dimensions

The body, which is pictured in Figure 7, will have a height of 18 centimeters and can hold up to 1 liter of water at a time. It will be made of clear plastic which will have markings at every 100 mL and 4 ounces of water to give the user a sense of how much water they are drinking. The bottom of *The Bottle* will be curved to spread the force when hit to prevent chipping and for easier moulding and cooling when manufacturing.

Cap

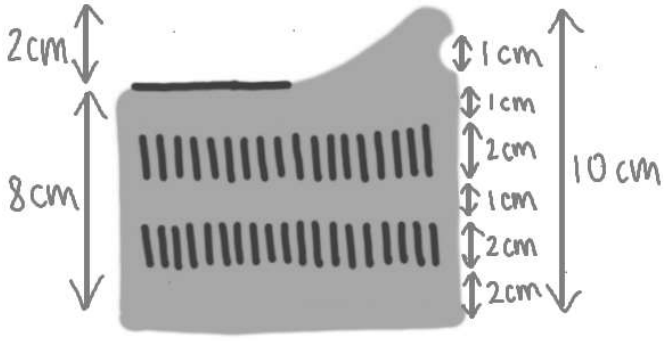


Figure 8: The Bottle's cap with dimensions

The cap, shown in Figure 8, is where the atmospheric water generator will be located. The cap will be 10 centimeters tall and contains 5 main components: the solar panel, the air filter, the fan, the condenser and the water filter (Figure 9).

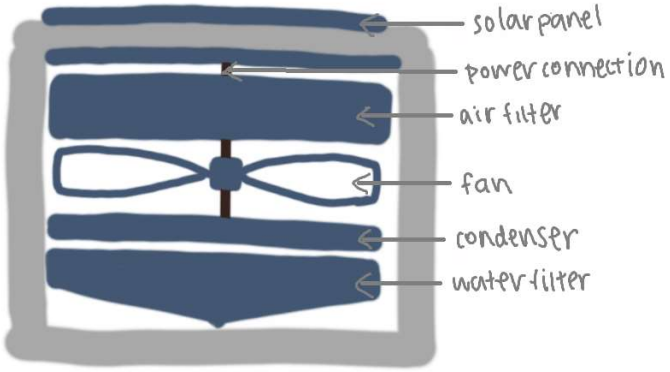


Figure 9: Interior of The Bottle's cap

The cap will be made of plastic and will be separable by twisting the pieces apart to allow the components to be accessed for easy cleaning. The cap will also have a hole that allows users to attach a hook and gives the user the option to attach *The Bottle* onto their bag which lets the people carry *The Bottle* hand free while keeping it open to the air.

Solar Panel

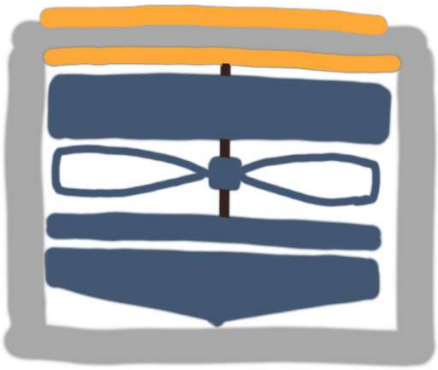


Figure 10: Interior of The Bottle's cap with the solar panel highlighted in yellow

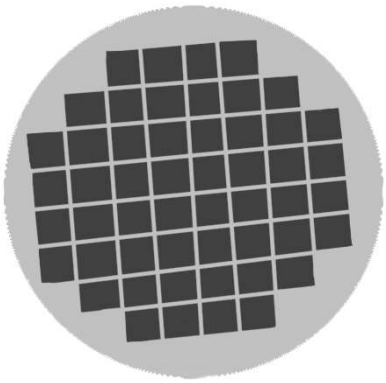


Figure 11: Top view of The Bottle's cap showing the solar panel

The solar panel is located at the top of the lid (Figure 10 and Figure 11) so it can be exposed directly to the sun to collect power to run the different components of the atmospheric water generator.

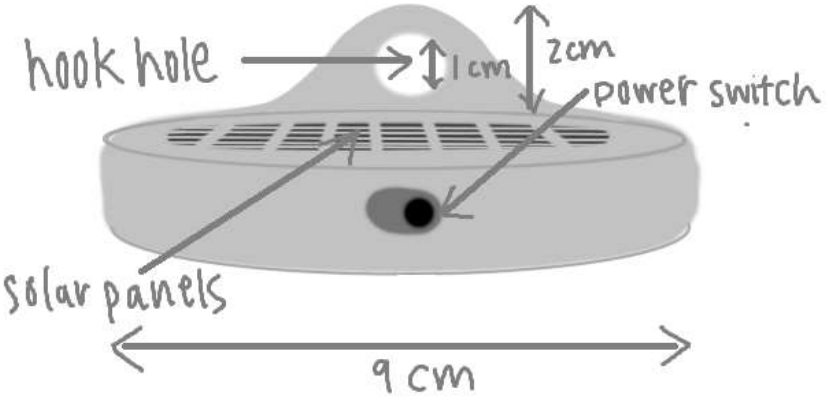


Figure 12: Lid of the cap with dimensions and parts labeled

The solar panel will have a diameter of 9 centimeters and will have a height of 1.5 centimeters (Figure 12). As shown in Figure 8, wires carrying the power generated will run down the center of the cap in a hard plastic encasing to reach the motor running the fan and the condenser.

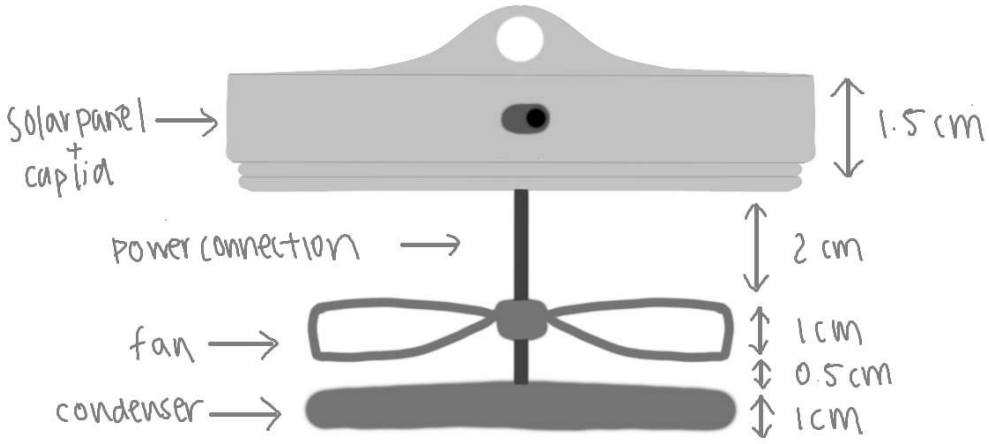


Figure 13: Lid of the cap with

The solar panel will have its own detachable unit from the rest of the cap which will open access to the rest of the parts inside the cap. When the solar panel is unscrewed, the power connection will remain attached to the fan and the condenser which then can be disassembled for cleaning.

