SIFTAIR SUSTAINABLE AIR FILTRATION SYSTEM

BIOMIMETIC DESIGN ASSIGNMENT 12.1

NOVEMBER 17, 2019

PROBLEM STATEMENT

339 million people suffer from asthma worldwide and it's a leading chronic condition in children, making air pollution a major threat for humanity today. "While we've made progress over the last 40-plus years improving air quality in the U.S. thanks to the Clean Air Act, climate change will make it harder in the future to meet pollution standards, which are designed to protect health," says Kim Knowlton, senior scientist and deputy director of the NRDC Science Center.

There is also a racial divide that comes into play concerning asthma and air quality. Risk of developing asthma can be traced to genetics and environmental factors, and African Americans and Hispanics have significantly higher asthma rates than whites. This also leads to them having a significantly higher rate of doctor visits and hospitalizations as a result of asthma and asthma related complications.

1 Global Asthma Network. The Global Asthma Report 2018. Accessed October 19, 2019. www.globalasthmareport.org.

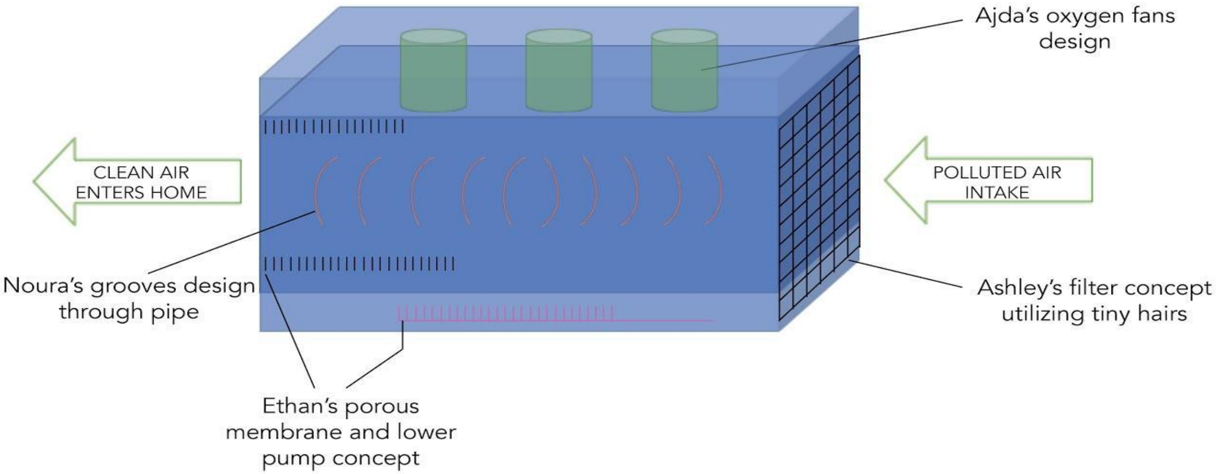
2 Asthma and Allergy Foundation of America. Ethnic Disparities in Asthma. Accessed October 19, 2019. www.aafa.org.

3 Mackenzie, Jill. "Air Pollution: Everything You Need to Know." NDRC, November 1, 2016 https://www.nrdc.org/stories/air-pollution-everything-you-need-know.

DESIGN OBJECTIVE

This project explores air filtration and how to improve air quality in our homes and buildings. There are many health risks associated with poor air quality, especially in major metropolitan areas where air quality is lowest. Designing a more effective air filter will help people lead healthier lives. Furthermore, making an air filter that doesn't need replacing will lead to more money in consumers' pockets, and less waste in our landfills.

Traditional air filters are single use and get discarded after being used for only one to three months, on average, and ultimately end up in landfills. Not to mention, the costs add up and those who need them most often can't afford them. Improving air quality and making effective air filtration is a more sustainable choice for the environment, will lead to healthier living conditions, and will help to reduce racial disparities in health.



DESIGN SOLUTION

This air purifier design removes VOCs (Volatile Organic Compounds) from the air. It pulls air in from outside, cleans the air, and pushes the air into the living space. The filter is low maintenance, low cost, and requires minimal upkeep to function well. By combining aspects of our four designs together, we've created a unique design that can be installed either within the home, or as an addition onto an outdoor AC unit. It filters the air efficiently utilizing this unique variety of filtration methods.

Materials: Stainless steel for pipes, Luffa plant fibers for filter.

