Design Document

Team: GAPS-Prototype Team
Solar Power Supply Prototype
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**Table of Contents:**

## 1. Design Status

| | | |
|---|---|---|
| **Phase 6: Service / Maintenance** | **Status:** ***To be done***<br>**Semester: N/A** | ● |
| **Phase 5: Delivery** | **Status:** ***In Process***<br>**Semester: N/A** | ● |
| **Phase 4: Detailed Design** | **Status:** ***Completed***<br>**Semester: Fall 2015** | ● |
| **Phase 3: Conceptual Design** | **Status:** ***Completed***<br>**Semester: Fall 2015** | ● |
| **Phase 2: Specification Development** | **Status:** ***Completed***<br>**Semester: Fall 2015** | ● |
| **Phase 1: Project Identification** | **Status:** ***Completed***<br>**Semester: Fall 2015** | ● |

## 2. Project Plan

| Milestones | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 | Week 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Research Solar Panels | X | X | X | | | | | | | | | | | | |
| Hook up prototype | | | | X | X | | | | | | | | | | |
| Brainstorming animation draft 1 | | | X | X | | | | | | | | | | | |
| Animation draft 1 is completed | | | | | X | | | | | | | | | | |
| Test prototype | | | | X | X | X | | | | | | | | | |
| Create storyboard for animation draft 2 | | | | | | X | | | | | | | | | |
| Prototype is completely functional (Must be completed by October Break) | | | | | | | | | | | | | | | |
| Animation draft 2 is completed (by October Break) | | | | | | | | | | | | | | | |
| Redesigning prototype | | | | | | | | | | | | | | | |
| Redesign is approved | | | | | | | | | | | | | | | |
| Ordering of new prototype parts | | | | | | | | | | | | | | | |
| Construction of new prototype | | | | | | | | | | | | | | | |
| New prototype is completed | | | | | | | | | | | | | | | |

## 3. Project Identification

### 3.1 Description of Community Partner

There are several community partners for the solar prototype project. Both EPICS and Purdue University will be able to use the model as a teaching tool for elementary school students to high school students and college students. The GAPS Brazil and Colombia teams will also use the solar prototype to better understand solar power so that they can create more effective solar power systems for Medellin and A'Ukre.

Also, the solar power team will teach the Brazil and Colombia teams about solar power and help them design the power systems.

The GAPS teams, EPICS, and Purdue University will receive the prototype deliverable.

Another outcome of the project will be an animation of the solar power system to help explain how the system works. This could be delivered to anyone with an internet connection worldwide if the animation is posted online. People around the world could benefit from this and learn how solar power systems work.

### 3.2 Stakeholders:

| **Project:** | ***Solar Prototype*** |
|---|---|
| **#** | **Stakeholder** |
| **1** | ***EPICS at Purdue*** |
| **2** | ***GAPS Colombia and Brazil teams*** |
| **3** | ***Purdue University students*** |
| **4** | ***Greater Lafayette elementary through high school students*** |
| **5** | ***A'Ukre villagers*** |
| **6** | ***Medellín residents and students of the school*** |
| **7** | ***Universidad de Antioquia team*** |
| **8** | ***Solar power system manufacturers*** |

### 3.3 Social Context:

Our project will affect the community by making it easier to teach and understand solar power systems. It will be especially effective because our project will be fit for teaching students of all ages. It can be used in elementary and middle school classrooms to teach students about solar energy and electric circuits and in high school classrooms to get students interested in solar power or engineering. The project can be used for demonstrations at Purdue to showcase the work EPICS students are doing. It will attract prospective students to Purdue and get them interested in solar power. Also, it will be a tangible example of how the EPICS design process works. We also hope to publish the animation online to teach more people worldwide about solar power in a simple, interesting, attractive format.

This project is also important because the GAPS Colombia and Brazil team will interact with the prototype to learn about solar power systems. This will inform both of their projects when they begin designing the solar power systems for each of their respective villages. If the prototype and animation are successful, they will clearly convey the process by which solar power systems function. We want to make it as easy as possible for the other two GAPS teams to learn about solar power so that they can continue with their projects.

