

# Environmental Sensing Invention

Checkpoint 1

**Team 301:**

Timothy Drafz  
Salsabil Soliman  
Fatema Alshehhi  
Sivanee Naghichetty

**Arizona State University**  
**EGR 314**  
**Prof. Travis Kelley**

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# 1.0 Team Organization

## 1.1 Charter

As a team, we are planning on applying all the knowledge we gained in electrical and mechanical skills into a new product. Our team will put full effort into designing a new environmental sensing product that aids users and is user friendly.

For goals our group would like to:

- Create a product that real world customers would consider using.
- Build a high value and efficient product and to be easy to manufacture and access for the user.
- Focus on our users and make our product easy to understand and use.
- Create a new design/idea in the environmental field that focuses on solving a real challenge.
- Challenge ourselves to design and build something that could be included on a resumé.

## 1.2 Product Mission Statement

Our team mission statement is to improve the clean energy generation industry, specifically solar energy, and make it more efficient so that users are able to get the most benefit from their solar energy source.

When coming up with the charter and mission statement for our team we discussed what we wanted our goals to be first. Once we had an idea for some of our goals we looked at the project requirements and thought of what we may want our mission statement and charter to be. When discussing this we wanted to make sure we emphasized the user friendliness aspect of a product since we felt that would be one of the most crucial parts of any design we made. After forming the charter we then specified our mission statement down to solar energy efficiency. This was because we started to develop an idea of where we may want our actual design to be, and what was actually achievable in the semester.

## 2.0 User Needs, Benchmarking and Requirements

Starting our project by benchmarking all the liked products from the markets that have specific features. As a team we were looking for existing products that sense the environment and take action according to the data gathered. Moreover, our main process to help us find these products was benchmarking. After every team member finished their benchmarking we started looking for the positive and negative reviews in order to take a look at the challenges that are already in the market. Our goal is to solve one of the issues that will help the environment positively, not only that take data from it. Based on that we gathered 60 user needs and as a team we added 40 more in a brainstorming session. After that, the user needs were categorized into two main groups which are efficiency and user interactions. Next we ranked them from one to 3 which one is the most important need. Below you will go over our steps.

### 2.1 Voice Of Customers

#### Benchmarking

##### **Product #1** [Robot Vacuum](#)

**Keyword:** Cleaning Robot

**Search Result Link:** [Link](#)



- Price: \$159.99
- Vendor: YunIntel on amazon
- Description: 2700Pa Strong Suction, Super-Thin Robotic Vacuum Cleaner, Compatible with Alexa, Clean Schedule, Self-Charging, Ideal for Pet Hair, Hard Floor, Medium-Pile Carpet

Positive comments:

Voice of the customer	Restated customer needs
This vacuum works great on thick carpet with multiple rugs. I was extremely surprised to see that it balances having solid suction power while not tearing up fringes on my multiple Moroccan rugs. On one cycle, it only gets caught maybe once and that's only if it's an unusual object in the way (like a rubber bottle). It does occasionally flip one of the corners of the rugs but far better than I thought it would do.	<ol style="list-style-type: none"> <li>1. Have to work on different environment/surface (explicit)</li> <li>2. Doesn't lose power quickly (explicit)</li> <li>3. Does not corrupt/damage the surface (explicit)</li> <li>4. Solid balance (explicit)</li> <li>5. Knows how to process data and act when unusual object was on the way (latent)</li> </ol>
I looked at others twice to three times as much and saw the reviews on this one. I kid you not when I say this vacuum saved me sanity. The programmable times and the fact that I can set barriers is a perk.	<ol style="list-style-type: none"> <li>1. Good reviews/reputation (explicit)</li> <li>2. Ability to control the working time (explicit)</li> <li>3. Control the space in where it is working (explicit)</li> </ol>
I love this vacuum, especially for the price. This is my first robot vacuum so I cannot compare, but the amount of dirt it gets out of my carpet and floors is awesome. My kids even gave the vacuum a name. I use it almost everyday. It really does help when you are trying to multitask. I wish it had a longer battery, it lasts a little under an hour for my first floor because it does bump into a few things.	<ol style="list-style-type: none"> <li>1. Competitive price (explicit)</li> <li>2. Efficient work (latent)</li> <li>3. The ability to do daily work (latent)</li> <li>4. Need longer battery life (explicit)</li> <li>5. Efficient battery use (latent)</li> </ol>

Negative comments:

Voice of the customer	Restated customer needs
<p>This was difficult to set up on internet. We had to literally be right next to the router. The unit gets stuck under furniture or hung up on the tiniest things often. The time I spend rescuing it, defeats the purpose of having</p>	<ol style="list-style-type: none"> <li>1. Need to be easy to set up (explicit)</li> <li>2. Should be able to process data correctly as it should (latent)</li> <li>3. Should have less programming errors (latent)</li> <li>4. Should not waste users time and should meet the purpose that it was made for (explicit)</li> </ol>
<p>I was fairly pleased with this vacuum when I first received it; however the suction stopped working after 6 weeks of use. I contacted support who stated I would receive a replacement within 2-3 days, but it's been over a week and I haven't received either the replacement or a refund. Contacted support again. Replacement they promised was never sent so I requested a refund which was processed within a few hours.</p> <p>Update: support contacted me the day after. They also sent a new vacuum even though I had received refund. New vacuum received in 2 days.</p> <p>Update: replacement vacuum has stopped working.</p> <p>ALSO, company told me they would give me a \$25 gift card if I changed my review to 5 stars which I declined</p>	<ol style="list-style-type: none"> <li>1. Should last as long as it should, it worked for only 6 months (explicit)</li> <li>2. The replacement should be tested/inspected before giving it to the user (explicit)</li> <li>3. Should not have failure parts in more than one product/ all of the product line (latent)</li> </ol>

I've had this for a few months now and it was perfect. Up until it started just dying on its own in the middle of the floor and not turning on at all. Previously it would say when the battery is low and then go put itself on the charger. Now it just dies wherever it wants to and I find it later. It's only been a few months, this thing is going in the garbage.

1. Should have better feedback like showing battery remaining (explicit)
2. The product should not fail and turn on or show what type of error occurs as a feedback (explicit)
3. The battery life should not be getting shorter (latent)
4. Fixing programming issues (latent)

- Summary: We chose this product because we were thinking of a product that can sense the wind speed and temperature to calculate when and where to clean the solar panels. This is a cleaning robot which has a similar concept as our idea.

## Product #2 [Cleaning Robot](#)

**Keywords:** Cleaning Robot Solar

**Search Results Link:** [Link](#)



- Price: \$ 499
- Vendor: Home Robot LLC on Amazon
- Description: HOBOT-2S Window Cleaning Automatic Smart Robot with Dual Ultrasonic Water Spray and Control via Smartphone or Remote

Positive comments:

Voice of the customer	Restated customer needs
I found that the Hobot 2S was very easy to use. It works best on a window that is not filthy. The cleaning cloth only cleans a small amount of dirt before you need a clean one to replace it. I ordered 3 more cleaning pads and may end up ordering more. Once the dirty to clean ratio of the cleaning cloth is to the clean side, it does a great job and doesn't leave streaks on the window. I think it will be my window bot friend for a long time. I am quite happy with the job that it does.	<ol style="list-style-type: none"> <li>1. The product should be easy to use/ user friendly (latent)</li> <li>2. The product should work on multi dirt levels areas not just light (latent)</li> <li>3. The cleaning area should be bigger/wider (explicit)</li> <li>4. Would be better if it need replacement after working for a longer time (latent)</li> </ol>

<p>Amazing technology in a brilliant device!</p> <p>I live near a new construction project which spreads filth everywhere. On top of that, My windows haven't been cleaned for 2 years due to the pandemic.</p> <p>I was not expecting too much given the amount of dust and dirt on my windows but it worked like a charm!</p> <p>A few considerations:</p> <ol style="list-style-type: none"> <li>1. Make sure you manage your expectations by understanding what you need to do to make your robot successful. This robot needs more user interaction than a vacuum cleaning robot.</li> </ol>	<ol style="list-style-type: none"> <li>1. Smart technology/algorithm for user need and interaction (explicit)</li> <li>2. The product worked on a high dirt level surface (explicit)</li> <li>3. Improving user-robot interaction experience (latent)</li> <li>4. The robot need to be able to act by itself (latent)</li> </ol>
<p>I really like the new robot. The detergent itself is sprayed over the window, there is no need to wet the napkins. I clean windows every six months, now I can do it often. No stains! I like it!!</p>	<ol style="list-style-type: none"> <li>1. Cleaning product/water spray (explicit)</li> <li>2. The robot left no stains after cleaning (explicit)</li> <li>3. Can be used frequently (explicit)</li> </ol>

