THE OHIO STATE UNIVERSITY

Preliminary Design Review

Presented by: Manhattan 2 Rollable PV Capstone Team

Agenda

1. Project Goals
2. Concept Development
3. Preliminary Concept Design
4. Budget and Preliminary Parts List
5. Project Risk and Abatement Plan
6. Conclusion
7. Questions

Project Goals

Deliverables

A written report with the following will be provided as the final result:

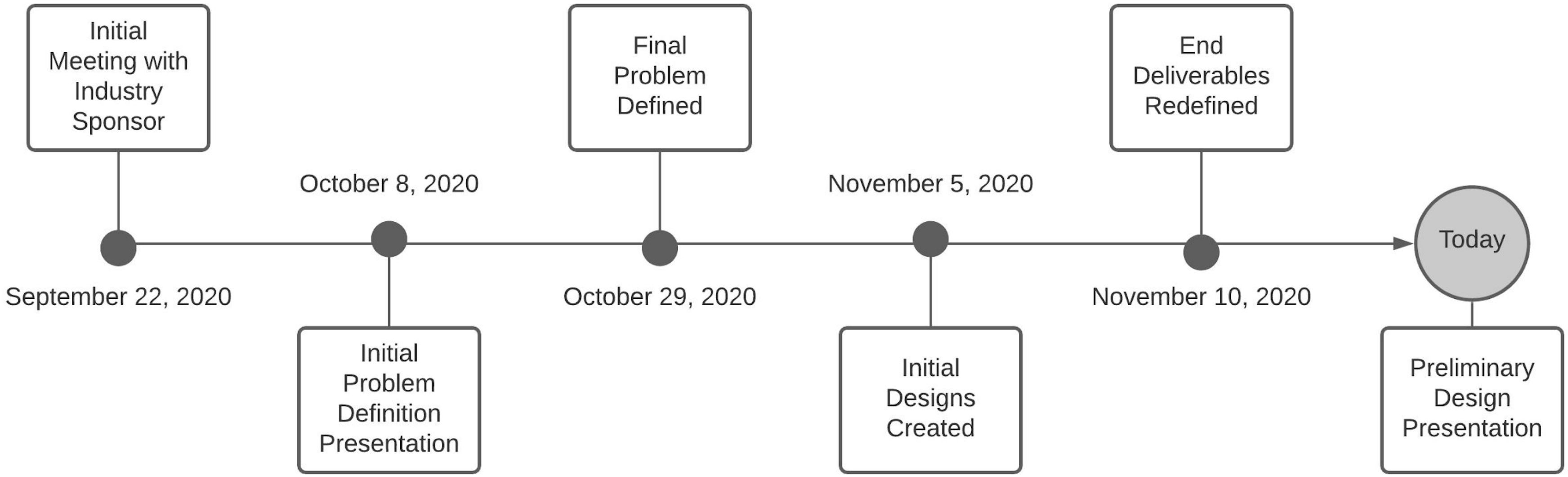
- Electrical Simulations
  - Multiple panel power combination
  - Effect of lightning strikes and static discharge

- Additional Simulations
  - 30-year simulation detailing effects of weather on soil erosion, wind effects, and heat dissipation