### 3.4 User Needs

| Project: | *Solar Prototype* | |
|---|---|---|
| Need # | User Need | Stakeholder |
| 1 | *Must  clearly convey solar power process* | *User* |
| 2 | *Words on prototype must be concise and clear, and well organized* | *User* |
| 3 | *Must be safe for use* | *User* |
| 4 | *Must be portable* | *User* |
| 5 | *Must be durable* | *User* |
| 6 | *Must be visually appealing* | *User* |
| 7 | *All components must be explained* | *User* |
| 8 | *Instructions on how to use prototype must be provided* | *User* |
| 9 | *Instructions on how to use prototype must be easy to follow* | *User* |
| 10 | *Any wires or hardware that makes the prototype cluttered should be hidden* | *User* |
| | | |
| | Project: Animation | |
| 1 | *Must be able to cross language barriers* | *User* |
| 2 | *Must be understandable for all ages* | *User* |
| 3 | *Must use as few words as possible* | *User* |
| 4 | *Must use universally understandable symbols* | *User* |
| 5 | *Must be visually attractive to capture and maintain attention* | *User* |
| 6 | *Must be brief (less than 3 minutes)* | *User* |

| | | |
|---|---|---|
| 7 | *Must follow the flow of electricity through components of the prototype as closely as possible* | *User* |

**3.5 Project Objectives:**
The main objective of this project is to educate users about solar energy systems using a prototype of a solar energy system that could be found in a home. The animation of the prototype will also help users understand how solar power works. This project is needed to teach students from elementary to college age about solar power and to demonstrate solar power for the general public. The project is also needed to educate the GAPS Brazil and Colombia teams about solar power so that they will be able to design their solar power systems for each of the villages.

**3.6 Outcomes/Deliverables**
The results of the project will be a well-functioning, low maintenance solar power system that is easy to understand and can effectively teach users about how solar power works. Students and GAPS team members will learn about the flow of energy through the different components of a solar power system as well as the purpose of each of the components. An animation of the flow of energy through the system will aid their understanding.

**4. Specification Development:**
There are no educational tools that include high power solar panels with an instructional unit attached. Since all of our circuitry has been bought from other companies and we did not create any new product, there is no need for a patent and we do not need to worry about intellectual property barriers. A comparable animation to ours can be found on youtube or a solar panel educational website, but the animation in combination with our educational display is unique to our team.

Specification Development Table 1. Project needs and specifications

| Project: | *Solar Panel Display* | | |
|---|---|---|---|
| Need # | User Need | Spec # | Specification |
| 1 | *Display must be able to stand on own* | | |

| | | | |
|---|---|---|---|
| | | 1.1 | *3D CAD design including holes for parts attached that is structurally sound by doing approximate tipping calculations* |
| 2 | *Must be made of nonconductive material* | | |
| | | 2.1 | *Fiberglass or plywood* |
| 3 | *Must be mobile* | | |
| | | 3.1 | *At least 4 wheels attached to bottom* |
| 4 | Circuit must be able to handle maximum power, voltage, and current specs of solar panels | | |
| | | 4.1 | At least 30W, 48V, and 2A |
| | | | |

**5. Conceptual Design:**

The solar panel prototype was previously constructed with the idea that its purpose will be to teach others in the EPICS program, fellow team members, and younger students. It is a setup that includes a full set of components to allow power from the solar panels to be safely converted to output power to a switch, outlet, and a fan. This setup is displayed on two connected wood boards on a stand as well as a portable wood frame for the solar panels. The brainstorming process has been introduced and started to consider further ideas to make the stand and setup look more professional, and to be of a higher quality material. Another goal is to create the setup in a way where the solar power flow is explicitly shown/understood. The low-resolution and proposed solution for the more feasible and simpler-to-understand setup will progress after October 14, 2015 (as proposed in semester timeline). Previous semesters such as Spring 2015, have described more of the conceptual design and the prototype components leading to this current design.