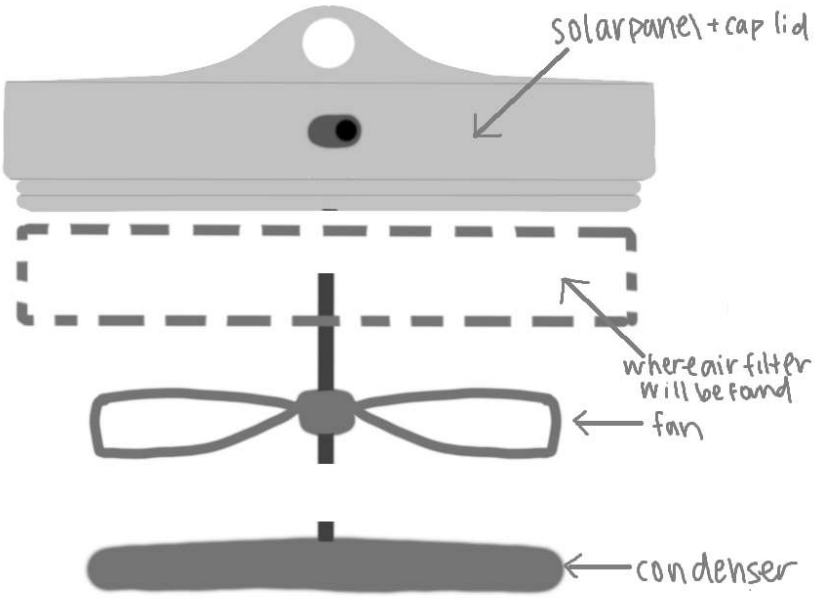


Figure 14: The lid of the cap disassembled with labeled parts

Because these parts have to be detachable from each other, which is shown in Figure 14, the power connections will be able to disconnect and reconnect. They also will be able to get wet without getting damaged or short circuiting. Next to the solar panel, there will be a switch to turn *The Bottle* on and off for when the customer does not want the fan or the condenser to be running.

Air Filter

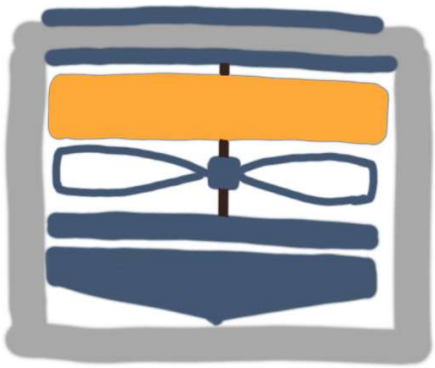


Figure 15: Interior of The Bottle's cap with the air filter highlighted in yellow

The air filter will sit beneath the solar panel, and behind and against the upper vents in the cap to filter out the dust and debris from the air that is pulled in (Figure 15).

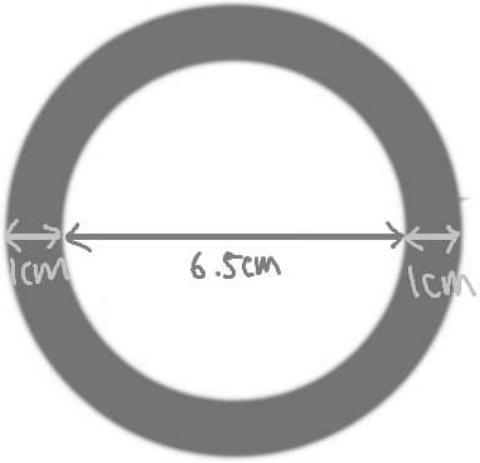


Figure 16: Top view of air filter with dimensions

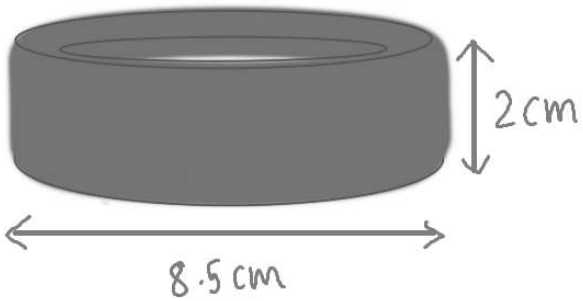


Figure 17: Side view of air filter with dimensions

The air filter will be a hollow cylinder and have an outer diameter of 8.5 centimeters, thickness of 1 centimeters, and a height of 2 centimeters (Figure 16 and Figure 17). The upper air vents run around the outside of the plastic shell of the cap to let air inside the atmospheric water generator. Each vent is 0.2 centimeters wide, 2 centimeters tall and 0.2 centimeters apart from each other. Once the solar panel is unscrewed from the rest of the cap, the air filter can be removed for washing. Because the air filter only takes care of physical particles, it can be cleaned by the user with water.

Fan

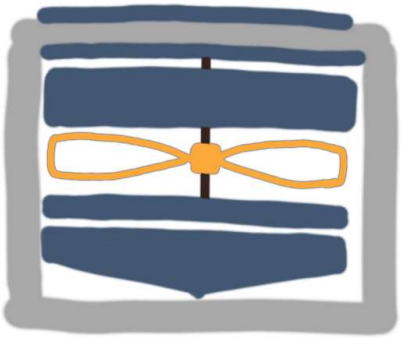


Figure 18: Interior of The Bottle's cap with the fan highlighted in yellow

Beneath the air filter is the fan (Figure 18). It has a diameter of 8 centimeters, fan blades with lengths of 3.5 centimeters. The motor in the middle has a diameter of 1 centimeter. The total height of the fan including the power connections is 3.25 centimeters (Figure 19). It will spin to circulate in air from the upper vents and push it out through the bottom of the fan to the condenser.