Negative comments:

Voice of the customer	Restated customer needs
<p>The device is insufficiency designed. Can't map out a window and therefore creates inconsistent pathways and incomplete cleaning. Gets stuck/confused against simple linear surfaces.</p>	<ol style="list-style-type: none"> <li>1. Design improvement is needed (explicit)</li> <li>2. Should be able to map out the area and create consistent pathways (explicit)</li> <li>3. The algorithm/coding need to be fixed as it gets stuck/confused against simple linear surfaces (explicit)</li> </ol>

<p>Does not clean 100% on all windows. The outside of my windows have a bezeled edge and it has trouble knowing where the edge of the window is which causes it to miss cleaning about 5% of the window. The inside of my windows are better but it can still miss corners and the very top and bottom.</p> <p>I feel like the cleaning patterns could be a little smarter around edges and corners of windows. Hopefully that improves with software updates.</p> <p>It's a bit pricey for not reliably cleaning 100% of the window.</p>	<ol style="list-style-type: none"> <li>1. Should be able to identify and mark the edges of the area (explicit)</li> <li>2. Should not miss areas and be able to clean the entire surface (explicit)</li> <li>3. The cleaning patterns should be improved/smarter (explicit)</li> <li>4. The prices should be reasonable for the technology and services it provides (latent)</li> </ol>
<p>It starts cleaning but never goes up. just goes down. the previous version was much better. it worked and cleaned glasses and windows. unfortunately this version seems to have an issue with the rotor band.</p>	<ol style="list-style-type: none"> <li>1. Should be able to move in any direction needed (explicit)</li> <li>2. Should use a reliable materials (latent)</li> <li>3. Should be able to operate efficiently in various conditions (latent)</li> </ol>

- Summary: For this second product search we found that window cleaning is similar to the solar panels. As it is in a vertical position therefore it shows how the robot should be able to efficiently move and operate in various directions against gravity.

### **Product #3 Sophinique Robot**

**Keywords:** Window Cleaning Robot

**Search Results Link:** [Link](#)



- Price: \$199.99
- Vendor: Sophinique on Amazon
- Description: X5 Window Vacuum Cleaner Smart Glass Cleaning Robotic with APP & Remote, Intelligent Automatic Cleaner Robot for Outdoor/Indoor Windows Table Tile Ceiling

Positive comments:

Voice of the customer	Restated customer needs
<p>have many windows and teenagers...the robot is a little noisy but I just leave the room while it works and it beeps when it is done in an area. I have only used it inside, have not really used the spray feature and keep it plugged in. Cleans great with 0% elbow grease. Comes with extra microfiber socks so the robot can keep working. Needs some supervision, and a little windex on all the hand and paw prints, but overall very pleased with my window cleaner robot.</p>	<ol style="list-style-type: none"> <li>1. The product is loud (explicit)</li> <li>2. The product needs to be watched (latent)</li> <li>3. The product can work for long periods of time (explicit)</li> </ol>

<p>Wonderful product! Works well! We have crazy high windows and this removes the haze and grime that accumulates. Are they perfect? No. Is it wayyyyyy better than never cleaning the 2nd floor windows in my house? Absolutely! Crisp and clear so I can enjoy the beautiful view!</p>	<ol style="list-style-type: none"> <li>1. Can reach high places safely (explicit)</li> <li>2. The product cleans heavy build-up (explicit)</li> </ol>
<p>My brother lives in an apartment building but for some reason, his windows will get dusty quite easily and he has totally given up cleaning because it was hard and no safe. I brought this X5 window cleaning for him and this really saved his day. There nothing needed other than putting the robot on the window and press the power button/or the remote. The robot will take care of the rest. Just to make sure to secure the robot just in case it falls. My brother has been using it for months and so far I have got no complaint from him. Pricy gift though</p>	<ol style="list-style-type: none"> <li>1. Can be used in smaller areas (explicit)</li> <li>2. The product may fall (latent)</li> <li>3. Long-lasting product (explicit)</li> </ol>

#### Negative comments:

Voice of the customer	Restated customer needs
<p>For starters, I thought this was cordless and it's not. It's loud. It cleans, but basically just knocks top layer off. My windows were fairly clean to begin with and they did look better than to begin with, but not a great job and not to my standards. I do not recommend at</p>	<ol style="list-style-type: none"> <li>1. The product should be wireless (explicit)</li> <li>2. The product needs to clean multiple layers (latent)</li> </ol>

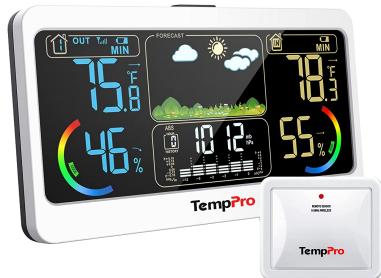
<p>all and waited too long to try to return. What a waste of money.</p>	
<p>Many of the instructions were unclear and even with contacting the manufacturer, some things still weren't clear (examples: the rope to keep the unit from falling if it lost power-where to put it, did there need to be a separate hook for each window?; what cleaning fluid to use and how much-using what the manufacturer recommending was not cleaning the window, I doubled it and it worked better). It took the robot 20 minutes to clean a relatively clean sliding glass door, when I could have cleaned it less than 5 minutes. Etc.</p>	<ol style="list-style-type: none"> <li>1. The product needs to be easy to use (explicit)</li> <li>2. The product should work faster (explicit)</li> </ol>
<p>Moves around randomly, does not follow the automatic cleaning patterns. No matter which pattern I chose, it made no difference. Kept cleaning the same spot, making a couple moves left a couple right. I could not navigate it manually either with the remote, as after each click it makes one move, so you have to stand there and keep clicking through every single step. I spent several hours trying to make it work, but no such luck. So, I gave up and cleaned my windows the traditional way. In addition the cleaning solution container is leaking.</p>	<ol style="list-style-type: none"> <li>1. The product follows set patterns (explicit)</li> <li>2. The product can be used manually (latent)</li> <li>3. Unable to restart automated sequence once broken (latent)</li> </ol>

- Summary: Our third product is the window cleaner robot. We chose this product because it is both innovative and easy to access, and also helps in cleaning by absorbing the dirt and small particles using wind energy pressure.

### **Product #4 Weather Station**

**Keywords:** Weather Station Indoor Outdoor

**Search Results Link:** [Link](#)



- Price: 42.12\$
- Vendor: Amazon
- Description: Wireless Home Weather Station with Digital Temperature Humidity Meter for Weather Forecast

Positive comments:

Voice of the customer	Restated customer needs
Very nice display and very easy to read from across the room.	<ol style="list-style-type: none"> <li>1. Nice Display and design (explicit)</li> <li>2. Good labeling and practical while using (explicit)</li> </ol>
Has been working flawlessly since purchased. Easy set up. We live in Minnesota, and have wild temperature swings, and it has been true from 99F to 12F so far.	<ol style="list-style-type: none"> <li>1. Easy to set up and use (explicit)</li> <li>2. Works with huge range of temperature (latent)</li> </ol>
I got this for all indoor use and it worked great. I have a poorly insulated cape cod home, so the master is upstairs and changes temp fast depending on the outside	<ol style="list-style-type: none"> <li>1. Good quality and work accurately anywhere under different conditions (explicit)</li> <li>2. Efficient and long lasting product (explicit)</li> </ol>

weather. I put the 2nd thermometer upstairs and could track how much I needed to pump AC/heat and if it needed vapor or dehumidifying. Then I moved it outside for the fall season so I knew how to dress when taking my dogs outside. Everything seems to work well, the humidity feels like it is accurate, and the temperature feels like its accurate. The interface is nice and hasn't stopped working for 6 months.

