# Energy

## Children's Educational Demonstrations (CED)

EPICS®

## CONTENTS

# SECTION 1: PROJECT IDENTIFICATION

## PROJECT OBJECTIVE STATEMENT

The objective of the Energy Project is to design an engaging interactive display that inspires children with an interest in clean energy engineering and an awareness of alternative energy solutions. The Energy Project hopes to deliver a product that enhances children's learning in a way that is different from reading about the subject in class, which aligns with the mission of Children's Educational Demonstrations: to provide children with alternative learning methods in the form of engaging, interactive displays.

## DESCRIPTION OF THE COMMUNITY PARTNER

The Project's community partner is the NSF Engineering Research Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR) located at Purdue University. CISTAR is a research center focused on investigating novel clean energy solutions and has an outreach program science fair each spring, which is where the Energy Project, once delivered, will be displayed.

## STAKEHOLDERS

Although our customers will be affected by our projects, there will also be other people affected. The children seeing this project and interacting with it will be affected by this project by building their knowledge on different types of energy.

This team and the stakeholder have vital interest in the success of this project. CISTAR will also be affected by the success of our project. If our project is successful more customers will be drawn to CISTAR.

Beyond the end user, anyone who is using this model has an interest in the upkeep and maintenance of this project. Although, it is the responsibility of this team to make sure the users know how to maintain this project.

## PROJECT SCOPE

We aim to create a rectangle display showing how different types of energy can power on a building model. We will leave a working display of diverse ways of harvesting energy to advance children's knowledge of the subject in a fun and interactive way.

We are currently working on the conceptual design and preliminary prototyping phase, therefore we should be focusing on documentation, ordering supplies, and detailing each section ideas. We will not be looking at the assembly and delivery portion right now, only up to assembly until we have all parts and feedback from CISTAR.

We have assumed that we will be able to use the labs on campus to 3D print designs very easily and that our materials will get when expected and not have any delays. We are also assuming we will be able to navigate using wiring and electronics on to connect the buttons to the display.

## USER NEED LIST

| Need # | Stakeholder | User Need |
|---|---|---|
| **1** | CISTAR | *Needs to be durable and easy to maintain* |
| **2** | CISTAR | *Able to be viewed by multiple children at once* |
| **3** | CISTAR | *Displays various energy sources* |
| **4** | Children | *Must be intuitive to use and provide an engaging experience* |
| **5** | Parents | *Must be safe to use* |
| **6** | EPICS coordinators | *Must be cost-effective and within budget* |

## EXPECTED OVERALL PROJECT TIMELINE

*Project Start Date:* Spring 2021 *Original Target Delivery Date:* Fall 2021

The original target delivery date was set to be the end of the Fall 2021 semester, but a reorienting of project objectives following design review at the end of Spring 2021 has postponed the anticipated delivery date to the Spring 2022 semester. The Energy Project hopes to complete prototyping by midsemester Spring 2022, then shift focus to manufacturing and technical writing for the remainder of Spring 2022. A detailed Gantt chart for the project's Fall 2021 goals can be found in Section 6.

# SECTION 2: SPECIFICATION DEVELOPMENT

## DESCRIPTION OF THE USE CONTEXT

This project will be used to educate middle-school-aged children on several types of energy, the associated costs, and why we use many different methods of generating power. This interactive display will challenge students to think creatively and solve hypothetical problems using real world science. Upon successful completion of the task the interactive display will light up and provide positive feedback that the right answer has been reached. The only way that this project may be misused is if students intentionally break the interactive pieces or are not engaging with the prompts and situations provided. The model and circuitry components will be completely sealed off from the end users.

This project will need to be plugged into the wall to work and supply power to the circuits running the interactive components. Students will interact with individual pieces embedded with magnetically controlled switches that will engage and disengage the interactive displays of the project.

This project will be 40 inches by 15 inches and should fit comfortably on top of most tables and will easily sit against a wall to maximize space and the students that can interact with it at the same time.