PROCESS OVERVIEW

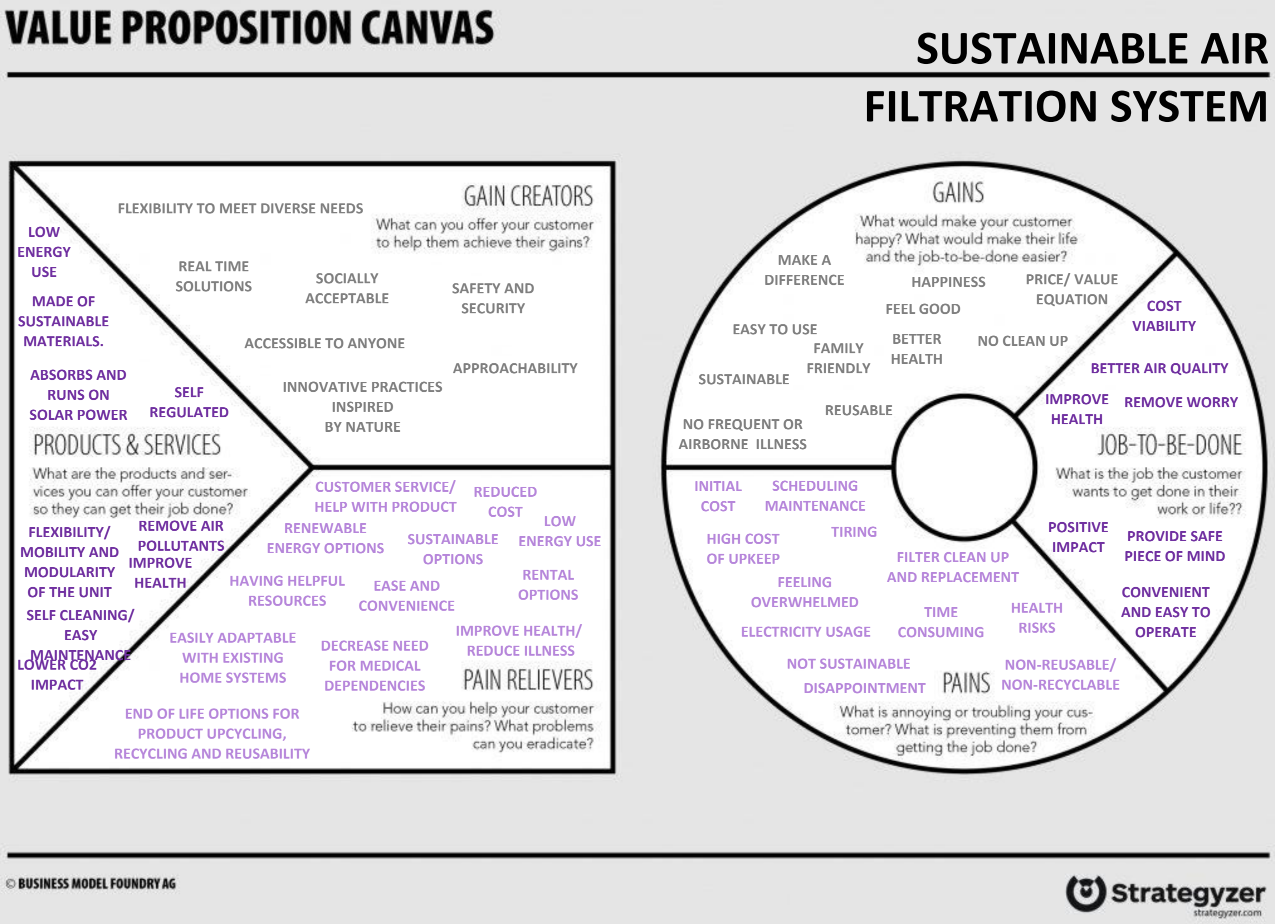
When designing the SiftAir filtration system we took necessary precautions to ensure that dust and hazardous chemicals do not enter homes and leave odors and fumes that could potentially harm our customers. We looked back at Mother Nature for inspiration and examined the functions of respiration found all around us.

BUILDING THE BUSINESS CASE

There is an urgent need to manage downside risks of air pollution and create shared value by incorporating sustainable solutions for all stakeholders, including the environment.

Our team examined current forms of air filtration and did an empathy exercise to understand our core consumer and define their needs and values. We identified families around the world to be our most concerned consumers as they want to improve living conditions for their children and themselves.