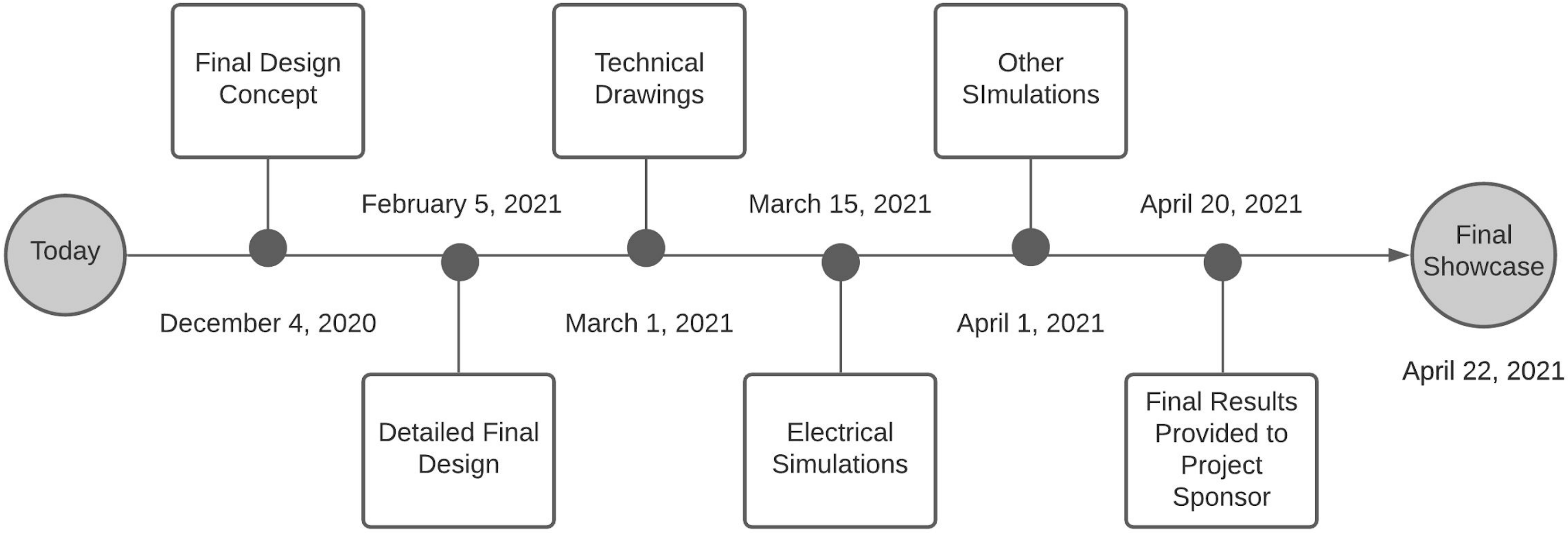
- Technical Drawings
  - Detailed drawings and explanation of method, materials, and equipment needed to install rollable PV cells direct to land

*** A small-scale "proof of concept" prototype will also be provided depending on Ohio State's future COVID-19 restrictions ***

Past Milestones



Future Goals



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Concept Development

1 Project Goals

2 Concept Development

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Concept Road Map

- Research
  - Meetings with Glenn Weinreb
  - Individual research
- Group Brainstorming
  - General discussion on needs and requirements
- Attribute Listing
  - Table of essential project components
- Individual Design
  - Each member created a concept design for the module system

Needs Chart

Design Needs	Priority [1(low) - 5(high)]
Improve Electrical Safety	5
Reduce Material Cost	5
Increase Scalability	4
Increase Heat Dissipation	2
System Monitoring	3
Increase Durability (Lifetime)	3
Enterprise Needs	
Reduce Production Cost	5
Reduce Lead Time for Production	1