The next team involved with the project, CISTAR, and the end users will be responsible for maintaining this project and reaching out to the EPICS team for any upkeep and maintenance that this project requires. This project should be quite simple and robust and should not need any major maintenance or any work done on it. Everything about the design and components included in the project has been selected and engineered to be as simple as possible while still completing the necessary task with reliability for years to come.

The project will be kept indoors and away from excessive heat and moisture to keep it in the best working condition and safe for use. The project will be exposed to the public as well as children that may damage the project. For this reason, the project has been specifically designed to minimize potential damage. The models will be entirely sealed off from the children to help protect them. The only pieces that are touched by the children are small 3D printed activator pieces that will engage the display if the children choose the correct answer. These pieces have been designed to be strong enough to stand up to regular wear and tear. There should be no significant security issues regarding this project. This project needs to be durable enough to withstand normal use and abuse from children.

This project offers no major social or societal factors that need to be taken into consideration. This project will be written in English and other languages will not be supported.

The technological limitations of this project are that the project must be plugged into the wall to work. Beyond being plugged into a standard outlet to be powered on, the project will require no other technology from the user and no necessary knowledge of technology to use the project to its fullest extent.

## BENCHMARKING

The Energy Project has investigated existing market solutions to the project's design goal. While there are plenty of online resources about the various types of energy and the situations in which they are used, there is no real alternative to our final product. There are no interactive models specifically centered around this topic and of the solutions that are like our project they are not near the size or complexity. Our solution would be most comparable to active demonstrations and interactive classroom activities that these students complete in their normal coursework. Our final product is also like many interactive displays and exhibits commonly found in science museums. There are no potential barriers from intellectual property involved in our project.

## SPECIFICATION LIST

A list of developed specifications is outlined in the table below. Each specification is based on a user need established in Section 1 and is restated in the table for convenience.

| Need # | User Need | Spec # | Specification |
|---|---|---|---|
| **1** | *Needs to be durable and easy to maintain* | 1.1 | Ensure parts needed for repair are cost-effective and easily acquired |
| | | 1.2 | Provide user maintenance manual |
| **2** | *Able to be simultaneously viewed by multiple children* | 2.1 | *Large enough to accommodate at least 3 children at once* |

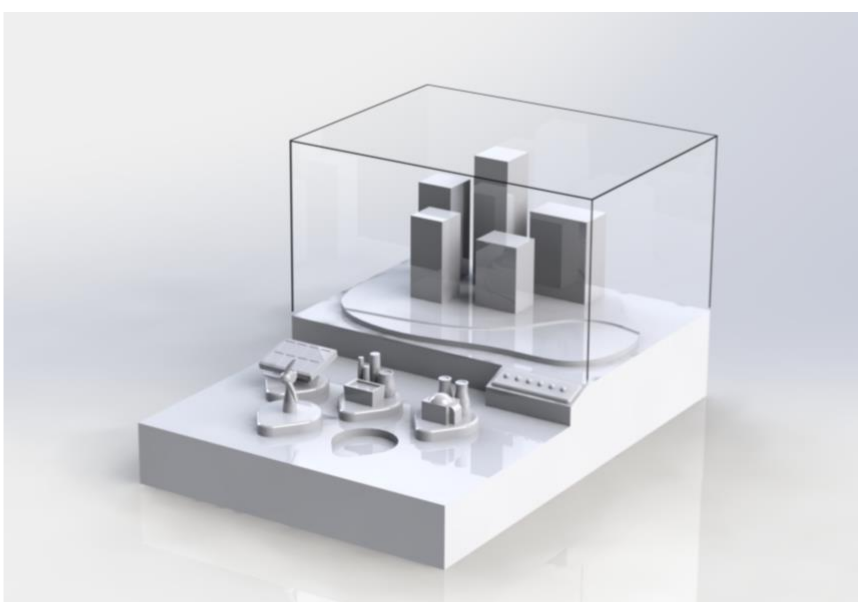
| | | | |
|---|---|---|---|
| **3** | *Displays various energy sources* | 3.1 | Include at least 4 power plant types (Solar, Wind, Coal, Nuclear) |
| **4** | *Must provide an intuitive, engaging experience* | 4.1 | Power plant minigame with 4 difficulty levels |
| **5** | *Must be safe to use* | 5.1 | *Should not have exposed electrical components* |
| | | 5.2 | *Should not have any possible pinch points* |
| **6** | *Must be cost-effective and within budget* | 6.1 | *Keep unit cost (per level) to be under $200 USD* |