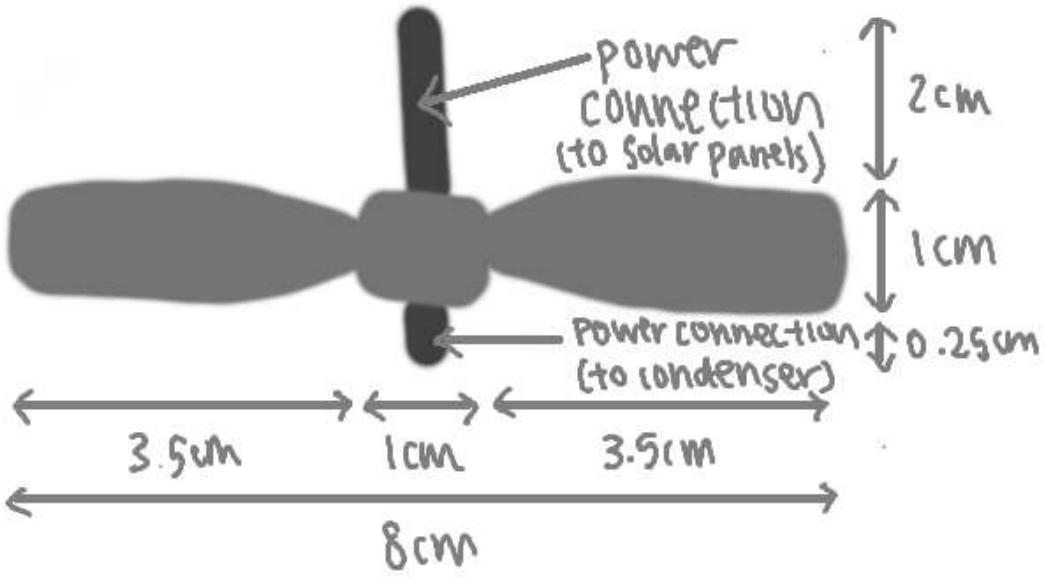


Figure 19: Side view of fan with dimensions and parts labeled

The fans will balance between a high static pressure fan and a high airflow fan. High airflow fans push a larger volume of air than high static pressure fans that push a smaller volume of air, however, with a stronger force. High airflow is ideal for environments of little to no obstruction while high static pressure fans are used for when air flow is not high, thus, more force is required (Techquickie 2016). Because the fans will face some obstruction from the air filter in front of the vents, but still needs to pull and push as much air as possible to the condenser, the fan needs to be in the between the two opposite styles of fans.

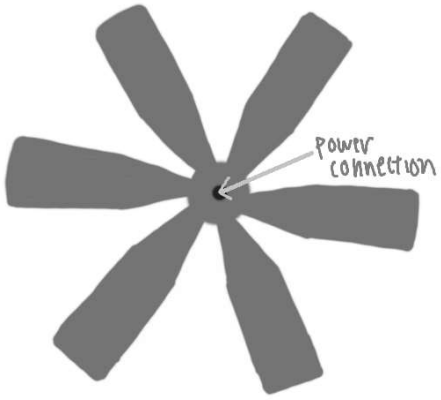


Figure 20: Top view of the fan with labeled parts

The motor to spin the blades will be powered by the solar panels and attached to the cap through the power connection (Figure 20). The power connection will also run through the fan and connect to the condenser located below it.

Condenser

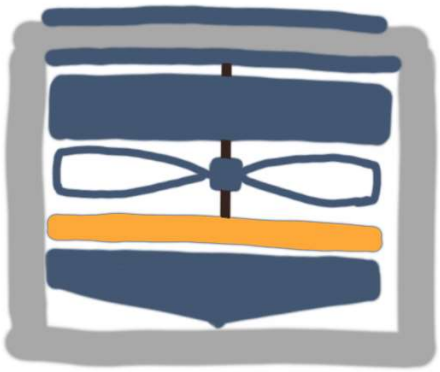


Figure 21: Interior of The Bottle's cap with the condenser highlighted in yellow

The condenser, that is located below the fan (Figure 21), will have a diameter of 8 centimeters, coil diameters of 0.75 centimeters, a motor with a height and width of 1 centimeters and a total height with the power connection of 1.25 centimeters (Figure 22).

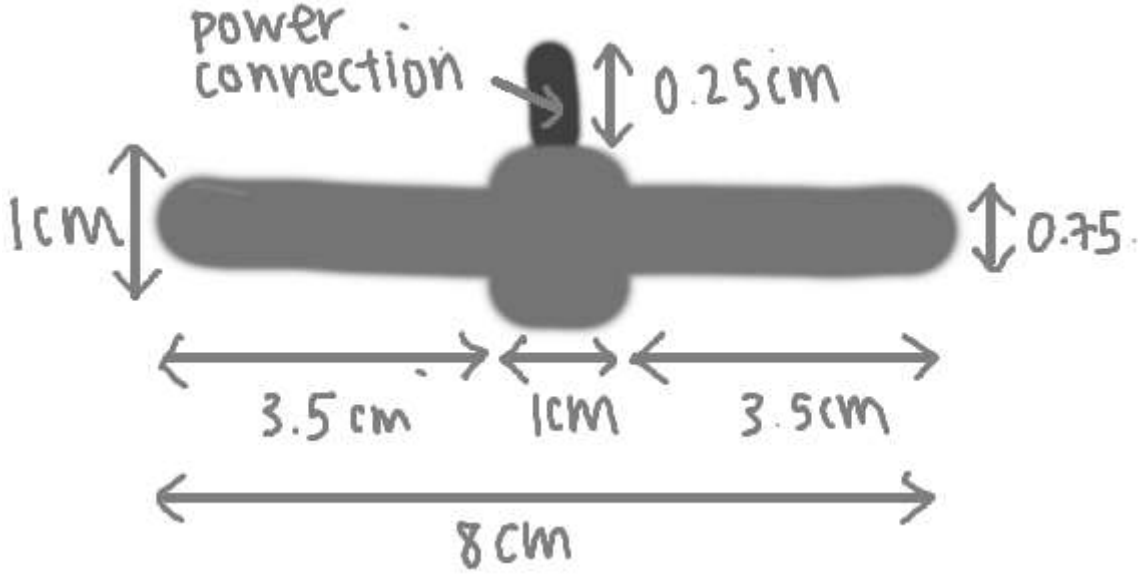


Figure 22: Side view of condenser with dimensions and parts labeled

The cap around the condenser will have vents identical to the vents around the air filter which will let the air flow out and prevent pressure build up from continuously sucking in air.

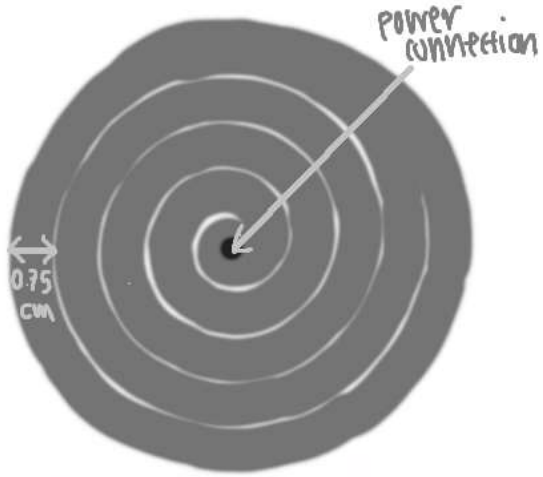


Figure 23: Top view of the condenser with dimensions and parts labeled

The condenser works by having the metal coil cool the water vapor in the air that was blown in by the fan to dew point which will turn it into liquid water (National Geographic, 2011). The build up of the liquid on the metal will cause the water to drip down to the water filter. The condenser will be cooled using the power from the solar panel connected by the power connection running down from the fan and the solar panel (Figure 23).