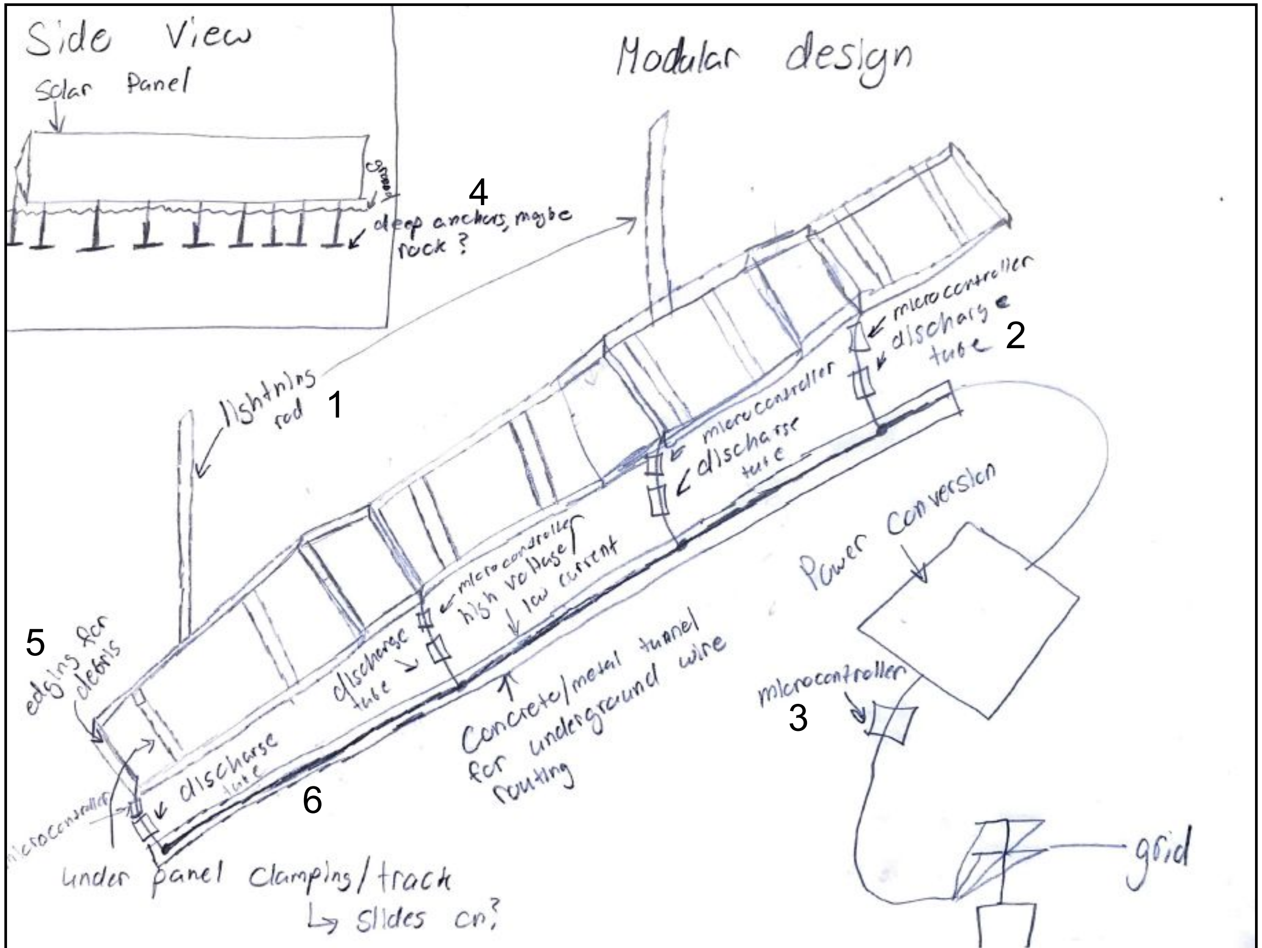
Attribute Listing

Weather protection	Panel Holds/Attachments	Land Installation Process	Heat Distribution	Power Conversion
Glass Layer above	Staking to ground	Shape Land	Panel Elevation	Power Routing
extreme weather - tarp	Panel Orientation	Wiring	Spacing	Transformer Conversion
waterproof	Electrical Connections	Lay Panels	Material	Power Correction
dust shielding	Panel Clamping	Connect wiring to solar		
		Easy connection between module		

