ENGR 100H: Final Project Report

Algae Roof Tiles

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Product Summary:

For our project, we envision a product that will utilize a natural process of carbon sequestration to capture carbon dioxide in the air and contribute to cooling buildings. Our product idea is to create roof tiles and panels that contain algae that remove carbon dioxide from the atmosphere. The product would be a thin box filled with algae and water that is exposed to sunlight and the atmosphere. Our product would help the problem of growing global temperatures caused by climate change by sequestering carbon dioxide and cooling buildings. Our end-users would be the owners of buildings who want to pay less on their monthly cooling costs and decrease the carbon footprint of their buildings.

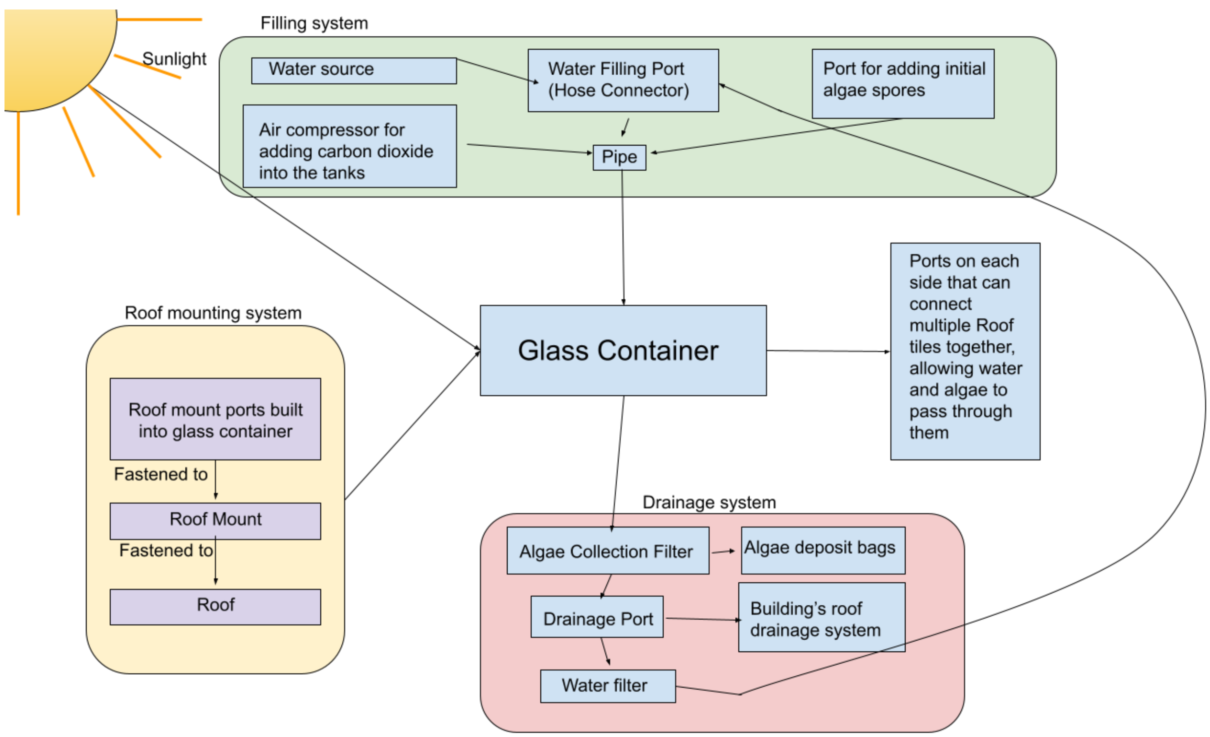
Users and Stakeholders:

Our algae roof tile product attracts those who value sustainability and saving energy, thus our end-users are owners of buildings who want to pay less on their monthly cooling costs and decrease the carbon footprint of their buildings. This includes commercial consumers, such as large companies, and private homeowners. Their feature needs are similar, as they both require an environmentally sustainable product to decrease their carbon footprint. Private homeowners prioritize aesthetics more than commercial consumers. Commercial consumers have more space to house the drainage and storage system for the algae. Our stakeholders include big corporations that are looking to offset their carbon emissions. Additionally, manufacturing companies, algae farmers, and glass producers are all stakeholders in the manufacturing component of our product. They each supply the necessary materials for production of the algae roof tiles. In terms of sales, end-user customers are also stakeholders, as they ultimately decide the success of the product through their purchase.