This exercise helped us define the most important needs our consumers expected to be solved. Additionally we discovered and prioritized opportunities our air filter design needed to meet in order to deliver those positive results for our target audience.



SCOPING PROCESS

The next steps in our process of discovery included translating our consumers' needs into biological terms and utilizing strategies found in nature for implementation in our design.

How might we…? → How does Nature…?

PROBLEM: CURRENTLY AIR FILTERS

APPROACH: DESIGN TO EMULATE STRATEGIES FOUND IN NATURE TO

USE A LOT OF ENERGY	→	RUN ON MINIMAL ENERGY
ARE EXPENSIVE	→	SELF CLEAN AND BE REUSABLE
ARE INEFFECTIVE	→	USE OPTIMAL DESIGN FEATURES FOR BETTER AIR FILTRATION

PROBLEM: ENERGY USE AND DEPENDENCE
BIOLOGICAL INSPIRATION: ABILITY TO COLLECT AND STORE MORE ENERGY THAN NEEDED

There are a couple of different animals that can survive in harsh environment by hibernating for a period of time. They can perform low level motor functions with minimal energy. Spotted Turtles and Whale Sharks are just two examples of such animals.

The Spotted Turtle is an energy utilization specialist and is great specifically in their ability to sustain life while conserving stored energy for long periods of time. The spotted turtle has an ability to survive an entire winter at the bottom of a body of water at freezing temperatures. The turtles do this by shutting down their entire system and only using enough stored oxygen and energy needed to run the most vital organs.

On the other hand, the Whale Shark is the only filter feeding shark that can feed while stationary. By opening and closing their mouths, whale sharks create suction, drawing snack-filled water into their mouths. As water filled with nutrients and food runs through and is expelled out of the shark's gills, the food is trapped in 20 spongy filter pads inside their throats.

How were nature's unifying patterns considered?

The desired strategy emulated in our air filter design is the ability of both the Spotted Turtle's and the Whale Shark's abilities to operate at an absolute minimum.

The filter will circulate and purify air while absorbing and grabbing the air pollutants from the air. The power air pump will run on low energy that can absorb air when needed and shut off when not.

Evidence:

https://asknature.org/strategy/specialized-gills-filter-plankton/

https://www.sharksider.com/whale-shark-diet/

https://en.wikipedia.org/wiki/Whale_shark

PROBLEM: SHORT LIFESPAN BIOLOGICAL INSPIRATION:

What can we learn from Mother Nature when it comes to keeping surfaces and air in our homes clean? She provides us with lots of low-energy, non-toxic ideas for staying clean. Usually, she favors “structural” solutions over chemical or energetic ones.

For example, the unique shape of the cells that make up the pansy flower petal are cone shaped. Cone shapes allow for the ability to utilize gravity’s pull. Water that lands at the top of a cone will naturally fall down all sides of the cone, taking dirt and debris with it as it goes. The water droplet will also then have momentum as it moves down to not just land on the petal but move beyond and off of it. This works for the pansy flower in keeping the surface clean and capable of capturing light. It can’t afford to allow dirt to restrict the amount of light to get in, a it’s needed for photosynthesis and the survival of the plant.

Hairs are used as the material for the pads of the feet because it allows for the same overall function that a solid foot would provide, as far as distributing weight and allowing for movement. However, because it uses small hairs the actual surface is broken up into tiny parts. These small parts are then able to shake the dirt off far more easily than were the feet to be a solid piece of material. Insect’s hairy foot pads are able to clean themselves easily and effectively due to the small surface area of the hairs and using the insect's natural movement to shake dirt off.

How were nature’s unifying patterns considered?

The pansy flower petal was considered in the design of the fibrous filter component because of its unique cone shaped cells. Due to the unique shape and angle, anytime it rains water droplets attach to the dirt and utilize gravity’s pull to naturally whisk away and fall to the ground. So here, we’ve mimicked how nature uses shape to determine functionality.

There are millions of tiny hairs on an insect’s feet, and the hairs utilize natural movement and vibration to clean themselves. Here, we’ve mimicked how nature relies on feely available energy to function.