The condenser will be made of metal because metal is able to conduct “coldness”, meaning heat can be removed from the material to make it cold (Helmenstine 2019). Coils maximizes the surface area that the water vapor can contact and lets the water flow through it, in comparison to a solid flat disk.

Water Filter

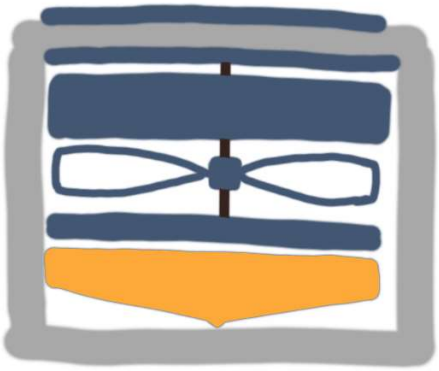


Figure 24: Interior of The Bottle’s cap with the condenser highlighted in yellow

Figure 25: Top view of water filter

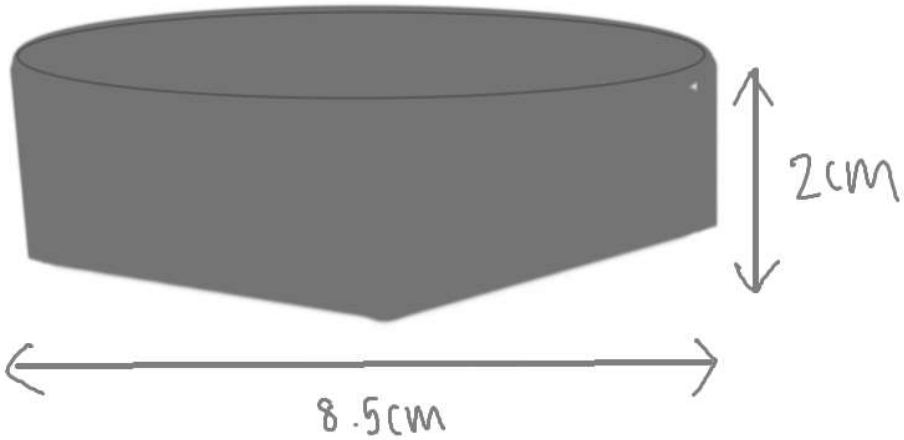


Figure 26: Side view of water filter

The water filter will be below the condenser (Figure 24). It will be a circular disk with a point at the end to funnel the water out of it. The water filter will have a height of 2 centimeters and a width of 8.5 centimeters (Figure 25 and Figure 26).

The water filter will catch the water created by the condenser and filter it free of contaminants and harmful chemicals. The filter will be replaceable in contrast to the air filter that could be washed and reused because the water filter cleans out the chemicals using chemical processes which have no way to be cleaned. Therefore, the water filter will also be another detachable unit from the whole cap.

Assembly

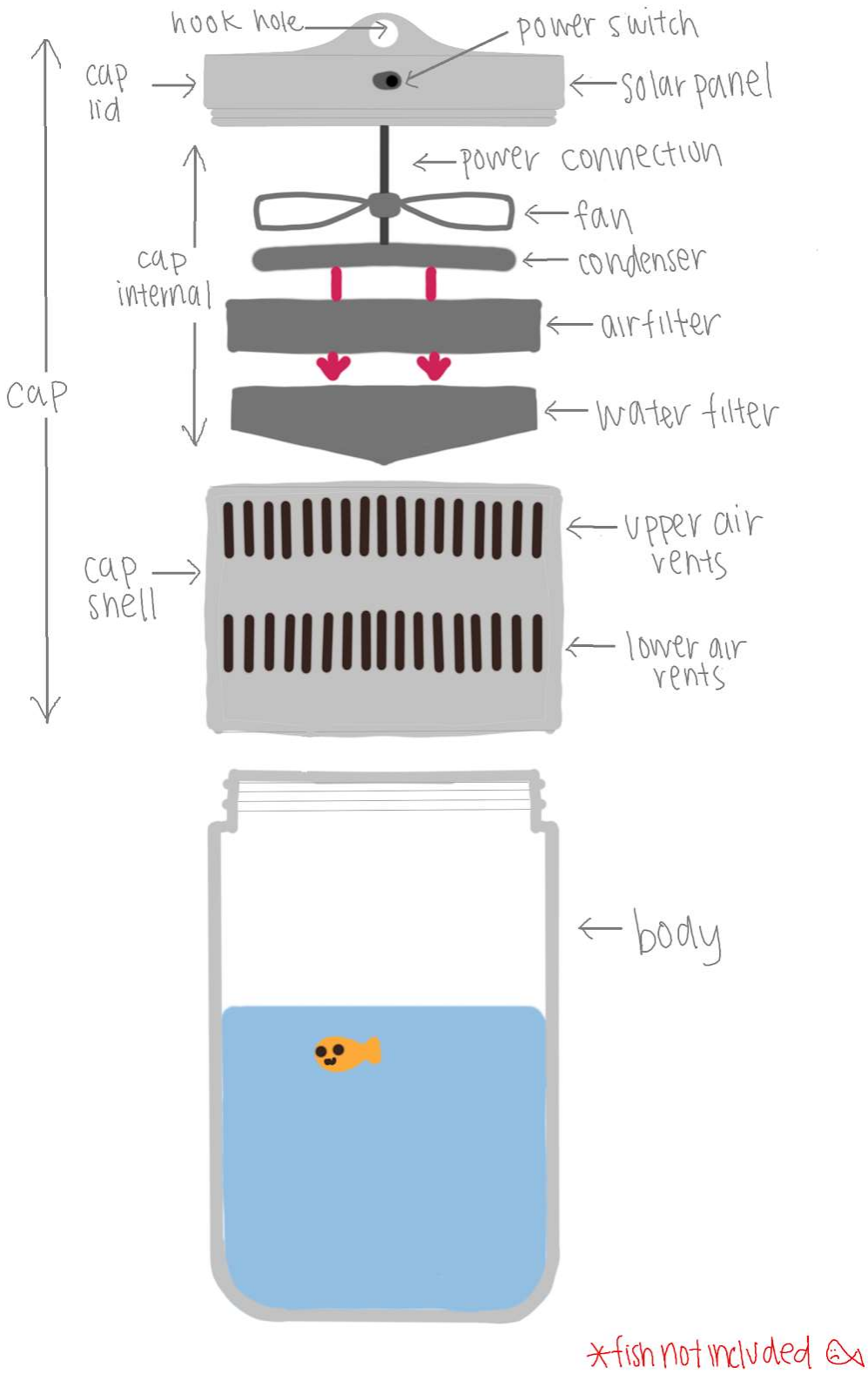


Figure 27: The Bottle disassembled with labeled parts

Figure 27 shows how the different parts disassemble. In order to reassemble the entire bottle, the fan and condenser would have to be detached from the solar panel and the air filter ring would be strung onto the power connection then the fan and condenser would be reconnected to the solar panel. Then the water filter, condenser, fan and air filter would be fit into the cap shell and the cap lid with the solar panels would be screwed on to put together the cap.