## SECTION 3: CONCEPTUAL DESIGN

### CONCEPT GENERATION

In the Spring 2021 semester, the team planned on creating a hexagonal display that children could walk around to see the change in energy type use over time. Also planned was an online quiz for the children to take to test their understanding after viewing the model. During the final design review in Spring 2021, design reviewers brought up the concern of this model's interactivity – after all, this would not be significantly different from a typical classroom setting besides seeing physical models of each energy power plant type.

Following this design review feedback, the Fall 2021 team decided to reorient project goals and redesign, starting again from the concept generation stage. New ideas focused on improving the project's interactivity and implementation of engaging elements to gain and maintain children's interest.



One concept that the team decided to proceed with is a minigame-style display with "chess pieces" of various power plant types. These "chess pieces" will be mixed-and-matched in a power plant complex, or "build plate," to provide adequate power to a community. These communities effectively act as "levels" of various difficulty and offer different power requirement scenarios—such as large cities, suburban communities, and rural towns—that the children would strive to solve. The successful "power-ing" of a community will manifest in the form of each community "lighting up" in order to provide children with a tangible sense of accomplishment.

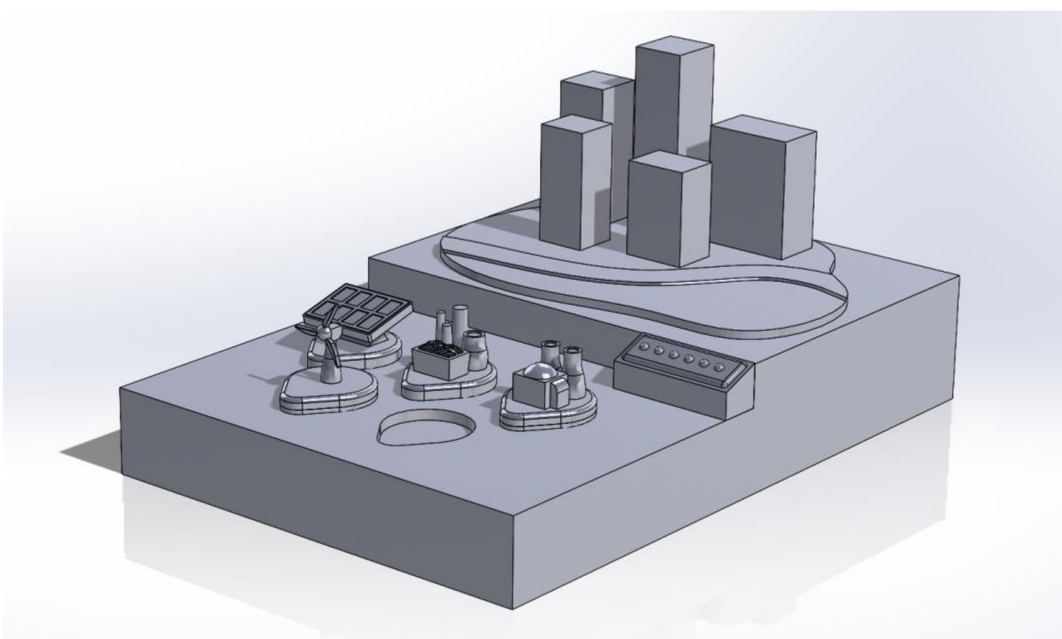
Through this interactive display, it is the Energy Project's hope that children will walk away with knowledge of the unique power requirements that each different community presents.