#### Negative comments:

Voice of the customer	Restated customer needs
It didn't work correctly out of the box neither did the second one or the third.	<ol style="list-style-type: none"> <li>1. The product should work probably in different conditions (latent)</li> <li>2. Features should be mentioned and readable for customers (explicit)</li> </ol>
Outside would not work	<ol style="list-style-type: none"> <li>1. Sensing product work inside and outside under different conditions (latent)</li> <li>2. Good Materials to use outside (explicit)</li> </ol>
I already have a similar "Weather Station" and I have to say this one made me appreciate how good my original is.  First off, the outdoor temperature sensor only updates to the main station ***once an hour***. I tested it both with temperature AND with turning the unit off and it took over an hour for the main	<ol style="list-style-type: none"> <li>1. Good electrical and mechanical build (explicit)</li> <li>2. Comfortable for users when it comes to extranls features (explicit)</li> </ol>

station to "lose contact" and zero out on the outdoor temperature. That's just plain not good enough when you are having rapid temperature fluctuations. 15min should be the absolute maximum between updates.

Second, the electric wire for the main unit is maybe 4ft long. Not long enough to reach my outlet (My original unit has a 6ft wire which is more useful). There's a second, shorter wire to charge the outdoor sensor ... both use the round DC-type plug which I hate.

Finally, I really like having a clock on the unit, which I have on my original.

All in all, there are far better options out there. Wouldn't purchase this one again

- Summary: We chose this product because it calculate sthe pressure outside and give us accurate weather report.

## **Product #5 Humidity Sensor Switch**

**Keywords:** Humidity Sensor Switch

**Search Results Link:** [Link](#)



- Price: 26\$
- Vendor: Amazon
- Description: humidity sensor fan switch uses a microprocessor combined with the advanced digital sensing technology. To detect the humid level in the bathroom and automatically turn on the exhaust fan for ventilation, keep your bathroom dry and clean, creating a healthy environment for you and your family.

Positive comments:

Voice of the customer	Restated customer needs
This product works great, and costs way less than the box stores	<ol style="list-style-type: none"> <li>1. Good price with good quality (explicit)</li> <li>2. Long lasting Materials (explicit)</li> </ol>
The humidity switch works very nicely with our new high-volume bathroom exhaust fan. It was easy to install and set up. It allows you to calibrate the humidistat against other known humidity-reading devices for better accuracy. We	<ol style="list-style-type: none"> <li>1. Works under worst circumstance and has good features (latent)</li> <li>2. It does the job accurately and takes actions fast (latent)</li> </ol>

<p>look forward to the fan automatically starting and shutting off as humidity warrants and not worrying about leaving the fan on when we are away. Compared to alternatives at the big box stores, this product provides a good product at a fair price. So far, I recommend it</p>	
<p>Installation was fairly easy. I don't understand why a ground wire wasn't needed. Either the instructions weren't included or were lost but I was able to print them off the internet. You, at least I did, need to read the programming instruction several time to understand what you need to do. After the 2nd programming, I think that I've gotten the switch working like I need. It turns out that my laundry room wasn't as humid as I suspected. The auto on had yet to happen. But I like the timer on manual.</p>	<ol style="list-style-type: none"> <li>1. Good set up process and easy (explicit)</li> <li>2. Good instructions and make it as simple as possible (explicit)</li> </ol>

#### Negative comments:

Voice of the customer	Restated customer needs
<p>My criticisms will be somewhat technical. But if you want the TL;DR this product just SUCKS. Here's why.</p> <p>- Turning on the fan is a confusing double press of the "M" key. 1st</p>	<ol style="list-style-type: none"> <li>1. Easy to use and understand how it works (explicit)</li> <li>2. It should have high sensing and accurately does its job (latent)</li> </ol>

press turns on the light, 2nd press turns on the fan. Super confusing for guests.

- Menus are labeled by numbers, which you have to cross-reference with the manual to understand what they control. Otherwise, they just look like a bunch of random numbers. No text.
- Humidity sensor requires calibration, otherwise, switch will turn on at the wrong times.
- Switch often does not turn on when the mirror is obviously foggy

----- Technical Feedback -----

This product has a flawed approach to sensing humidity. Humidity is something that fluctuates as part of the weather. A rainy day will trend your indoor humidity higher than a sunny day. The Ortis switch doesn't monitor the room's humidity for these changes. Instead, it keeps it at a setpoint RH%. This means that it's possible for your bathroom fan to run nonstop on a rainy day just because the RH% is higher than your setpoint.

A better approach to this rather than acting like a thermostat is to monitor the room's RH% over a

<p>long period of time and look for rapid spikes in humidity, like when you're taking a shower. There are switches the likes of Leviton that do this for you without you having to think about it. It's my belief that a smart switch should make your lifestyle easier, not harder.</p> <p>Note on usability:</p> <p>The interface is poorly programmed with menus being represented by numbers and confusing instructions even when you read them word-by-word. If I have to pull out the instructions every time I use it, I can imagine that guests would be intimidated by a switch like this and just never turn on the bathroom fan</p>	
<p>Yes this was easy to install but there is _NO_ ground connection point for a device meant to operate in a wet/damp environment. Thus I have to give this device a failing grade. I ended up attaching a ground connection to the metal faceplate where it attaches to the wallbox but still this is very suboptimal for the use this is intended for.</p>	<ol style="list-style-type: none"> <li>1. It should state how to be used in different environments with good instructions (explicit)</li> <li>2. Customer services that are aware of common issues between users to answer questions or common questions answered on the instruction paper (explicit)</li> </ol>
<p>Update March 20, 2022. Switch doesn't work now. Reads 98% humidity all the time. Will need to replace already and only had three months.</p>	<ol style="list-style-type: none"> <li>1. Easy to fix any issue (explicit)</li> <li>2. It does not need regular maintenance (explicit)</li> </ol>

I've got it installed but can't say I'm thrilled with it. Has a crappy interface that requires you to know what mode 01 or 05 or 07 is to understand how to get it to work. Not sure what is wrong with an icon or english or something. If you lose the directions you'll not have a clue how to set this thing.

I've seen the humidity higher than I'd like given where I set the thing at and I'm partially judging this based on the control I had previously which came on when expected w/o fail. It didn't have the fancy readout but it just worked.

- Summary: The product is affordable but from the customer feedback, we understand that the product needs lots of additional features so it is easy for the user to use it. The product comparatively has good lifetime and has good spare parts and also has easy set up process.

## Jamboard Progress and Steps

Here you can see the 100 ideas gathered.

The product should be easy to use/ user friendly	The product should work on multi dirt levels areas not just light	The cleaning area should be bigger/wider	Would be better if it need replacement after working for a longer time	The product worked on a high dirt level surface	Improving user-robot interaction experience	Cleaning product/water spray	Can be used frequently	efficient/functional design	Can shut itself down to save power
Nice Display and design	Efficient and long lasting product	Good electrical and mechanical build	the cleaning area should be bigger/wider	Smart technology/algorithm for user need and interaction	Improving user-robot interaction experience	The robot need to be able to act by itself	The robot left no stains after cleaning	easy to maintain	able to map out the area and create consistent pathways
Easy to use	Works on multiple layers	Follows set patterns	Can be manually operated	Can automatically restart programmed sequence	Ability to control the working time	Competitive price	Should be able to process data correctly as it should	efficient battery life	The robot need to be able to act by itself
Does not need to be watched	Can work for longer periods of time	Cleans heavy build-up	Can reach high places safely	can recharge itself	Does not break easily	Can be used in smaller areas	Long-lasting	Wireless	Finishes quickly
Need longer battery life	Efficient battery use	Control the space in where it is working	Knows how to process data and act when unusual object was on the way	Ability to control the working time	cost efficient	Solid balance	Does not corrupt/damage the surface	Doesn't lose power quickly	Have to work on different environment/surface
can work under any pressure of work given	feedback to the user like showing battery remaining	does not waste users time and meet the purpose that it was made for	sustainable	uses less resources	easy to set up	Can process data correctly as it should	does not have Programming errors	Efficient work	The ability to do daily work

should have camera installed	have an emergency shutdown option								
the ability of manual/remote troubleshooting	can be both manually/self controlled	should be able to move from solar panel to another	should know its way back to the charging station	should be able to know when to charge itself	should be able to know how long does it run on a certain charge	should be able to calculate the efficiency according to the sensor data such as wind speed and humidity	should be able to operate in different area size	should give daily-weekly reports to the user to collect data	should be able to store the data collected
is safe to use	use the energy generated by the solar panels to recharge	know when is the best time to start/stop working	easy to move from one place to another	can operate by itself for a long time periods	needs less human supervision	the ability to deal with different weather conditions	should have a good electrical isolation for safety purposes	must be waterproof	the user should be able to track the robot
Good price with good quality	Long-lasting Materials	Works under worst circumstances and has good features	Should not miss areas and be able to clean the entire surface	The cleaning patterns should be improved/smarter	The prices should be reasonable for the technology and services it provides	Should be able to move in any direction needed	Should use a reliable materials	Should be able to operate efficiently in various conditions	easy to maintain
Should be able to identify and mark the edges of the area	It does not need regular maintenance	The algorithm/coding need to be fixed as it gets confused against simple linear surfaces/ should be able to clearly identify the path	It does the job accurately and takes actions fast	Good set up process	Good instructions and make it as simple as possible	It should states how to be used in different environment with good instructions	Customer services that is aware of common issues being faced to answer question or common questions answered on the instruction paper	It should have high sensing and accurately does it job	Easy to use and understand

## ● Grouping and Ranking

It was categorized into two groups and ranked based on color and number.