**6. Detailed Design**

**6.1 Design Process**

The design process had started before Fall 2015, which led to this current design. So far, the Fall of 2015 Prototype team's Bill of Materials only consists of a couple high power resistors. These resistors cost about $5 from Radio Shack and were used to test the i-v curve of each solar panel.

| Sub-Process | Item | Made/ Bought | Vendor | Quantity |
|---|---|---|---|---|
| *I-V Curve testing* | Resistors | Bought | Radio Shack | 3 |

No assembly or manufacturing were needed for this current design. A few modifications were made to the current design of the prototype learning tool: the ammeters were removed, wires were disconnected and connected for current and voltage testing purposes, and an animation will now be included to the prototype learning tool.

**6.2 Prototype Process:**

The current design of the prototype learning tool is as follows: two solar panels are propped at a changeable angle upon a portable wooden frame. This frame is a little wider than the doorway, so to be portable its legs must be flattened and carried sideways through a single door. The next component in the setup is the Solar Combiner. This is attached onto the wooden setup of the learning tool on the side labeled “Outside” and is connected to the two solar panels. It then flows current to the Charge Controller. The Charge Controller is a smart device that can choose where to send current and can stop sending current if there is too much. This is also connected onto the wooden prototype board. The current then flows to the inverter and the battery. The inverter is velcroed onto the wooden board and the battery is solidly attached to the board. As of today 9/29/2015, the current is being sent only to the battery from the charge controller. The current is then supposed to pass through the Breaker Box, which is on the side of the prototype board labeled “Inside” and then to flow to the switch, and the fan and outlet to show the connections work. If too much current is being pulled through to the “Inside”, the Breaker Box will break its connection to stop the flow of current, and can also be manually switched back to closed. The prototype learning tool is made of wood and is held up by a base piece of wood and painted gold or black. Pieces of tape remain on each component to show the flow of energy and paper labels headline each side of the board.

The animation will be added as an extra tool to help cross language and knowledge barriers to teach others on the solar power supply process. Brainstorming and collaboration have begun on the animation, and the general outline has been formed. It will be a short video of the flow of current in the solar components starting from the solar rays hitting the solar panels until the power outputting into a fan or switch. More has been discussed on what should be included in the video, and the consensus is that the animation will show a simple yet informative way of the solar rays activating the solar panels to power, the battery charging, and the breaker receiving too much current along with the overall general flow of current in the system. The beginning steps have been pieced together into a video of the roadmap of the Solar Power Supply Prototype. To see the begining animation, follow https://www.dropbox.com/s/wdfqurqdrhrye2j/Epics.mov?oref=e .

**6.3 Risk Analysis:**

Some potential risks to the Solar Power Supply Prototype is having current flow the wrong way, too much current going to a component, a component break such as one of the panels since they have to be carried for a small amount of time through a single doorway, or the possibility of overcharging the battery. Fortunately, a lot of these risks can be prevented and avoided altogether. The Charge Controller, Inverter, and Breaker Box are all/contain fuses or the capability of opening a connection so these potential risks do not occur. So the largest potential risk to consider is the damage of a component, whether it be on transportation or just because of a wrong connection. The recommended action to avoid this risk to to take extra caution of the surroundings and situations to prevent anything from breaking, falling, or being harmed. Everyone using this Solar Power Supply Prototype must be aware of the potential risk.

## 7. Delivery

### 7.1 Project User Manual:

The circuitry should be connected as described in Sect. 6.2. Once proper connections have been made on the display unit, connect the display to the two black cords coming off the solar panels with the connections on the solar combiner box. Once this connection has been made, tilt the solar panels so that the shadow from the PVC pipe on the side shows sun shining through. This means that the solar panels are tilted at the optimal angle for maximum power. If the battery is more than 40% charged, then the outlet, light switch, and fan are ready to be used. If the battery is less than 40% charged, then the battery will continue to charge until ready for use.

### 7.2 Maintenance:

The solar panels may lose maximum power abilities due to dust or scratches. Therefore, more power may be generated if the solar panels are cleaned of any dust and if they are not kept in harsh environments where they may be damaged.