## PROTOTYPING

Prototyping completed in the Fall 2021 semester is divided into Mechanical and Electrical sections, each of which are further divided into subsections for organization.

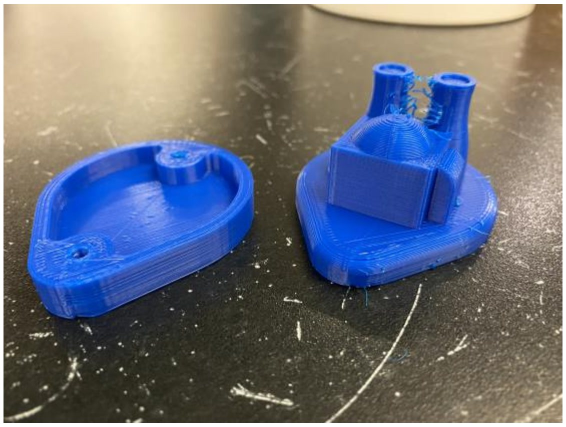
### MECHANICAL DESIGN

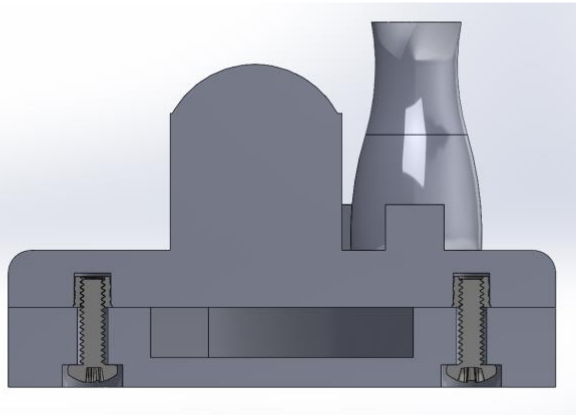
Mechanical design includes creating the build plate and chess pieces, as well as the diorama section of the display. The build plate will be created out of laser-cut wood panels, while the power plant chess pieces and diorama will be 3D printed. Pictured below is a CAD model assembly of build plate, chess pieces, and diorama sections that make up one "level" of the game.



The types of power plants represented by chess pieces include solar, wind, coal, and nuclear power. The chess pieces have been designed with 3D printing in mind, and are either completely printable without supports or can easily be split into parts that can be printable without supports. The wind plant's fan blades, for instance, have been designed with a flat cross section—rather than a true-to-life slanted blade design—for ease of 3D printing.

A model of the nuclear plant has been printed out to test optimal 3D printer settings, appropriate geometric dimensioning and tolerancing, and heat-set insert applicability. The 3D printed prototype is pictured below.