Evidence:

- https://www.researchgate.net/publication/51697484_Hierarchically_structured_superhydrophobic_flowers_with_low_hysteresis_of_the_wild_pansy_Viola_tricolor_-_new_design_principles_for_biomimetic_materials
- https://www.sciencefriday.com/segments/microscopic-hairs-keep-some-critters-clean/

PROBLEM: STRUCTURAL DESIGN
BIOLOGICAL INSPIRATION: FILTRATION INSIDE THE BASKING SHARKS MOUTH

The Basking Shark has the biggest mouth of any shark in the ocean. The second largest shark in the world lives in cool water during the summer and warm water during the winter that is full of plankton. The Basking Shark opens its wide mouth, plankton is brought inside and filtered through its gills called gill rakers. This is their strategy used for feeding and so particles don't clog up by accumulating on the surface of their mouth.

The filtering structures function as cross- flow filtration. As plankton gets sucked in, it moves parallel to the grooves. The plankton gets fed on and access water gets redirected into the grooves of its mouth and exits through the gill rakers carrying other small particles not needed with it.

" As water flows into the grooves, it interacts with the edge of the gill arch and rolls up into a region of swirling water called a vortex. This vortex stays within the groove and helps prevent clogging by forcing food particles to aggregate at the corners of the groove or stay suspended in the swirling water. This keeps particles out of the way of the porous gill raker surface where water exits." (Ask nature)

How were nature's unifying patterns considered?

The groove shape from the basking shark's interior mouth was considered as a pattern to allow for filtration.

Cross-flow filtration is a technique the basking shark uses for filtration. "Cross flow filtration is when the flow is applied tangentially across the membrane surface. As feed flows across the membrane surface, filtrate passes through while concentrate accumulates at the opposite end of the membrane. The tangential flow of the membrane creates a shearing effect on the surface of the membrane, which in turn reduces fouling." (Synderfilteration)

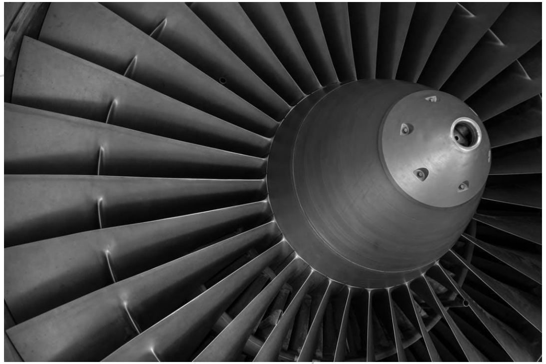
This has been used to inspire filters, turbines, biomedical and polymeric membrane technology.

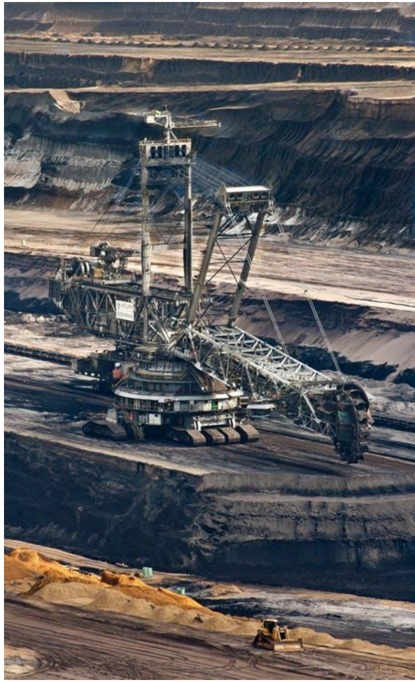
Evidence:

- https://asknature.org/idea/strait-power/#.Xc-TgTJKhp8
- https://oceanbites.org/fish-help-design-better-filters/
- https://synderfiltration.com/learning-center/articles/module-configurations-process/cross-flow-membrane-operations/

CURRENT DESIGN LIMITATIONS

- A prototype to be made for engineering tests to be implemented
- The best location for the filtration system, this would have to be tested in order to find out where it works best
- Material would have to be experimented on to find the most efficient sustainable material for the design to be implemented back into the circular economy
- Unknow: cost of manufacture, current infrastructure and location, CO2 impact
- Raw Materials: some are recyclable but not all are renewable (Materials: Stainless steel for pipes, Luffa plant fibers for filter)





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We are a collection of students working towards a Master's Degree is Sustainable Design from MCAD. We live all over the world - The UAE, Hungary, and the United States. Our combined experiences, diverse backgrounds, and varied professional design experiences provide us with a unique take on design solutions.

THANK YOU

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