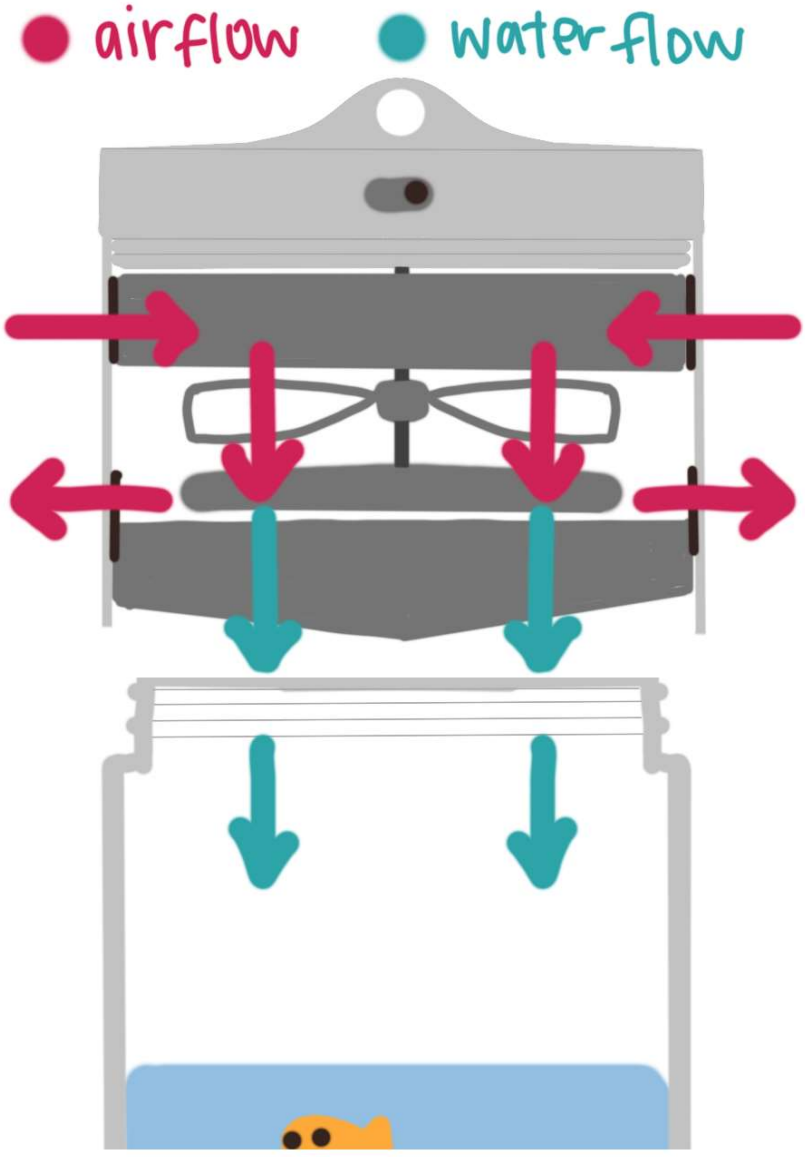


Figure 28: Air and water flow in The Bottle

As shown in Figure 28, when the power switch is turned on, the air would flow in through the upper vents and be filtered through an air filter. Then the air would be pushed down by the fan to the condenser where the water vapor in the air will be cooled to dew point and turned into condensation. The condensation will build up to form droplets that fall through the cracks of the

cois and into the water filter to be filtered for safe drinking and into the body of *The Bottle*. The rest of the air will get pushed out through the lower air vents to prevent a build up of pressure in the *The Bottle*.

Customer Usage

To use *The Bottle*, customers have to turn on the solar panel and put it in sunlight to start generating power. The cap of *The Bottle* also needs to be exposed to air which will create the water. When the user wants to drink water, they can use it like any other water bottle: untwist the cap and drink. They will need to clean and replace the components of the air water generator every 2 months or when needed.

MANUFACTURING PROCESS

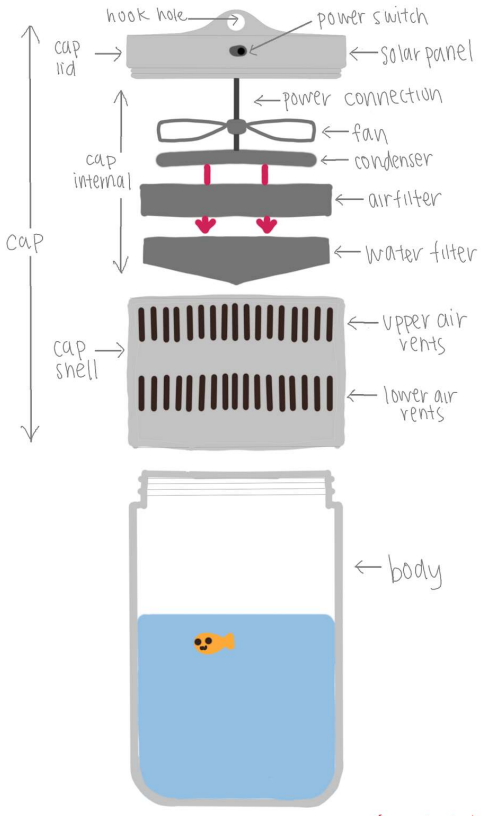


Figure 29: Assembly of The Bottle

When building *The Bottle*, it involves the assembly of solar panel, an air filter, a fan, a condenser, and a water filter in addition to the stainless steel water bottle.Figure 29 depicts the design of the water bottle and its components.

Stainless Steel Water Bottle

In order to create the body of a stainless water bottle, it would first require pipe cutting. After pipe cutting, there are 2 methods of expansion, or shaping the water bottle into a cylinder. The first method is water expansion. It uses the huge pressure of water to shape the pipe into a bottle shape, and a round stainless steel plate would be welded onto the bottom.The second method, stretching, is when round plates of stainless steel are stretched into a cylinder with a bottom. After shaping the stainless steel into a water bottle, it would require shaping the bottle size and then making a bottleneck at the top by squeezing the upside down of a bottle, or the open end of the bottle. The steps are followed by cleaning the water bottle, removing the lubricating oil and dust during molding and then inspection of the water bottle. Afterwards, welding the mouth edge and grinding the welding seam allows the surface of the water bottle to be smooth. The finalization of the water bottle is cleaning the water bottle, external coating, pattern and logo printing, and packing and shipping.