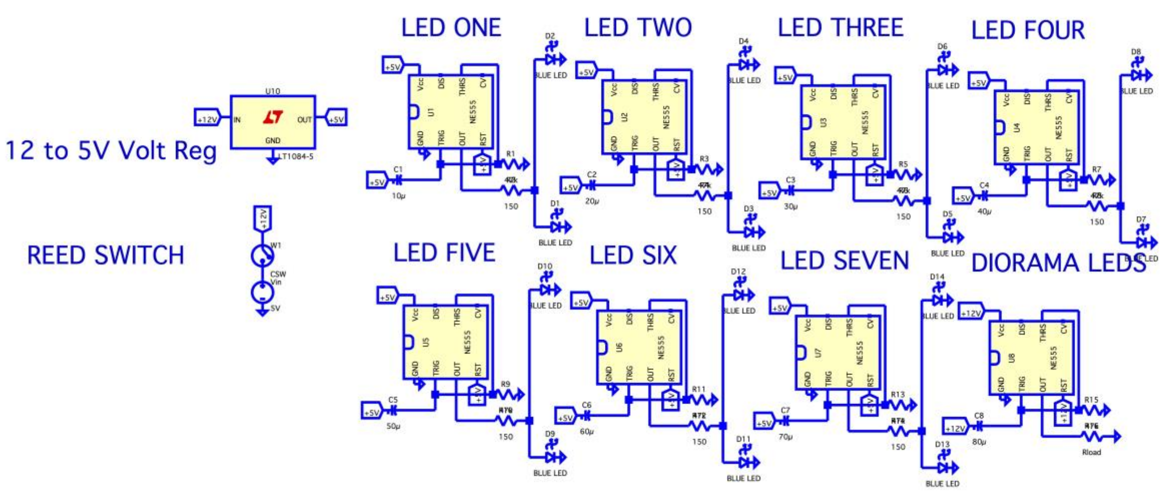


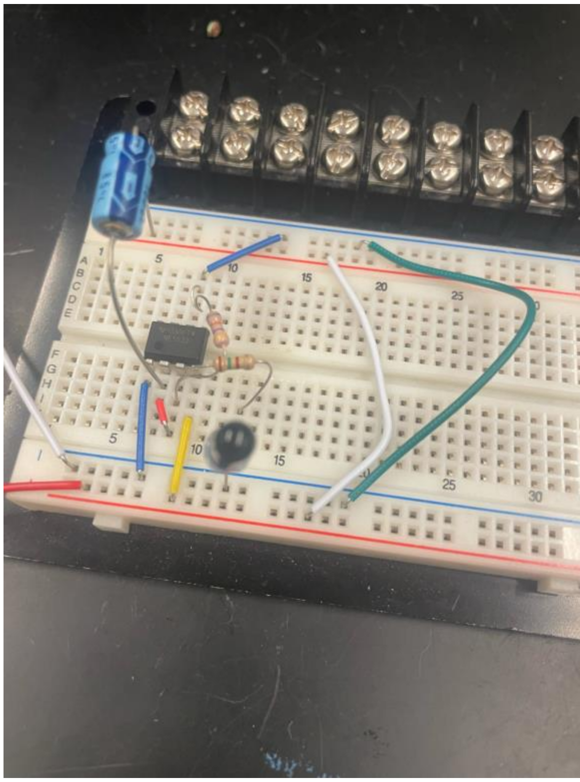


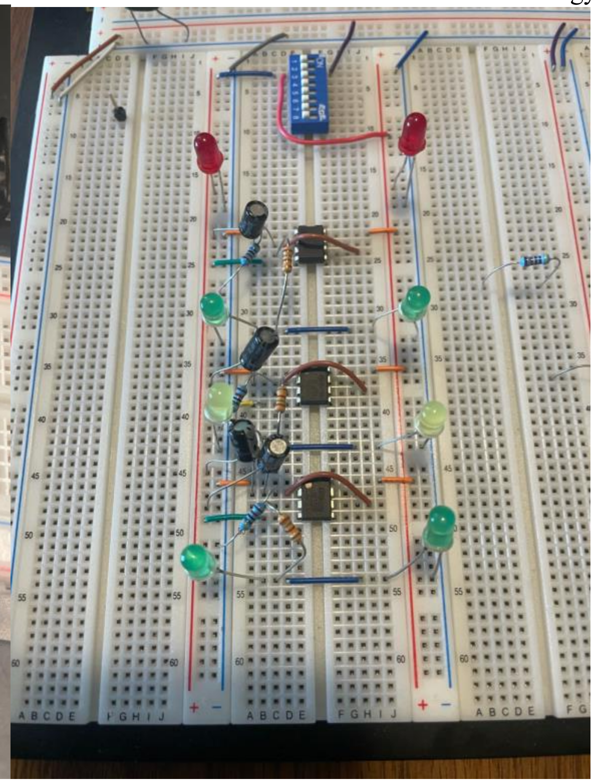
As seen above left, each chess piece has a hollow base to accommodate magnetic inserts that actuate Reed Switches mounted underneath the base plate. Holding the two chess piece segments together will be two imperial 4-40, 3/8-inch screws and matching tapered heat-set inserts, both sourced from McMaster-Carr. The team is awaiting purchase of these components and has not yet tested the strength and reliability of the design. Also shown above is a cross-section of the nuclear chess piece showing intended assembly of these parts.