User interaction										1:orange 2:yellow 3:green 1: is the most important
The product should be easy to use/ user friendly	Smart technology/algorithm for user need and interaction	The product should work on multi dirt levels areas not just light	can be both manually/self controlled	Improving user-robot interaction experience	Nice Display and design	Efficient work	Knows how to process data and act when unusual object was on the way	Efficient and long-lasting product	should give daily-weekly reports to the user to collect data	
Can automatically restart programmed sequence	feedback to the user like showing battery remaining	Good electrical and mechanical build	know when is the best time to start/stop working	should know its way back to the charging station	The robot need to be able to act by itself	should have a camera installed	the ability to deal with different weather conditions	Should be able to identify and mark the edges of the area	should be able to operate in different area size	
can operate by itself for a long time periods										

Efficiency										1:orange 2:yellow 3:green 1: is the most important
The product should work on multi dirt levels areas not just light	The cleaning area should be bigger/wider	Can shut itself down to save power	efficient/functional design	Can be used frequently	The product should be easy to use/ user friendly	The product worked on a high dirt level surface	Finishes work quickly	Follows set patterns	Control the space in where it is working	
Does not need to be watched	Can work for longer periods of time	Can automatically restart programmed sequence	Ability to control the working time	Cleans heavy build-up	Competitive price	can work under any pressure of work given	Can process data correctly as it should	Works on multiple layers	Wireless	
The ability to do daily work	Can be used in smaller areas	does not have Programming errors	does not waste user's time and meets the purpose that it was made for	uses fewer resources	easy to set up	does not have Programming errors	Does not break easily	Easy to use	cost efficient	
Should be able to process data correctly as it should	Can process data correctly as it should	can recharge itself	Should be able to map out the area and create consistent pathways	efficient battery life	uses less resources	Solid balance	Doesn't lose power quickly	Long-lasting		

Can be used in smaller areas	Need longer battery life	Ability to control the working time	The robot need to be able to act by itself	Smart technology/algorithm for user need and interaction	The robot left no stains after cleaning	sustainable	Good electrical and mechanical build	should be able to know how long it runs on a certain charge	should be able to calculate the efficiency according to the sensor data such as wind speed and humidity
the ability of manual/remote troubleshooting	should be able to store the data collected	use the energy generated by the solar panels to recharge	should be able to move from solar panel to another	use the energy generated by the solar panels to recharge	should be able to know when to charge itself	must be waterproof	Good price with good quality	Long-lasting Materials	
the user should be able to track the robot	Should use a reliable materials	easy to move from one place to another							

## User Needs and Benchmarking Assessment

At the end of our user needs and benchmarking process we are moving to the product requirements section. It was important to understand the concepts on every product that we benchmarked. So based on what our outcome in the user needs is determiningng the main requirements of our product. Overall the steps are becoming more clear for theteam to choose the main challenge we are going to solve.

## 2.2 Product Requirements

In the product requirement we converted the most ranked needs into requirements to our project.

### Introduction

Today renewable energy is playing a huge role in saving the planet and also acknowledging people about nature. In this project, our team is going to build a functional robot to sense dust, temperature, and humidity, and take action to clean any solar panel or tool that needs regular cleaning for efficiency. Most of us are not aware of how solar panels play a huge role in reducing the footprint pollution around the world. As a team we decided to focus and solve a challenge that will increasingly affect the usage of solar panels.

The project mainly aims to sense and collect data based on how efficient are solar panels and compare the efficiency before and after the cleaning. Moreover, it aims to support and increasingly affect solar panel users and new customers.

### Objectives

Our project aims to spread the culture of solar panels and make them more efficient for old and new users. Our main goal is to build an easy-to-set-up, lightweight, and good-quality solar panel cleaner that reacts fast whenever it feels a certain quantity of dust. On the other hand, it will be featured with different sensors such as temperature, and humidity sensors.

### Stakeholders

#### Target group

Our target group is the people that have solar panels installed in their home/company or those looking to install solar panels in the near future.

#### Target purchaser

Target group profile with attention given to farmers, home-owners and companies.

#### Customer service

We are aiming to provide good instructions and answers to the most common questions with the product. Moreover, we are aiming to provide good quality materials and an easy-to-set-up product.

#### Retailers

Retailers might oversee the projects at the showcase and endorse them to their company for selling to the public.

## Use Cases

### **User Story #1: Derock**

Derock is a 52-year-old farmer from the Midwest that wakes up before sunrise and finishes after sunset. He just recently bought solar panels to help reduce electricity costs and keep tools charged up for the day. He is not that technology savvy, but has found that SolarXCL is easy to use and maintain. When he's working throughout the day, he knows that he is getting the maximum efficiency his solar panels will allow. This lets him work uninterrupted for more productive days.

Occasionally storms will pass through the area and kick-up dirt and mix with the rainfall to make mud that covers the panels. Derrick has his SolarXCL setup to automatically detect the newly added grime. When the storm passes, SolarXCL will clean off the panels again giving Derrick peace of mind.

### **User Story #2: Vianna**

Vianna is a 36-year-old mother of three. She has two children currently in primary school, and the third is a toddler still at home. The family recently got solar panels installed for their home to reduce their monthly power costs. During the day Vianna takes care of various house chores, and takes care of the toddler. She likes to unwind by watching shows or movies on Netflix. She has set up her SolarXCL to detect larger dirt-piles to make sure it gets cleaned off so their power efficiency is always as high as possible. This removes one task for her and lets the family enjoy extra movie nights with the money saved.

The ease-of-use of SolarXCL has made Vianna fall in love with it. She tells all her friends and neighbors about the product if they ever choose to get solar panels installed. She has become a long-term customer.

### **User Story #3: Kei**

Kei is the CEO of a technology company; in one of the tropical countries he turned his company into an eco-friendly system. He mainly insisted and focused on having solar panels to power electricity into his company. During winter and summer seasons he noticed that the AC is not cooling or heating fast so he asked his team to check the solar system in his company. Once they did, they saw how some panels were uncleaned and obviously not efficiently working. He looked online and found our product SolarXCL. He noticed how the cooling system improved.

## **Aspects**

### **1. Product Design**

- 1.1 The product is build with high quality materials
- 1.2 The product is easy to set up
- 1.3 The product has good appearance
- 1.4 The product has creative features compared to the ones in the market
- 1.5 The product will sense the dust, temperature and humidity
- 1.6 The Product will work with battery
- 1.7 The product has good stability

### **2. Functionality**

- 2.1 The product needs software programming to achieve the required mission of cleaning the solar panels.
- 2.2 The product will sense different things and that will be done through an open-source code.
- 2.3 The product should not require complicated instructions or coding.
- 2.4 The product will be able to work manually

### **3. Interactivity**

- 3.1 The product will work wirelessly with a mobile application.
- 3.2 The product shall be adjusted to clean at regular intervals if the customer chooses.
- 3.3 The user interface will be intuitive for all users after a few minutes of use.

### **4. Adaptive Intelligence**

- 4.1 The product shall detect when a layer of debris has built-up on the solar panels and clean it off.
- 4.2 The product will detect if it will rain or is raining based on current humidity and cease functions until it clears.

### **5. Customization**

- 5.1 The product will be height adjustable for different solar panels.
- 5.2 The product will be adjustable to clean surfaces of differing weather and environmental conditions.

### **6. Manufacturing**

- 6.1 The total cost of the product will be  $\leq \$60$ .
- 6.2 The product will be designed to assemble in under three hours.
- 6.3 The product will avoid use of toxic waste.

