Prototype Concept

This document presents the prototype concept for a design that minimizes dust accumulation in order to improve efficiency and adaptability of urban solar panels in the Sahel under varying environmental conditions.

I. Prototype Concept Development

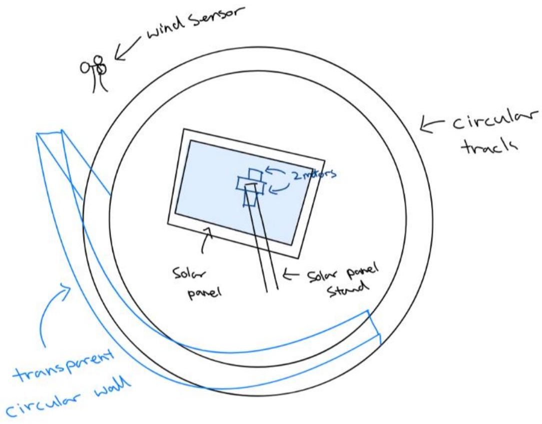

Figure 1: A sketch of the prototype, particularly highlighting a rounded track with a circular wall, along with two motors on the solar panel stand. Wind sensors are located outside of the circular track.

Our design concept consists of an integrated system that takes in input from the environment (wind speed and direction, rain intensity, time of day) and uses it to optimally configure the orientation and tilt of the solar panel, as well as the placement of a wind-blocking barrier. The barrier consists of hinged clear strips for smooth corner transitions. Through research on key environmental factors in the Sahel, responding to wind conditions was identified as the **primary focus** of this prototype, because wind conditions have a greater effect on dust accumulation than rain, and the system architecture for responding to rain is largely the same as that for wind, so there was no need to duplicate it in this prototype. To effectively test the concept, the following prototype options were considered *(Meeting Minutes – Studio 6B)*:

1. A rounded square track for the barrier to demonstrate its durability and flexibility while withstanding environmental stressors
2. A newly designed solar panel stand capable of tilting in the x and y direction to optimize sun exposure and minimize dust accumulation
3. Integration of a control system that processes data from a weathervane, adjusting lower-fidelity versions of the barrier and solar panel tilt in response to weather conditions.

The third option was chosen because the design's success depends on both the barrier and solar panel adapting to wind conditions. Prototyping the system controls and the different components working together validates its ability to detect levels of winds and adjust accordingly, ensuring real-world effectiveness. By choosing to prototype two actuators and a sensor, the full scale of the mechatronics solution is shown, along with how the key functions of the design interact with each other. Additionally, consulting with our TAs provided an outside perspective, helping identify the most confusing aspects of the design and determining what should be prototyped *(Meeting Minutes – Studio 6B)*. The specific parts and shape of the prototype were chosen based on the materials available along with the capabilities and time required to create the prototype.

II. Prototype System Description

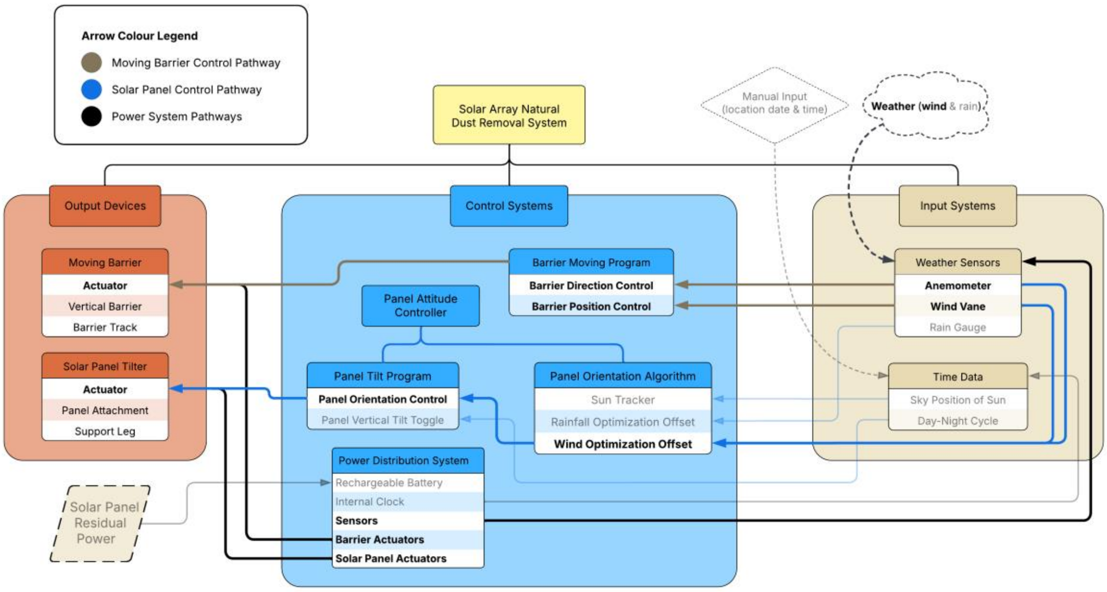

Figure 2: The system architecture diagram highlights the three high level systems followed by the subsystems. All the subsystems are in this diagram but those that will not be implemented in this prototype are greyed out.

The prototype is divided into three subsystems: a track and barrier system, panel tilt mechanism, and control mechanism. A key focus is demonstrating how these components interact together, with the control system processing input from the weather vane to adjust the barrier and solar panel accordingly.

Firstly, the track is represented in the prototype as a circular track, with an arc-shaped barrier moving along it using a motor. Although the design concept involves hinging multiple pieces, a one-piece rounded barrier will be used in the prototype, since the focus is not on the composition of the barrier. Secondly, the tilt mechanism will be represented by a panel sitting on a leg with two perpendicular motors (rotating about the x- and y-axes). This enables the solar panel to fully control both vertical tilt and cardinal orientation based on the wind direction, speed, and the position of the sun. This prototype will not actively track the sun, as its position can be inferred from the time of day and latitude, which can be directly programmed into the system. Wind data will be collected using both a windspeed sensor and a wind direction sensor. These sensors will send data to a microcontroller, which will process it and use an algorithm to calculate output to actuators that adjust barrier position and panel tilt and orientation. It is important to note that the windspeed sensor being used in the prototype may require some modifications to the testing process to demonstrate its use due to the limitations of wind sensors available for use from MyFab.

III. Future Considerations

Proceeding into Phase 3, the following questions should be considered:

1. How does the system respond to sudden wind gusts versus consistent wind patterns?
2. Are the motor and structural components resistant to environmental factors like dust, heat, moisture, other extreme weather conditions?
3. What are the optimal scaling and measurements for the barrier, distance to the panels, and panel height to maximize system performance?
4. How will the prototype be tested for different wind speeds and patterns?