## ELECTRICAL DESIGN

Pictured below are the schematics and initial prototypes of the LED timer circuit that will be replicated many times throughout the project and will control the dynamically powered LED power indicator. This circuit will be connected to Reed switches that are effectively magnetically operated switches that will provide power to the LED power display and the corresponding diorama if and only if the user identifies the correct source of energy to fit the given problem description. These switches will be embedded into the 3D printed interactive pieces and the main platform of the model as shown in the previous section.







As supplies come in, this circuit will be transferred from a solderless breadboard to a much more compact and robust soldered silicon platform. This will make the circuit more compact, reliable, and robust for use in the project. The use of 555 timer chips seen in the circuit above and capacitors of differing values allow the team to control the activation of different lights, motors, and other features embedded within the interactive model to activate at various times and simulate create more interesting effects. This was chosen deliberately as an improvement based on the feedback of last semester's design to directly address concerns that the project was not interactive or stimulating enough for the end user.

Circuit prototyping will continue with the addition and integration of reed switches, a 12V power supply, and voltage regulator circuits to enhance simplicity and reliability for the project partner and end user

## CONCEPT CONVERGENCE

Concept convergence will be completed after the completion of preliminary prototyping and proof-of-concept. This section will include a decision matrix used to select the final concept, on a feature-by-feature basis, that the team will go forward with in development.

## PROPOSED SOLUTION

This section will be completed in the future and will include a complete description of the proposed design concept, including sketches and process diagrams to adequately convey the concept.

# SECTION 4: DETAILED DESIGN

## BILL OF MATERIAL (B.O.M)

This section will be completed at the completion of the conceptual design stage and will provide a list of all of the components, both manufactured and purchased, that go into the final design.

## PRINTS/SCHEMATICS/CODE

As with the Bill of Materials, this section will be completed at the completion of the conceptual design stage. This section will provide links to any relevant material that describe the technical details of each component and the overall assembly or technology stack, whether the project is physical, virtual, or both. These materials will be of quality and completeness such that a 3rd party of reasonable skill could fabricate the project without additional instruction.

## MANUFACTURING AND ASSEMBLY PROCESSES

This section, to be completed in the future, will describe the methods used to manufacture and assemble the final product. Major iterations of the design will be described in separate sub-sections, and descriptions will be sufficient for an average freshman engineering student to replicate the product.

## RISK ANALYSIS

Risk analysis and mitigation will be completed in the future by the team. The team anticipates utilizing the FMEA technique based on the American Society for Quality FMEA's template.

## VERIFICATION

Verification will be completed in the future. This section will include a table summarizing verification results and will adequately demonstrate that each design specification has been met.

## VALIDATION

Validation will be completed in the future. This section will include a table summarizing validation results of and a link to the complete validation test report. This section will adequately demonstrate that each user need has been met.

# SECTION 5: PROJECT DELIVERY

Section 5: Project Delivery will be completed when the team anticipates delivery. This section will include a User/Service Manual, a completed delivery checklist, customer satisfaction questionnaire completed by the community partner, and a record of project delivery.

# SECTION 6: CURRENT SEMESTER RECORD

## POINT OF CONTACT FOR FUTURE TEAM MEMBERS (E.G DESIGN LEAD)

| | |
|---|---|
| **Name:** | **Jane Chen** |
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## POINT OF CONTACT AT THE COMMMUNITY PARTNER ORGANIZATION