Attribute Listing

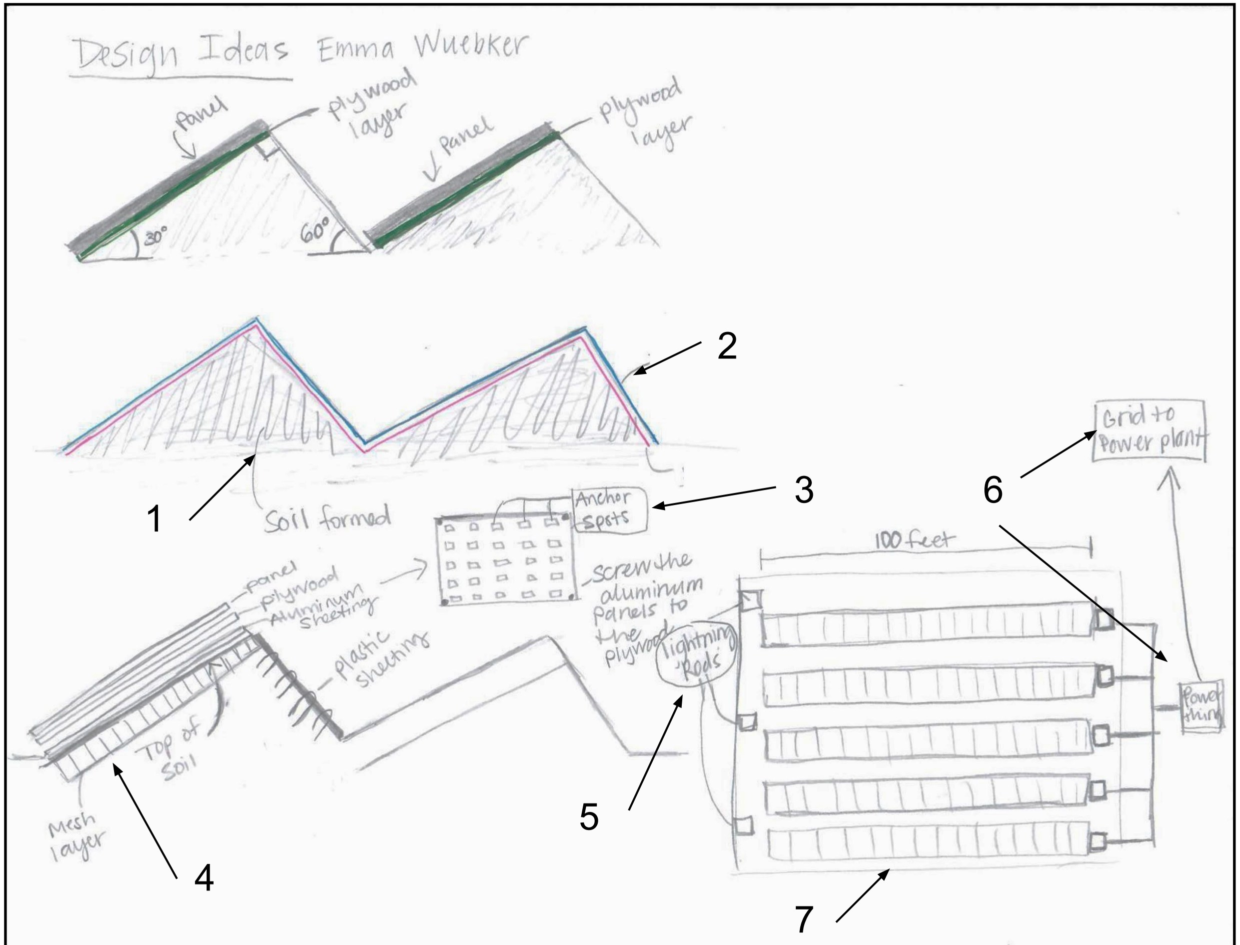
Electrical Protection	Communications	Economics	Maintenance	Dropping Weight
Lightning Rods	Microcontroller Placement	Material choice	Day to Day Cleaning	Different Materials
Gas Discharge Tubes	User Interface	Labor demands	Anchoring repairs	Different Way of Laying Down
Material choice to reduce discharge	Monitoring Components	Power costs	Electrical Repairs	
			Weather Damage	