Solar Panel

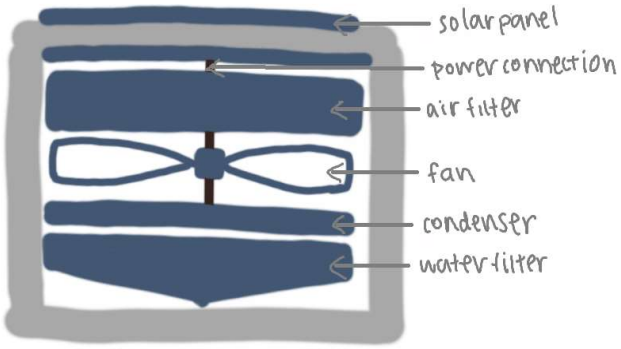


Figure 30: Layout of the cap

Figure 30 shows the cap and the entire system of converting air from the atmosphere into drinking water. The first component inside the cap of the water bottle is the solar panel. It is located on the top of the bottle cap. The first step when making a solar panel is to purify the silicon by releasing the oxygen and then putting a rod of silicon through a heated area many times in the same direction, shifting the impurities to one end during each pass. After that, the Czochralski process is implemented by dipping a seed crystal into melted polycrystalline. When it is withdrawn and rotated, a crystal, or a boule, is created. Some of the silicon undergo P type doping, which is adding Boron impurities to the silicon, during this process. It creates the P type semiconductor. Figure 31 depicts the Czochralski process.

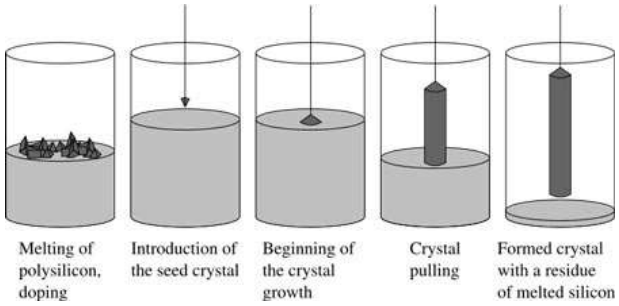


Figure 31: Czochralski Process

Picture from: http://www.top-alternative-energy-sources.com/Czochralski-process.html

After the crystals are created, they are sliced to make silicon wafers and then polished to remove the saw marks. The silicon wafers that did not undergo P type doping are subjected to N type doping. A small amount of phosphorus atoms are added into the silicon when the silicon is heated at a temperature slightly below its melting point, in which the silicon is in a porous state, creating N type semiconductor. N type is usually thinner while P type is usually thicker. P type is on the bottom, and N type is on the top. Figure 32 depicts the PN junction and the overall layout of a solar panel.

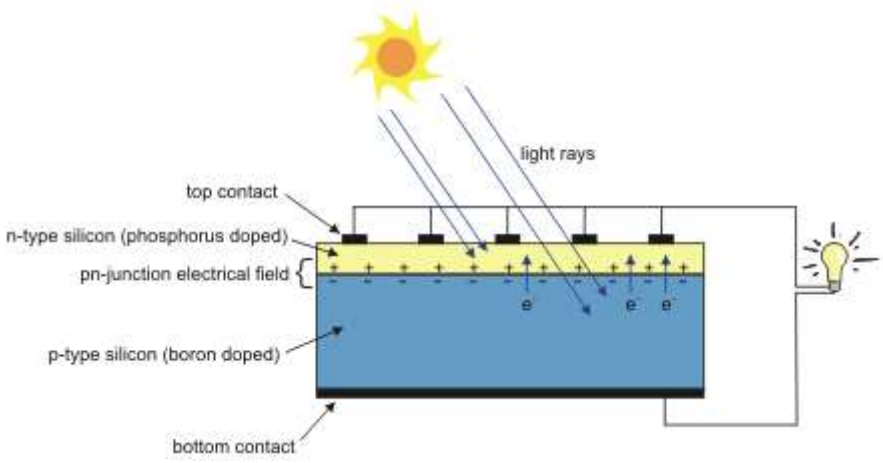


Figure 32: layout of solar panel

Picture from: https://www.lrc.rpi.edu/programs/nlpip/lightinganswers/photovoltaic/04-photovoltaic-panels-work.asp

Electrical contacts are then added to the solar cells, and they connect the solar cells together. Thin strips are then placed to connect the electrical contacts and are used to carry the electric current produced by the solar panel out to an external load. Because pure silicon is shiny and reflects up to 35% of the sunlight, anti-reflective coating is put on the silicon wafers to maximize the amount of energy absorbed. The solar cells are then sealed in silicon rubber and placed in a frame with a backsheet and a cover for protection.

Air Filter

The second component is an air filter. Air filters are usually composed of a spun fiberglass material or pleated paper/cloth in a frame. The filters block most of the particles and contaminants from entering the water bottle. The filters should be changed when they are dirtied. There are 3 types of air filters that will be put in our system. The pre-filter is a thin foam filter placed over the pleated air filter that catches the big particles. The pleated paper filter is thin enough to let air pass but catches most of the other particles and debris, while the foam filter, coated in oil, serves as a last barrier to catch the small particles and debris. Figure 33 shows the overall process of manufacturing an air filter.

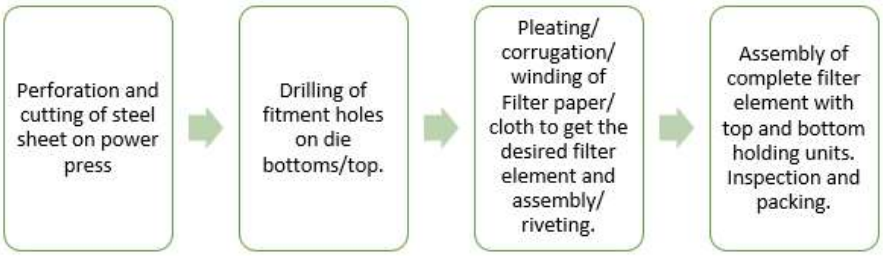


Figure 33: Manufacturing process of air filter

Picture from: https://www.techsciresearch.com/blog/manufacturing-air-filters/93.html

Fan

The third component, the fan, draws the air into the system. A small fan is made by just simply connecting a motor to the battery, which is the solar panels in our product, a switch to turn the fan on and off, and the fan blades. The process would require soldering the switch to the battery and the motor to the switch. Figure 34 is the type of system for the fan that we are aiming for, but we will get rid of the standing post of the fan as drawn in the design.