Functional Description:

Our product primarily uses a glass container filled with water and algae to remove CO_2 from the atmosphere. The system is built on a mounting system to allow for more modularity and to implement any necessary equipment underneath the tiles. To get the CO_2 and water into the system, there is a pipe that connects to the tile. The pipe connects to an air compressor, a water tank, and a third port in case more algae is added into the system. The glass container has holes to allow air to enter and allow for the algae to perform photosynthesis. The algae will then absorb the CO_2 being pumped into the system and convert it into oxygen and biomass. With biomass being a byproduct, a drainage system is implemented underneath the tiles in order to remove the additional algae not needed in the system. This drainage system will also allow for the water to be recycled back into the system. We also added sealable ports on the sides to allow for multiple tiles to be connected together.

Block Diagram:



System Requirements:

Our high-level system requirements are summarized in the table below.

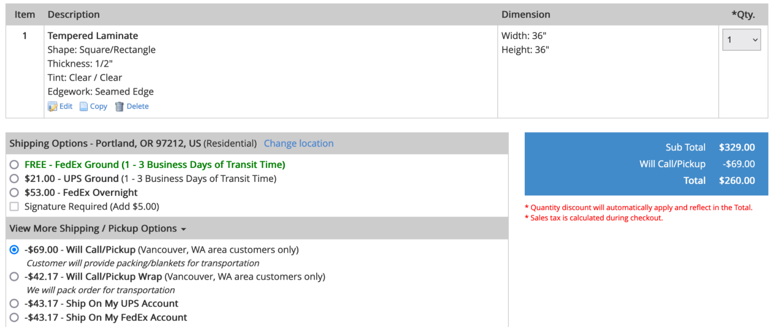
#	Requirement Type	Requirement Description	Planned Test

1	Functional	The tile should be strong enough to withstand a lot of snow and rain	Test the tile by putting it under 4 feet of snow. If it can withstand this amount of snow, it can withstand any amount of rain.
2	Functional	The tile should be strong enough to withstand strong hail as well as any potential small objects that could strike the tiles	Test the tile by dropping a bunch of small metal bearings on it to simulate hail and make sure it doesn't sustain any damage
3	Non-functional	Needs to be the right size, big enough so that we don't need too many tiles for a roof, but not so big that they are hard to install	The final size for the tile should be 3 ft by 3 ft by 0.5 feet deep.
4	Non-functional	Needs to weigh about the same as a solar panel so that we know that buildings can support the tile	Should be <4 pounds per square ft in weight, can be weighed using a digital scale with a resolution of 0.1 pounds.
5	Functional	Needs to be easily serviceable to replace old water and get rid of old algae	Should have a valve and filter to allow drainage of water and algae
6	Functional	Needs to be able to refill water and algae easily	Should have a hose that can easily fill the tanks with water as well as the air that contains the needed carbon dioxide
7	Non-functional	The tile needs to be somewhat visually appealing, or at least not visually unappealing	Should go through multiple iterations to find the iteration that looks the most appealing and has the highest chance to not look ugly.
8	Functional	The tile housing/container needs to be clear to allow sunlight through	Test by shining light through the tile housing to see if the light makes it through the container

9	Functional	The design should be tileable so that it can be easily expanded with more units	By putting ports on each side for a connection, we allow for two tiles to be put together so that they both work to absorb CO_2. We can test a 3x3 configuration to fully test that capability
10	Functional	Should require as little maintenance as possible	By having a water filter, we can recycle the water so that it doesn't need to be refilled very often. We can test running a tile for a week, see how much water we need to add to the system to keep it running, and this should be less than 0.1 ft^3 over the course of the week.

Budget:

Budget Item	Requirement Description	Budget Item Total (for 6 months)
Mechanical Engineer	We estimate that it would take one mechanical engineer about 16 weeks to complete 5 prototypes of our product. We estimate around 4 weeks for design and planning, which would mostly be using software tools to create mockups of the product. It would take the engineer 8 weeks to develop and build the first prototype of the product. We also estimate that it would take 4 weeks to build and test all 4 of the remaining prototypes. Using the median hourly wage of a mechanical engineer of $ 48.47 (from the bureau of labor statistics), and assuming the engineer is working an average of 40 hours per week. We estimate the cost of hiring an engineer to be 40 * 16 * $48.47 = $31020.8	$31,020.8
Glass	We estimate that we will need ~ 150ft^2 of 0.5in thick tempered laminate glass panes. We need tempered glass so the glass can support the weight and pressure of the water, and laminate so it doesn't break as easily if anything falls on it. We calculated the ~ 150ft^2 by calculating the surface area of the glass of each box, which will be 36 x 36 inches and 6 inches tall, multiplying it by 5 for each box, and adding 30ft^2 for margin of error in case we break any in manufacturing. We found a supplier in Portland that waives all delivery fees for local pickup here.	$13,000