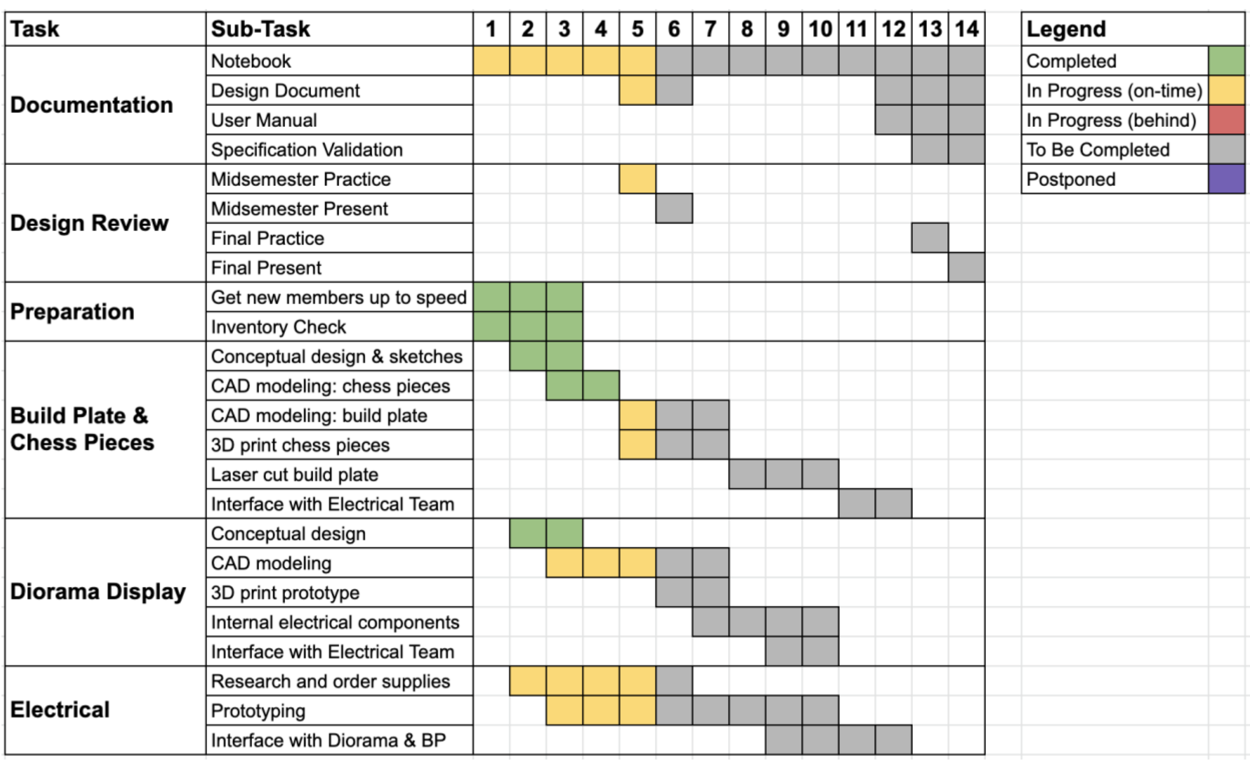
| | |
|---|---|
| **Name:** | **Maeve Drummond-Oakes** |
| **Email:** | **maeve@purdue.edu** |

## CURRENT PROJECT STATUS: FALL 2021

Following design review feedback at the end of Spring 2021, the team has decided to move forward with redesign, starting from the stage of conceptual design. Beyond details provided in Section 3, the team is currently in the process of preliminary proof-of-concept prototyping. We are simultaneously working on both the mechanical and electrical aspects of the design, with work split among team members with backgrounds in each discipline.

## CURRENT SEMESTER PROJECT TIMELINE

The Gantt chart below details the team's current semester project plan. A legend is included to the right of the chart for understanding.




Last revised 9/26/2021

The major milestone we aim to complete this semester is the completion of a prototype of one "level," including the electronic circuit design and its interface with all mechanical aspects. We are currently in the process of creating CAD assemblies and purchasing necessary materials for prototyping.

## TRANSITION REPORT

This section will be completed at the end of the Fall 2021 semester, and will include:

- Storage location and login info for all team materials (code, CAD models, etc.)
- Major milestones completed
- Major roadblocks encountered and suggested remedy
- Suggested next-steps for next semester's team
- Team leadership roles that have been established for next semester

This concludes the Energy Project's Fall 2021 Midsemester Design Document. On the following pages are Appendices detailing past semester records.