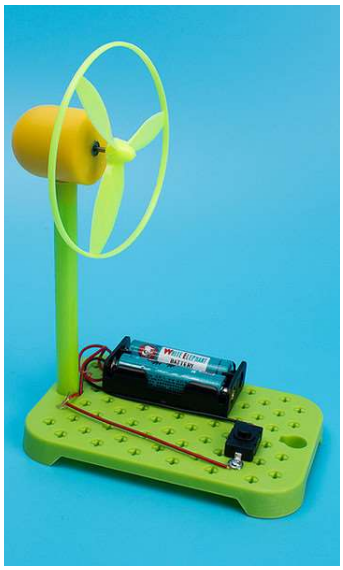


Figure 34: Fan layout

Picture from: https://www.dhgate.com/product/diy-electric-fan-self-control-summer-model/413031680.html

Condenser

The next component is the condenser, which turns the humidity in the air into water. Condenser coils are made of copper tubing with aluminum fins or all-aluminum tubing in order to allow heat to be transferred rapidly. The manufacturing process of it is to cut, bend, and solder the coins of the copper onto the main device, our water bottle. The condensers take high pressure and high temperature water vapor and release heat to its surroundings, converting the vapor to liquid and lowering the temperature. We plan on making a condenser smaller but similar to the one in Figure 35.

Figure 35 Condenser coils

Picture from: https://www.coowor.com/p/20170815133836805CF3RDY/Refrigeration-units-condenser-coil.htm

Water Filter

The last component of the water bottle cap consists of a water filter. We plan on buying the water bottle filters from Brita. The type of water filter used is the activated carbon filter, which uses charcoal. Charcoal traps the contaminants due to its large surface area, and carbon acts like a magnet and traps the contaminants internally as water passes through. Carbon also reduces chemicals like chlorine through a chemical reaction when the water passes through the filter. Filter 36 shows an overview of the filtration process of an activated carbon filter.

Figure 36: Overview of Filtration process in water filter

Picture from: https://www.aliexpress.com/item/32720656527.html

There are 2 main ways to manufacture an activation carbon filter, extrusion and compression molding. Extrusion is when a mixture of carbon and polymeric binder is used to form a tubular-shaped porous block, and the block is twisted by melting the mixture. The block is then shaped into blocks and cut to fit into water cartridges. The second method, compression molding, is when the mixture of carbon and polymeric binder are added into individual molds and sintered, which is heating the mixture at a temperature below melting point to make the material into a porous mass. Different carbon and binder mesh result in different amounts of porosity in the carbon blocks. This method is more labor intensive and has a slower production rate, but it is more flexible on dimensions. As a result, our team has decided to use compression molding for the dimensions.

Lastly, the water bottle cap with air vents will be created through the process of blow molding. Blow molding is when pieces of plastic are heated and blown into the mold of the desired shape. Figure 37 depicts the ideal cap with the air vents for our product.

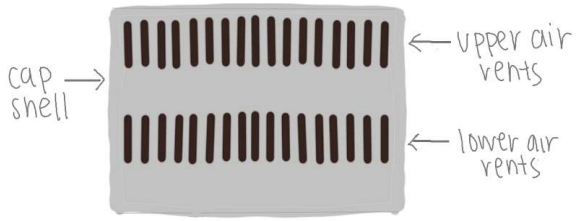


Figure 37: design for cap with air vents

Manufacturing Destination

After careful consideration, our product will be manufactured overseas, specifically in China. The manufacturing costs of that in the US were just simply too high. According to the nation master, the minimum wage in the US is $7.25 while China's was only $1.73. In addition, China has a labor force of 819.5 million, significantly greater than 154.9 million. This showed how investing in China showed less costs spent on labor and the increase in efficiency due to the difference in labor force.

By manufacturing overseas, we will save costs due to lower amounts of money spent on labor, shipping and warehousing. We were deciding between India and China. Both China and India have lower costs of labor. India has a greater population than China, but China has a higher rank of depth of specialized skills at work, which we value greatly due to the technology used on our product. Our product requires many specialized skills in order to ensure the quality. The chart below shows how India may have a lower cost in minimum wage, but the "availability of skilled employees rank" showed that China, who placed 41, was slightly better than India, 47.

Country	Monthly minimum wage	Human capital score (0 to 100)	Human capital rank	Development rank	Know-how rank	Economic complexity rank	Availability of skilled employees rank
Cambodia	$182	57.28	92	107	121	75	118
China	$140-346	67.72	34	47	44	18	41
India	$66-202	55.29	103	65	79	42	47
Thailand	$200-214	66.15	40	66	51	25	83
Vietnam	$125-180	62.19	64	67	120	54	84

Figure 38:Comparison of countries

Pic from:https://www.intouch-quality.com/blog/manufacturing-in-india-vs-china

The deciding factor that resulted in us choosing China, not India was its infrastructure rank and the timelines rank. According to the chart depicted below, India's infrastructure is 52 while China placed 20. In addition, India's timelines rank is 52 while China is 27. It hints of how India's infrastructure may be affecting its timelines rank.This is an important factor because transportation is extremely vital, and India's inferior infrastructure may result in missing deadlines or unexpected accidents. As a result,through careful consideration, our team decided to manufacture our product in China.

Country	LPI rank	LPI score	Customs rank	Infrastructure rank	International shipments rank	Logistics competence rank	Tracking & tracing rank	Timeliness rank
Cambodia	98	2.58	109	130	71	111	111	84
China	26	3.61	31	20	18	27	27	27
India	44	3.18	40	52	44	42	38	52
Thailand	32	3.41	36	41	25	32	33	28
Vietnam	39	3.27	41	47	49	33	34	40

Figure 39: Comparison of countries

Pic from:https://www.intouch-quality.com/blog/manufacturing-in-india-vs-china

MATERIALS SELECTION

The Bottle has several different components in the final product and each component has a different composition of materials.

For the body of the water bottle, the following materials are options:

Table 10: Materials of Water Bottle

Material	Pros	Cons
Glass[1]	• Retains purity of taste • Easy to clean • Dishwasher safe	• Easily breakable • Doesn't insulate well • Can be expensive
Stainless Steel[2]	• Easy to wash and can use high temperatures to clean if needed • Bottles are safe to drink from and are BPA and Phthalate free • Easy to recycle if necessary • Long lasting • Can hold both hot and cold liquids	• Sometimes there's a metallic taste to the water • Bottle can dent if dropped • Paint sometimes peels off of the exterior of metal bottles
Aluminum[3]	• Easily recyclable • Odor resistant • Protect water from light	• Typically lined with plastic • Dents easily

	• Fairly lightweight	• Not dishwasher safe
BPA Free Plastic[3]	• Lightweight • Dishwasher safe • Cost less	• Not very insulated • May leak chemicals into bottle

Sources:

[1]Kilroy, D. S. (2019, August 19). Advantages of glass bottles over plastic become clear. Retrieved February 25, 2020, from https://www.chicagotribune.com/lifestyles/health/chi-glass-bottles-advantage20140331-story.html

[2]Coronado, S. (2013, January 30). Home. Retrieved February 25, 2020, from https://shawnacoronado.com/stainless-steel-water-bottle-pros-and-cons/

[3]Casper, M. (2018, July 5). What's the Best Type of Reusable Water Bottle? Retrieved February 25, 2020, from https://www.nourishedbite.com/nourishedbite/whats-the-best-type-of- water-bottle

We have decided to manufacture the body of *The Bottle* from stainless steel because it is the most practical option for this product because of the pros listed above.