### **7. Safety**

- 7.1 The product will be waterproof to avoid any electricity touch
- 7.2 The product will be small and light to avoid any accidents and to make it easy to move
- 7.3 The product will be stuck and well attached to the solar panel

## **Open Questions**

- How can we make the product more cost effective?
- How can we make the robot more energy efficient?
- How can the robot be more environmentally friendly?
- How can we give the user better user interaction with the robot?
- What would be the best technique for controlling the robot?

## **Product requirement Assessment**

Overall, the product requirement made our team focus goes more into solar panels challenges. Moreover, the seven categories helped intentionally in building the requirements of our final product. The categories Design Product, Functionality, Adaptive Intelligence, Interactivity, Manufacturing, Customization and Safety are our project main focus. After the process of product requirement we moved into brainstorming designs ideas and feature.

## **3.0 Design Ideation**

### **3.1 Background and Steps**

The purpose of these steps is to maximize the number of ideas for our final product. Using this process we are aiming to get three main concepts. We started by brainstorming all the ideas, features and styles of our projects. After that, we categorized the different ideas into four main categories which are environmental, daily life helper, farmers and common features . Moreover, we colored every category differently in order to make it easy to track every idea. Next we ranked all the ideas in a scale from one to three with one being the most important and three being the least important. Finally, we started designing our concepts based on our top ranked ideas.

## 3.2 Brainstorming Steps and Ideas

We brainstormed about 100 ideas and project concepts by thinking about the required features that we generated from the user needs list. We started with three different empty boards and started to fill them with the concepts/ideas sticky notes.

Changeable rules and materials	flexible, light, good display	less programming	helps with solar panels and renewable energy	Collecting data to actively take action	users would use it for different purposes	it can be used in different environments with high and low temperatures	its collecting data under water or air pressure
no more than 10V	the design is attracting	it fits most budgets	it does not need much maintenance	waterproof	it feels the wind and moves with it to generate energy	hybird	sparingly materials
it get powered by battery or solar panels	small flexible robot that sense the temperature and cleans the solar panels	a small robot sense humidity and start to clean the mirrors	a small robot that feels the high or very low temperature in cars and warn by sending signals and notifications via an application	a car or boat motor that has sensors so when the motor stops working in the middle of the ocean it measures the temperature and pressure if it's high it sends a signal to the nearest coastguard or police Station	a small wireless phone that shows temperature and pressure and connects to the nearest coastguard or police Station	it's useful for different ages	it feels the humidity and takes the water from it
it sense air flow and temperature	Emergency boats that have temperature sensors, humidity, and pressure so it can determine all of these info and act on it	a small watch for babies to determine their body temperature and their heart beats so when it's high it sends a signal to phone registered and it light up	it feels humidity in cars mirror and it gives signals	it senses the temperature humidity and oxygen in the air. If there is less oxygen the car sends signals to the phone registered	Vibrating mode and movement	collecting data to help researches	it's used in foggy days to sense humidity, temperatures and bodies near to the car
it is used in farms to sense temp and humidity and keep track of their plants and animals							

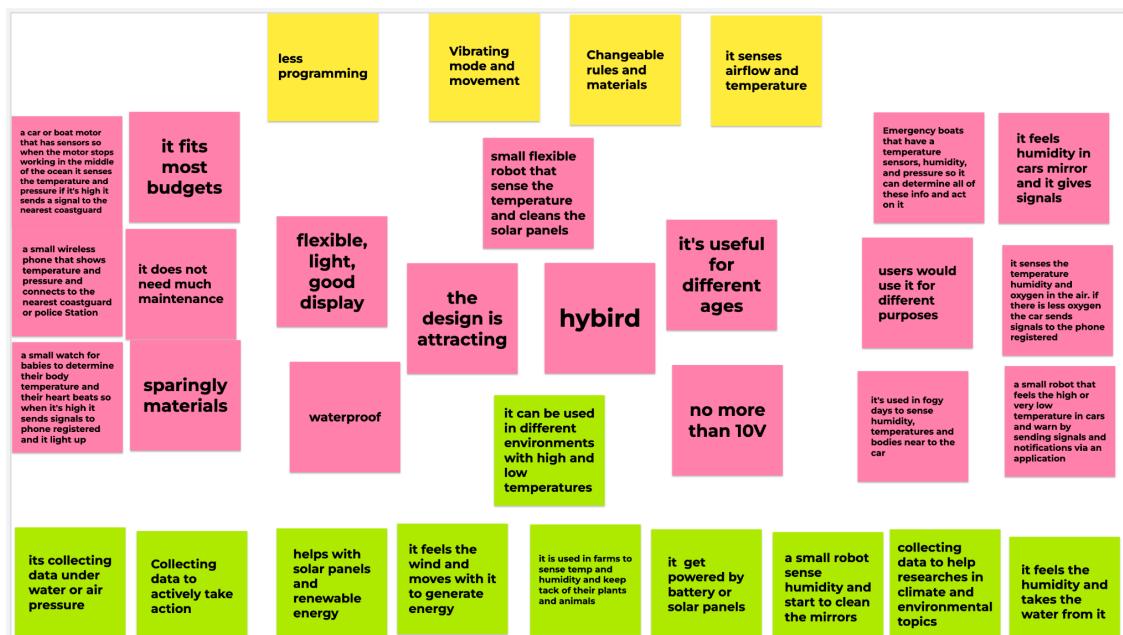
different technique for cleaning base on the dirt level to improve efficiency	knowing when it needs to be recharged	can plug itself to the charger when needed	estimates how long can it work on the current battery level						
easy to use and understand	give recommendations for the user based on the sensed data	a robot that have more than one feature and sense different types of data	different types of moving (wheels, flying, floating...)	have different types of speed/setting low, medium, high	emergency shutdown to avoid damaging the equipments	good isolation water/heat	can be used in bad weather	suggesting the type of the clothes based on the weather reading	can be controlled via app or from a long distance
predict weather changes by measuring the atmospheric pressure and temperature	measure temperature and atmospheric pressure to people when hiking	help sailors preserve food and goods	the ability to act by itself most of the time	have to use wifi	must be safe to use	gives feedback to the user when error occurs	interactive	user friendly	use rechargeable battery
help farmers	solve an environmental issue	sense environmental conditions	process data received from the sensors and does action base on that	controlling irrigation systems	help make greenhouse more efficient	temperature and humidity control	helping sailors/captains to drive by knowing the wind speed and direction to use less energy/fuel	controlling temperature and humidity to preserve food in the best condition possible	help in preserving goods like wood

different technique for cleaning base on the dirt level to improve efficiency	knowing when it needs to be recharged	can plug itself to the charger when needed	estimates how long can it work on the current battery level						
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- **Grouping**

After brainstorming our ideas we grouped them into the following four different colors:

Pink	Daily Life Ideas
Green	Environmental
Yellow	Farmers Help
Blue	Common Features



different technique for cleaning base on the dirt level to improve efficiency	knowing when it needs to be recharged	can plug itself to the charger when needed	estimates how long can it work on the current battery level						
easy to use and understand	give recommendations for the user based on the sensed data	a robot that have more than one feature and sense different types of data	different types of moving(wheels, flying,floating...)	have diffrent types of speed/setting low, medium, high	emergency shutdown to avoid damaging the equipments	good isolation water/heat	can be used in bad weather	suggesting the type of the clothes based on the weather reading	can be controlled via app or from a long distance
predict weather changes by measuring the atmospheric pressure and temperature	measure temperature and atmospheric pressure to people when hiking	help sailors preserve food and goods	the ability to act by itself most of the time	have to use wifi	must be safe to use	gives feedback to the user when error occurs	interactive	user friendly	use rechargeable battery
help farmers	solve an environmental issue	sense enviromantale conditions	process data received from the sensors and does action base on that	controlling irrigation systems	help make greenhouse more efficient	temperature and humidity control	helping sailors captains to drive by knowing the wind speed and direction to use less energy/fuel	controlling temperature and humidity to preserve food in the best condition possible	help in preserving goods like wood