Concept A



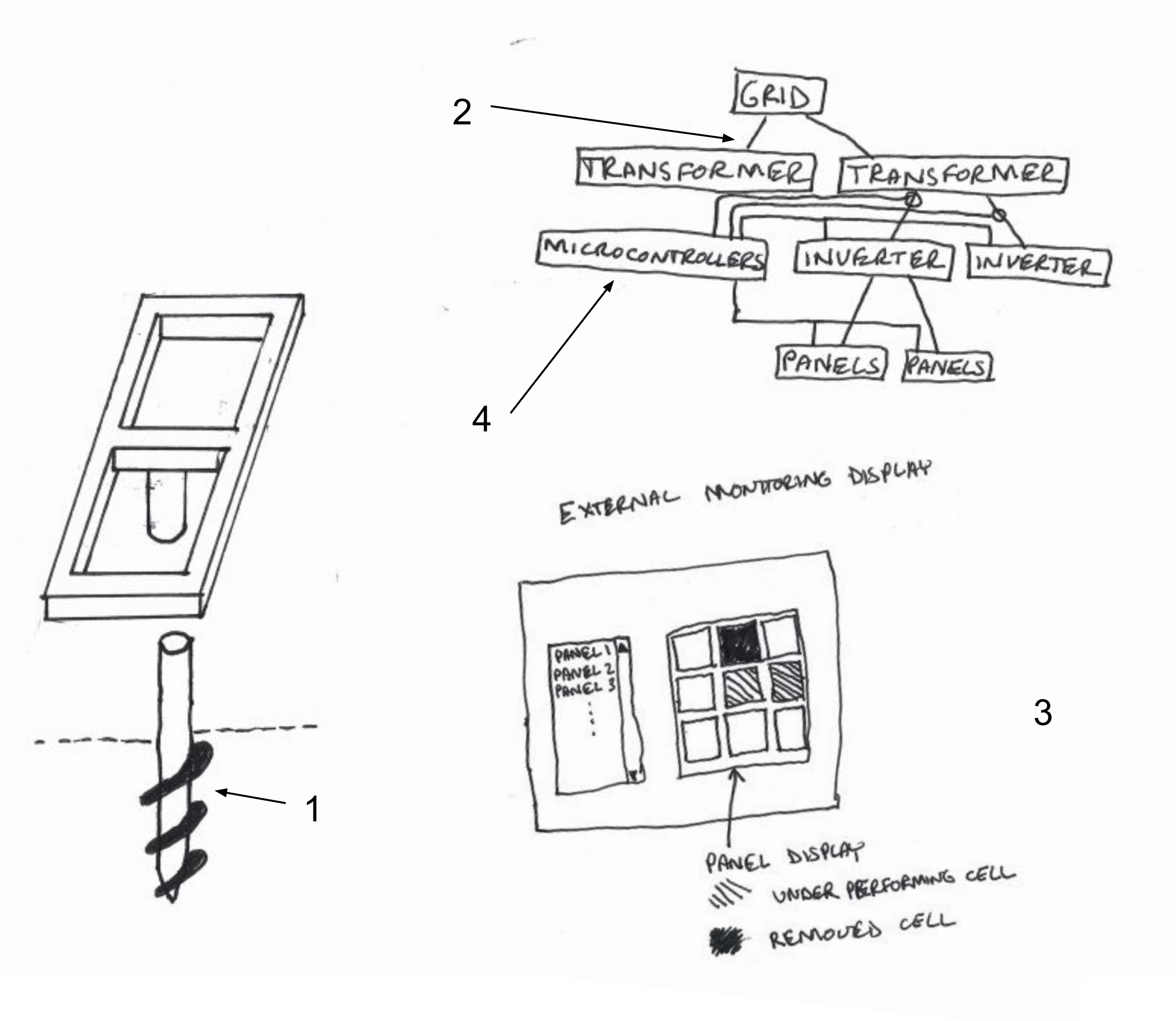
1. Lightning rods every other panel
2. Gas discharge tubes for each rollable section
3. Microcontrollers for each rollable section and for monitoring power conversion
4. Deep anchors into rock layers
5. Elevated edges for protection
6. Maintenance tunnel for wire routing