The next part of the water bottle will be the cap which has several components in itself including the solar panel, the air filter, the condenser and the water filter.

Solar panels are made up of multiple smaller solar cells, which absorb the light and turn it into electricity. The solar cells can be made up of Monocrystalline cells, Polycrystalline solar cells, or Thin Film solar cells. Monocrystalline cells are made of single crystalline silicon and are often colored and shaped cylindrically. These are the highest quality of the three. They are usually cut into this shape in an effort to make them more efficient (What is a Solar Cell Made Up of?). Polycrystalline solar cells don't need to be cut into their shape. Instead, they are moulded into squares after being melted, which gives them their perfect cube shape. This material results in less waste compared to the monocrystalline cells and is therefore considered to be midrange in terms of price and efficiency (What is a Solar Cell Made Up of?). Thin Film solar cells are created by placing multiple thin layers of photovoltaic on top of each other. There are a few different types including Amorphous silicon, Cadmium telluride, Copper indium gallium selenide, and Organic PV cells. The main difference is that they use different materials for the PV layers. These tend to be the most affordable option, but the least efficient in terms of energy (What is a Solar Cell Made Up of?). We choose to use polycrystalline solar cells in our solar panels in *The Bottle* because they are the best intermediate option with their affordability and medium level cost.

Table 11: Summary of the 3 Types of Solar Cells

Solar panel type	Advantages	Disadvantages
Monocrystalline	• High efficiency/performance • Aesthetics	• Higher costs
Polycrystalline	• Low cost	• Lower efficiency/performance
Thin-film	• Portable and flexible • Lightweight • Aesthetics	• Lowest efficiency/performance

Source: Types of Solar Panels, 2020

The next part of *The Bottle* is the air filter, which will be used to filter out any dust particles in the air to produce clean water. The two main options for air filters include the electrostatic polypropylene air filter and the nonwoven polyester air filter. Of the two main types of filters, we will be using the electrostatic polypropylene air filter because that filter is more compatible with the design. The electrostatic air filter creates energy as the air enters. The air then goes through the ionizers that are placed there and the charged particles send the dirty air particles towards the collector. This works well for *The Bottle* because the cleaned air can then go towards the rest of the parts (Simply The Best AC & Heating, 2019). The nonwoven polyester air filter contains many fibers randomly dispersed in different directions through an air laid web to form a uniform filter of high strength and durability. However, this will not fit well with *The Bottle* because these filters are not washable (Permatron).

Next, there is the condenser. In most water condensers, the most commonly used metals include copper–nickel alloys and stainless steel. The copper nickel alloys have a better heat transfer capacity than its alternative. In addition, it is also more resistant to corrosion than stainless steel. But, stainless steel is more resistant to ammonia corrosion. However in this case, that is irrelevant because ammonia should not be an issue. Therefore, we will be using the copper nickel alloys to make the condenser because it is the most viable option for *The Bottle* (Materials Selection, 2019).

The final part of the air to water condenser is the water filter. The water filter would be set up in a similar way to the Brita filters. These filters usually use activated carbon and ion-exchange resin similar to the air filtration system. The activated carbon part of the filter would be made from coconut shells and its primary purpose would be to clean and remove any substances that may impair taste. On the other hand, the ion exchange resin is meant to reduce the hardness of the water and any possible traces of copper from the condenser (Brita FAQ).

TESTING AND QUALITY ASSURANCE

Because *The Bottle* has many components to it, it must be tested in numerous ways to ensure quality and safety. The market for this bottle is nature enthusiasts, climbers, and hikers, so *The Bottle* will be exposed to very unique and unforgiving environments that it must withstand. We must test the endurance and strength of the bottle itself, the hygiene and safety of the drinking water it produces, and the electrical components in the cap. Water bottle tests are very observation based and qualitatively measured because more standards are for consumer experience than bottle safety (it is hard to make a water bottle unsafe).

(1) Pressure test: Because *The Bottle* is for nature enthusiasts, it must be durable at very high and low altitudes. Fluctuating pressures can often affect the form and seal of a container. We will put it through high and low pressures and make sure it does not affect the form or functionality of it.

(2) Drop tests: We will drop the bottle from multiple heights on multiple surfaces including rock, ice water, trees and bushes, and dirt. *The Bottle*'s most important quality (other than producing water) will be its physical durability because of the market we are targeting. We expect it to withstand a drop up to 200 ft.

(3) Shake tests: We will perform a simple shake test to make sure water does not leak from the multiple components on *The Bottle*.

(4) Temperature Test: Since the product will be exposed to extreme and varying environments, we must make sure the materials it is made of does not degrade at different temperatures. This includes both the endurance and functionality of it. Sometimes electronic components do not work as well in extremely cold or hot environments. We will expose the bottle to multiple temperatures and make sure it works up to standard in each one.

(5) Poor air quality test: It is crucial that our product can produce *clean* drinking water in any environment. Since the water comes from the air, poor air quality could potentially contaminate the water. We will test *The Bottle*'s functionality in areas with very poor air quality or simulated environments of poor air quality. Then, we will test the produced water to make sure it follows the EPA's standards of clean drinking water.

(6) Dry air test: Since *The Bottle's* functionality is dependent on the air in the atmosphere, we must test its functionality in dry environments where there is less water in the air. It must still produce clean drinking water (but may do it at a slower rate).

(7) Electrical Test: Since the electrical components of this bottle will be frequently exposed to water, we must ensure they are properly sealed or water proof. We will remove the components from the cap, soak them in water, and test to make sure the bottle still works. Consumers are encouraged to not fully submerge these components in water, but we must test to make sure they still work in that situation.

Although we will set *The Bottle* to regular high standards, the consumer must regularly wash the bottle and replace the cap. It requires proper maintenance in order to perform correctly.

Conclusion

Overall, *The Bottle* is designed to serve as a solution to the people with limited water sources. It is portable, convenient, and uses a renewable source of energy. *The Bottle* generates drinking water by drawing in water vapor in the air and condensing the vapor in the air. There are air and water filters throughout *The Bottle* to turn water created from water vapor into clean drinking water. This product ensures water security and allows nature enthusiasts across the globe to explore without limits.

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