App that reports energy output of panels to show user inefficiencies and report when cleaning required	Panels with wind speed detection that turn away from wind as much as possible to prevent build-up	Robot with power wash attachments to clean off dirt after sensing storm							
Retractable sprinkler (ceiling) system that closes at night and sprays off panels	App based robot that is sent out to clean via phone when user wants	Hydrophobic solar panel top to prevent water spot build-up	Cleaning robot that can detect when temps exceed a set threshold to prevent potential malfunctions	Panel with heating elements built into top layer to melt ice in inclement weather areas	Panels that detect build-up and alert owner of energy inefficiency	Power wash attachment to panel that washes every night	Robot that cleans panels at intervals unless detecting incoming rain/snow	Cleaning robot that can act as weather unit via app by collecting humidity, temp, wind speed, etc.	Panels that use actuators to lower into a water basin to rinse and go back up
Panels that sense rain and turn upside down	Panels that are connected to weather app to turn upside down before inclement weather	Robot connected to weather app that will go out and clean after storm	Robot programmed to clean at set intervals unless it detects large amount of humidity	Robot programmed to clean every night to allow maximum sun time for panel	Panel that vibrates to shake off dirt	Array of robots assigned to individual panels that act in unison to clean	Array of power wash attachments to each panel set to programmed interval cleaning	Large broom system that goes across multiple in-line panels to sweep off	Large-scale water cleaning system that can move across x/y axes to clean off panels in # x # area
Robot that can sense debris and go clean it with large brush	Attachment to panel that sprays water to clean when sensing debris	Small fans attached to panels that blow away dirt at set intervals	Robot programmed to timer so that it goes out and cleans at specified times	Solar panels set on motors that tilt to dump debris	Broom attachment that senses dirt and sweeps across panel to clean	Motors that flip panel upside down each night to remove debris and prevent overnight build-up	Large fan system set on industrial panel areas to clear off multiple panels	Robot using rotating bristle brushes to clean off panels	Windshield wiper style system attached to panels

## ● Ranking

Then, we moved every group of ideas to their own slide and ranked them according to the importance level and requirements for the project with number one being the most important.

		3 Daily life (pink)	2	1 1: is the most important
it's useful for different ages	no more than 10V	predict weather changes by measuring the air pressure and temperature	it senses the temperature humidity and oxygen in the air. If there is no oxygen then it sends signals to the phone registered	users would use it for different purposes
sparingly materials	it feels humidity in cars mirror and it gives signals		a small robot that feels the high or very low temperature in cars and warn by sending signals and notifications via an application	hybird
a small wireless phone that shows temperature and pressure and connects to the nearest coastguard or police Station	Robot that cleans panels at intervals unless detecting incoming rain/snow		It's used in foggy days to sense humidity, temperatures and bodies near to the car	easy to use and understand
suggesting the type of the clothes based on the weather reading	help in preserving goods like wood		a small watch for babies to determine their body temperature and their heart beats, humidity, so when it's high it sends signals to phone registered and it light up the bracelet	the design is attracting
help sailors preserve food and goods	Robot programmed to timer so that it goes out and cleans at specified times		a car or boat motor that has sensors so when the motor stops working in the middle of the ocean it sense the pressure if it's high it sends a signal to the nearest coastguard	user friendly
Robot using rotating bristle brushes to clean off panels	Robot that can sense debris and go clean it with large brush	Small fans attached to panels that blow away dirt at set intervals	helping sailors/captains to drive by knowing speed and direction to use less energy/fuel	give recommendations for the user based on the sensed data
			Robot programmed to clean at set intervals unless it detects large amount of humidity	process data received from the sensors and does action base on that
			Robot connected to weather app that will go out and clean after storm	Panels that detect build-up and alert owner of energy inefficiency
			Attachment to panel that sprays water to clean when sensing debris	it fits most budgets
				controlling temperature and humidity to preserve food in the best condition possible
				App based robot that is sent out to clean via phone when user wants
				Windshield wiper style system attached to panels
				have to use wifi
				must be safe to use
				temperature and humidity control

		3	2	1 1: is the most important
different technique for cleaning base on the dirt level to improve efficiency	Panels that sense rain and turn upside down			
it feels the humidity and takes the water from it	Hydrophobic solar panel top to prevent water spot build-up			
Large broom system that goes across multiple in-line panels to sweep off	Array of robots assigned to individual panels that act in unison to clean	Large fan system set on industrial panel areas to clear off multiple panels	solve an environmental issue	can be used in bad weather
Panel that vibrates to shake off dirt	it feels the wind and moves with it to generate energy	Panels that use actuators to lower into a water basin to rinse and go back up	interactive	sense Enviromantale conditions
Robot programmed to clean at set intervals unless it detects large amount of humidity	Panels that are connected to weather app to turn upside down before inclement weather	Panel with heating elements built into top layer to melt ice in inclement weather areas	gives feedback to the user when error occurs	process data received from the sensors and does action base on that
		its collecting data under water or air pressure	helps with solar panels and renewable energy	Robot programmed to clean every night to allow maximum sun time for panel
				good isolation water/heat
				melt ice from the solar panels
				use rechargeable battery
				collecting data to help researches in climate and environmental topics
				Collecting data to actively take action
				must be safe to use
				have to use wifi
				it get powered by battery or solar panels

Enviromental (green)

3

2

1

1: is the most important

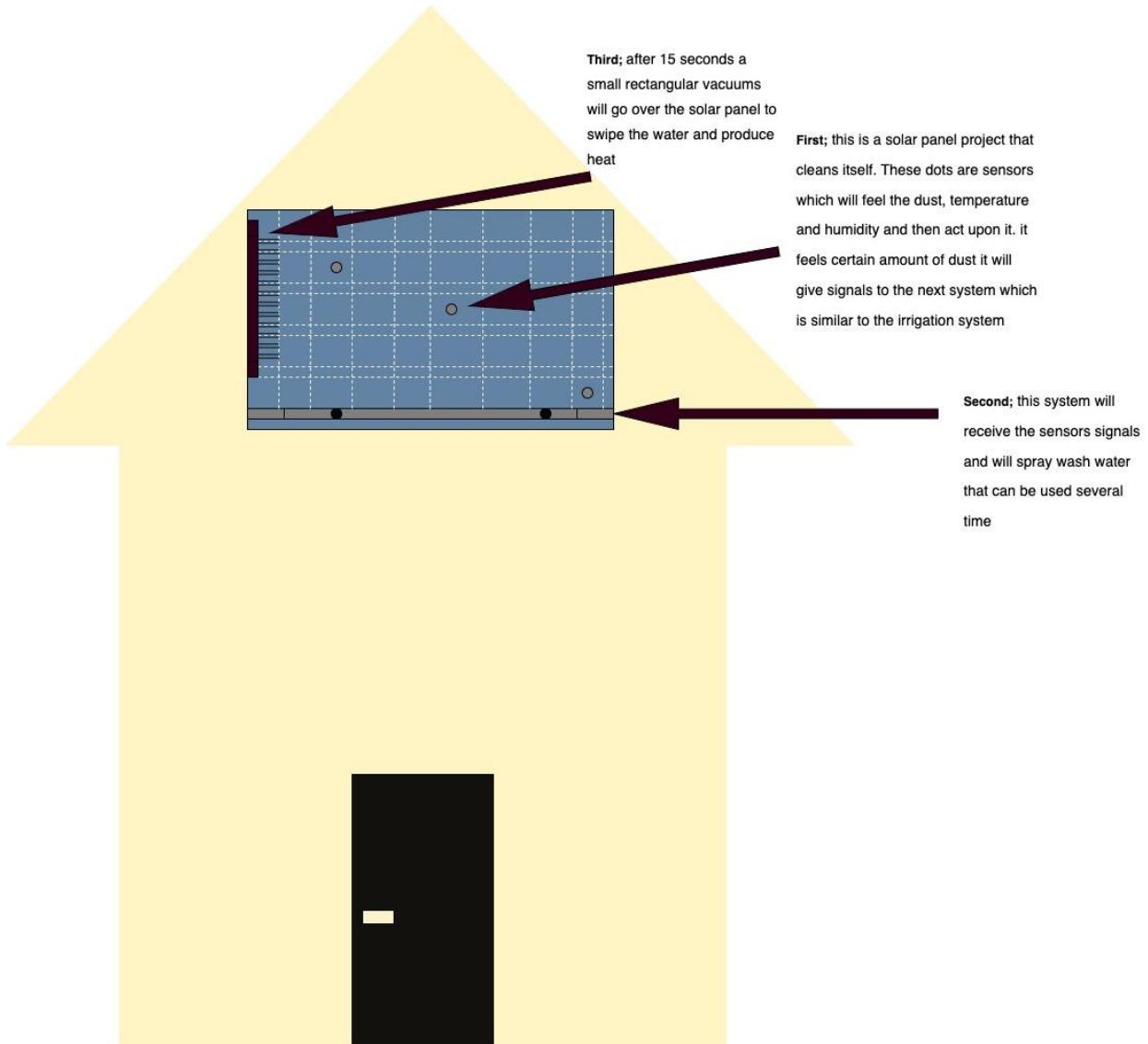
different types of moving (wheels, flying, floating...)	<b>Changeable rules and materials</b>	gives feedback to the user when error occurs	it is used in farms to sense temp and humidity and keep track of their plants and animals	Broom attachment that senses dirt and sweeps across panel to clean	process data received from the sensors and does action base on that	interactive
<b>Vibrating mode and movement</b>	<b>less programming</b>	estimates how long can it work on the current battery level	can plug itself to the charger when needed	Large-scale water cleaning system that can move across x-y axes to clean off panels in # x # area	good isolation water/heat	the ability to act by itself most of the time
App that reports energy output of panels to show user inefficiencies and report when cleaning required	Array of robots assigned to individual panels that act in unison to clean	help make greenhouse more efficient	controlling irrigation systems	Solar panels set on motors that tilt to dump debris	<b>must be safe to use</b>	<b>have to use wifi</b>
Motors that flip panel upside down each night to remove debris and prevent overnight build-up		<b>help farmers</b>	Panels with wind speed detection that turn away from wind as much as possible to prevent build-up	Array of power wash attachments to each panel set to programmed interval cleaning	it senses airflow and temperature	Power wash attachment to panel that washes every night
					Retractable sprinkler (ceiling) system that closes at night and sprays off panels	Windshield wiper style system attached to panels