Concept B



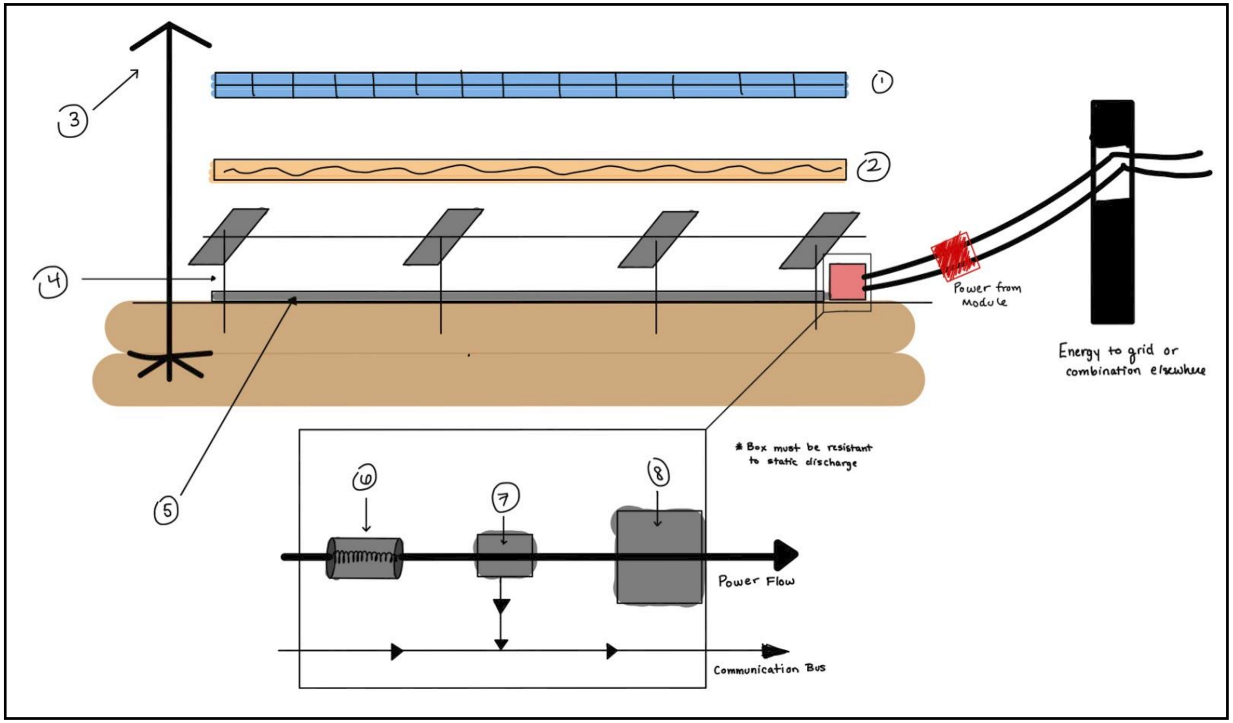
1. Formed soil mounds
2. Plastic sheeting to prevent erosion
3. Aluminum panel
4. Buried Mesh layer
5. Lightning rods
6. Electrical System
7. Panels laid out

Concept C



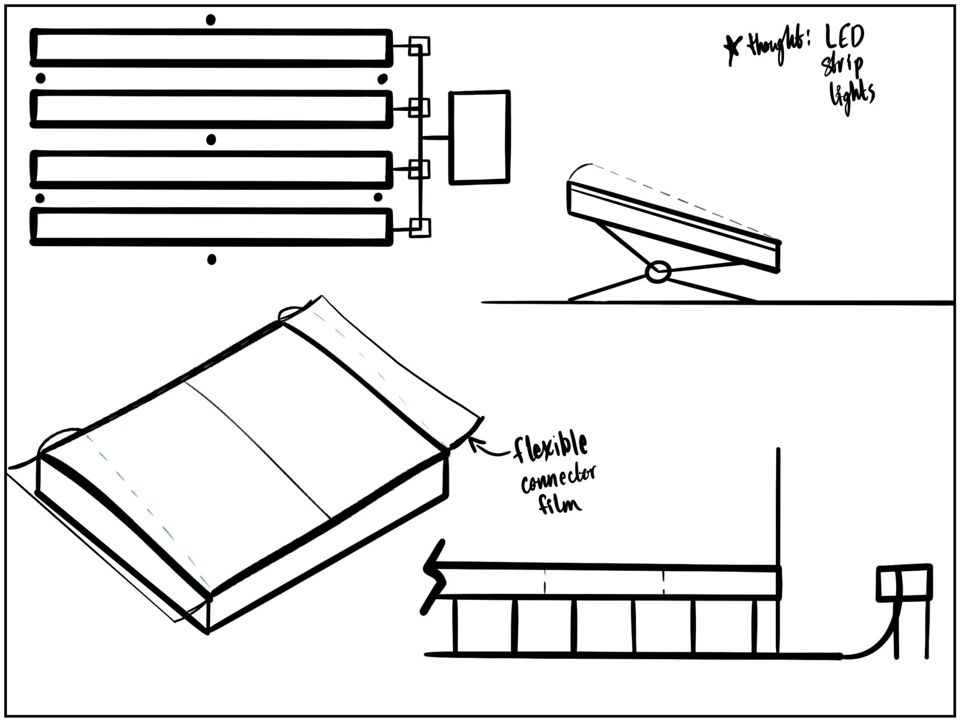
1. Screw anchoring system for quick installation
2. Electrical Cross-connections to prevent single point failures
3. External monitoring system to assist in maintenance plans and diagnostics
4. Processors to remove underperforming cells