		
Piping	We estimate that we will need ~ 2.5ft of 1.5in wide pvc piping for each box. This means we need 12.5ft of 1.5inch wide pvc pipe total, which we will round up to 15 ft total to account for potential errors. Here is a product at home depot that is more than we need for $64.	$64
Air compressor	We estimate that we would need one air compressor for each tile, but they do not need to be very powerful since they would only be necessary when we are refilling the tanks with air so the algae can filter out the carbon dioxide. Here is a cheap air compressor on amazon that we could repurpose for our product. The compressor is $27 * 5 = 135	$135
Filters	We need a water filter for each tile so the drained water can be reused. We don't think we need a very high-tech system as algae doesn't need to grow in pristine water. Here is a water filter that is intended for use in the kitchen that we could repurpose for our tile.	$175
Mesh netting	We estimate that we would need ~ 1 ft^2 of mesh netting per tile. This is to filter out the algae when the tile is draining completely. Here is more than enough mesh netting on Amazon for ~ $10	$10
Mounting system	We plan for each tile to have a mounting system that attaches it to the roof. Each tile would have around 6-12 inches of clearance from the roof to hide all the piping, filtering, air compressors, and mounting equipment so the only part of the product that sees daylight is the algae tank, maximizing the surface area that the algae has to absorb sunlight. Our mounting system would likely have to be custom. We've estimated that we would need ~ 200 inches of steel tubing to support each tile, which we can buy at home depot for ~ $400 for all 5 tiles and various fasteners, clamps, and screws.	$400
PVC fasteners	We need at least 10 of these for $9.60, 5 of these for $17.2, and 5 of these for $13.45.	$40.25
Total		**$44845.05**

Timeline:

Here we summarize the planned schedule for utilizing the provided six-month timeline to include design, development, testing, and final assembly and deployment of the algae roof tiles. We described the planned activities and outcome for each of these six months.

Month 1:

In the first month, our team would design the algae roof tiles. Our planned activities include expanding on the block diagram and researching user needs. Our planned outcome is a final plan of the algae roof tile prototype that is in line with the needs of our end-users.

Month 2:

In the second month, our team would develop the algae roof tiles. Our planned activities include gathering the necessary supplies from manufacturers, and building and iterating each prototype of the roof tiles. Our planned outcome is to have two developed prototypes done, with one in progress.

Month 3:

In the third month, our team would develop the algae roof tiles. Our planned activities include gathering the necessary supplies from manufacturers, and building and iterating each prototype of the roof tiles. Our planned outcome is to have all five developed prototypes finished and ready for testing.

Month 4:

In the fourth month, our team would conduct tests for the algae roof tiles. Our planned activities include testing each prototype in order to evaluate its performance. Then, we will focus on improving any weaknesses and look for ways to cut down costs.

Month 5:

In the fifth month, our team would finally assemble the algae roof tiles. Our planned activities include mass production of the final prototype of the roof tiles and finding potential investors. Our planned outcome is to have our product ready to deploy.

Month 6:

In the sixth month, our team would deploy the algae roof tiles. Our planned activities include acquiring customers and installing the final product. Our planned outcome is to have a few customers we can use for reviews, in order to further improve our product.

Product Competitors:

There currently is no equivalent item on the market that is comparable to our product idea. The most similar product to ours, and the most likely to directly compete with ours, is solar panels. Solar tile roofs are a product that have been around for a little over a decade now, and they offer clear advantages over regular roofs, like our algae roof tiles do. Solar panels in general, not just solar roofs, also compete with our product, as both of our products take up roof space and need sunlight to function. Having both an algae roof and a solar panel would be counterproductive, and so consumers would need to choose between the two options. The advantages of a solar roof are more self-evident than the advantages of an algae roof. A solar roof, or solar panels mounted on your roof, can directly power your home and reduce your electricity bill. The algae roof doesn't have this direct effect, as it isn't designed to generate power. One major difference, however, is that our tiles are aiming at a very different price point, which is hopefully much cheaper than solar.

Conclusion:

In the future, we would like to explore options of making these tiles applicable with other devices that lead to a green future. We think making a way for these tiles to link up with solar panels would be a very great way to expand our business. With leftover funds, we would like to push for getting interviews with people who could give their insight on where to make our product better, and how to market it to the companies we think are best suited for it. We also think that we should expand the ecosystem of our product to make it an option for buildings without flat roofs, or even use this technology for stand alone projects that are not attached to buildings. We think after a prototype is built we will evaluate the points that need improvements and focus on making the weaknesses less apparent. Building off of that we will account for potential ways to cut down costs after a prototype shows that this product is fully functional the way we intended it.