Farmers  
(yellow)

### 3.3 Product Concept Sketches

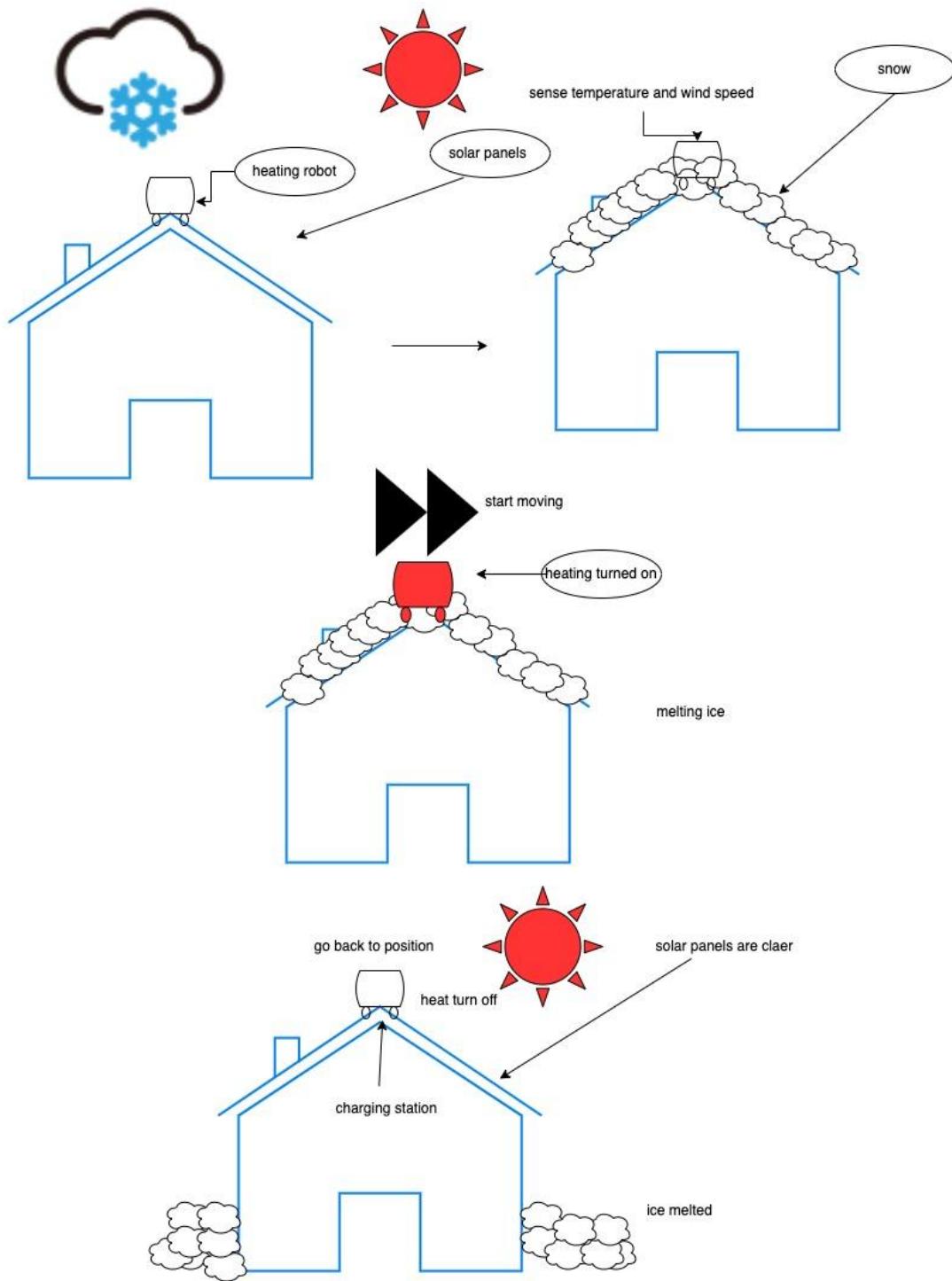
#### Design concept #1

The concept behind this design is to provide the market with fully equipped and ready to use solar panels. It has sensors to detect the dust, temperature and humidity. When it detects a certain amount of humidity or dust it sends signals to the washer system, and the whole system collaborates to get rid of the extra water and dust. This design is effective and full of different features.



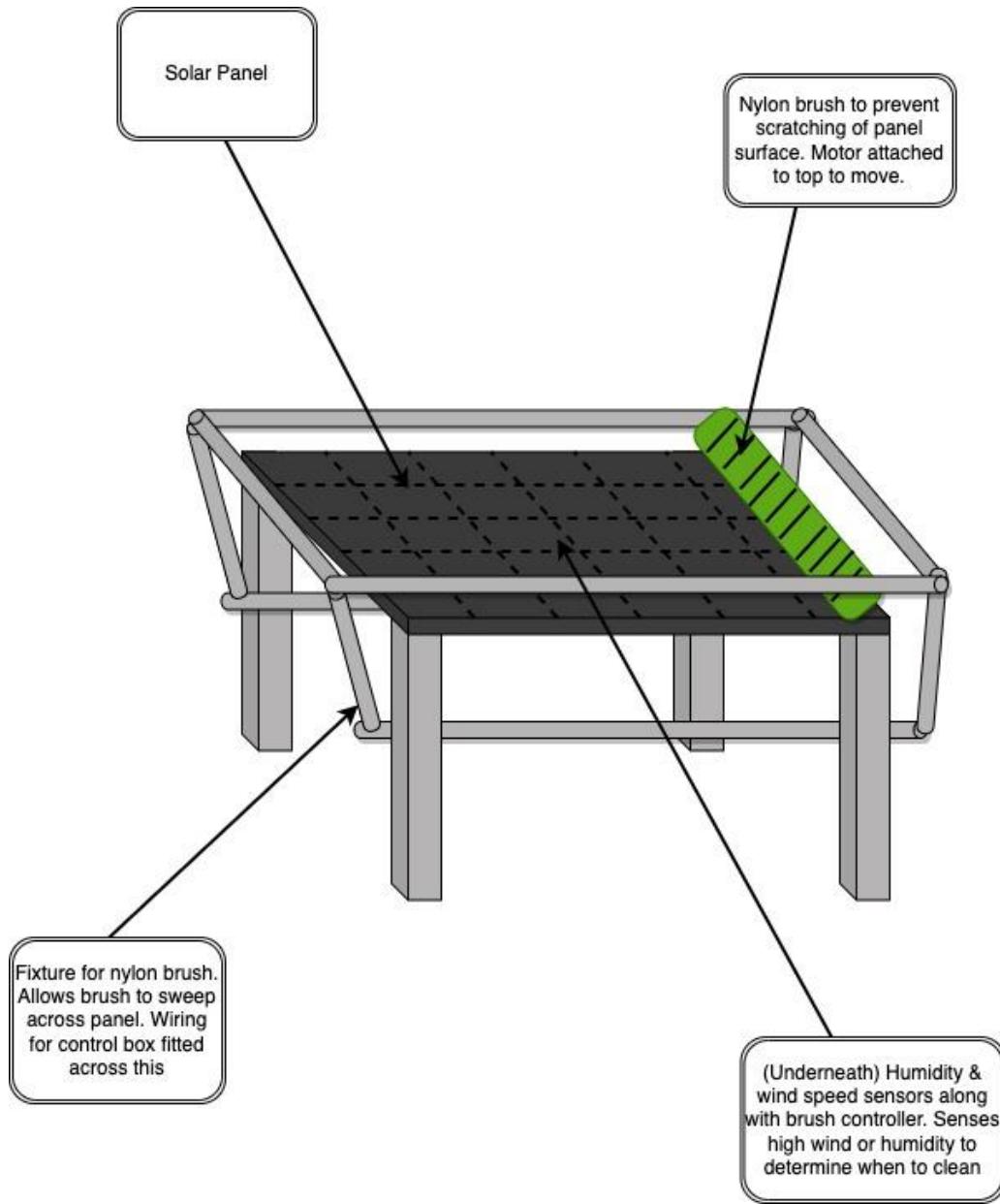
## Design Concept #2

The idea of this concept is a heat emitting robot that moves on the solar panels after a snow storm to melt the snow from the roof to. When the robot reads the temperature and wind speed that indicate the end of the storm for it to start to warm up and melt the snow. It also has a charging station that is powered by solar panels.



### Design Concept #3

A nylon brush attached to a motor and fixture to sweep across a solar panel. The controller is located underneath the panel and works in tandem with a humidity sensor and wind speed sensor. This lets the controller decide a good time to clean based on whether rain is likely or high winds have blown more dust and debris onto the panel.



### Design Ideation Assessment

Overall, the team now has a clear idea of what the final project will look and function like. The step of design ideation made all of us on the same page while we are brainstorming and designing. Finally we are looking for more feedback to take the final decision.

## 4.0 Appendix

### Communication Channels

Name	First Choice Communication	Second Choice Communication	Third Choice Communication
Fatema Alshehhi	<i>Discord</i>	<i>WhatsApp</i>	<i>Messages</i>
Sivanee Naghichetty	<i>Discord</i>	<i>WhatsApp</i>	<i>Messages</i>
Timothy Drafz	<i>Discord</i>	<i>Messages</i>	<i>WhatsApp</i>
Salsabil Soliman	<i>Discord</i>	<i>WhatsApp</i>	<i>Messages</i>

### Communication Procedures

Communication between group members will take place on Discord. Thus, the team will regularly meet and discuss any updates and plan their assignments outline and goals. Moreover, the team will email the professor as a communication method with the instructor for guidance and inquiries. Zoom/Discord meetings will also be held for updates or quick weekday meetups.

### Meeting Schedule

Our team availability can be found through this [link](#). Initially, we are planning to meet Fridays from 3:00 PM until 5:00 PM. However, our team will try to discuss and work all the main agenda through the class time. Additionally, we will hold zoom/Discord meetings on weekdays to discuss any updates and plan in-person meetings.

### Meeting Coordination

- We are going to remind each other by the meetings through discord.
- The meeting time is based on the [schedule of availability](#) and discussions at least a week before.
- Our preferred meeting methode is online through discord/zoom if no in-person work is required.
- Team members need to notify the team if there were any changes to their availability schedule to ensure that we are all attending the meetings on time.

### Team Coordination

- We set an earlier due date which ranges between 4-24 hours before the actual due date and make sure that every team member is checked off by the time that we set it.
- We will ask every team member about their knowledge and what part do they think they can do the best based on previous semesters projects or any projects that they did before.

- The assignments will be reviewed and validated by each team member before submission to ensure that we have everything as it should be.

## Roles and Responsibilities

Role		Duties
Meeting leader	Salsabil Soliman	Schedules team meetings, creates and distributes an agenda for each meeting, and runs each meeting
Meeting recorder	Sivanee	Takes minutes of each team meeting, including attendance, and records action items and to whom they are assigned
Assignment leader	Timothy	Coordinates the team's work on a given assignment to Canvas before the due date
Project monitor	Fatema	Tracks the team's progress relative to the project schedule (Gantt chart) and keeps team members apprised of deadlines and project status

## How will you assign technical responsibilities to the team members?

Responsibilities will be discussed among the team members and strengths will be noted. If no member is strong in an area required by the project, a team member will be assigned that duty with the expectation of help from other team members. They will be expected to learn enough about the responsibility to perform it through the semester.

## User needs list

1. The product should be easy to use/ user friendly
2. The product should work on multi dirt levels areas not just light
3. The cleaning area should be bigger/wider
4. Would be better if it need replacement after working for a longer time
5. The product worked on a high dirt level surface
6. Improving user-robot interaction experience
7. Cleaning product/water spray
8. Can be used frequently
9. Efficient/functional design
10. Can shut itself down to save power
11. Nice Display and design
12. Efficient and long-lasting product
13. Good electrical and mechanical build
14. the cleaning area should be bigger/wider
15. Smart technology/algorithm for user need and interaction

16. Improving user-robot interaction experience
17. The robot need to be able to act by itself
18. The robot left no stains after cleaning
19. Easy to maintain
20. Should be able to map out the area and create consistent pathways
21. Easy to use
22. Works on multiple layers
23. Follows set patterns
24. Can be manually operated
25. Can automatically restart programmed sequence
26. Ability to control the working time
27. Competitive price
28. Should be able to process data correctly as it should
29. Efficient battery life
30. The robot need to be able to act by itself
31. Does not need to be watched
32. Can work for longer periods of time
33. Cleans heavy build-up
34. Can reach high places safely
35. Can recharge itself
36. Does not break easily
37. Can be used in smaller areas
38. Long-lasting
39. Wireless
40. Finishes work quickly
41. Need longer battery life
42. Efficient battery use
43. Control the space in where it is working
44. Knows how to process data and act when unusual object was on the way
45. Ability to control the working time
46. Cost efficient
47. Solid balance
48. Does not corrupt/damage the surface
49. Doesn't lose power quickly
50. Have to work on different environment/surface
51. Can work under any pressure of work given
52. Feedback to the user like showing battery remaining
53. Does not waste user's time and meets the purpose that it was made for
54. Sustainable
55. Uses fewer resources

56. Easy to set up
57. Can process data correctly as it should
58. Does not have Programming errors
59. Efficient work
60. The ability to do daily work
61. Should have a camera installed
62. have an emergency shutdown option
63. The ability of manual/remote troubleshooting
64. Can be both manually/self controlled
65. should be able to move from solar panel to another
66. should know its way back to the charging station
67. should be able to know when to charge itself
68. should be able to know how long it runs on a certain charge
69. should be able to calculate the efficiency according to the sensor data such as wind speed and humidity
70. should be able to operate in different area size
71. should give daily-weekly reports to the user to collect data
72. should be able to store the data collected
73. is safe to use
74. use the energy generated by the solar panels to recharge
75. know when is the best time to start/stop working
76. easy to move from one place to another
77. can operate by itself for a long time periods
78. needs less human supervision
79. the ability to deal with different weather conditions
80. should have a good electrical isolation for safety purposes
81. must be waterproof
82. the user should be able to track the robot
83. Good price with good quality
84. Long-lasting Materials
85. Works under worst circumstances and has good features
86. Should not miss areas and be able to clean the entire surface
87. The cleaning patterns should be improved/smarter
88. The prices should be reasonable for the technology and services it provides
89. Should be able to move in any direction needed
90. Should use a reliable materials
91. Should be able to operate efficiently in various conditions
92. easy to maintain
93. Should be able to identify and mark the edges of the area
94. It does not need regular maintenance

95. The algorithm/coding need to be fixed as it gets stuck/confused against simple linear surfaces/ should be able to clearly identify the path
96. It does the job accurately and takes actions fast
97. Good set up process
98. Good instructions and make it as simple as possible
99. It should states how to be used in different environment with good instructions
100. Customer services that is aware of common issues between users to answer questions or common questions answered on the instruction paper
101. It should have high sensing and accurately does its job
102. Easy to use and understand

## **Our Team Milestones**

Concept presentation: 1/23/2023

Design presentation: 2/22/2023

Design freeze: 3/24/2023

Planned release: 4/28/2023