Concept D



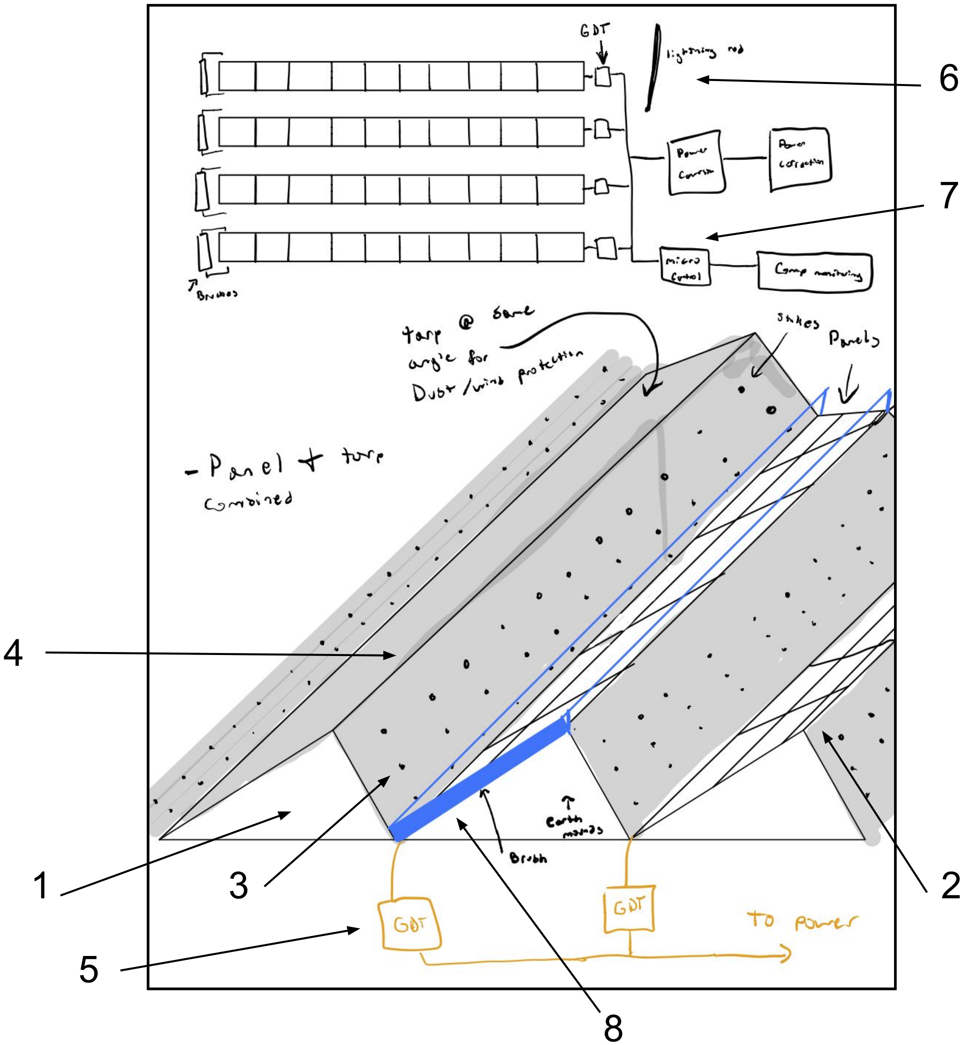
1. Rollable Solar Panel
2. Rollable Thermal Material
3. Lightning Rods
4. Supports
5. Power and communication bus conduit
6. Lightning strike overvoltage protection
7. Microcontroller
8. Power Combination

Concept E



1. Flexible, Rollable Panels
2. Placed on Pivoting Bases
3. Lightning Rods Throughout the Field
4. Clear, Protective Film Angled above Panels
5. Electrical Components Running through the Ground
6. Microcontroller for Subsections
7. Control Center for Overall System

Concept F



1. Packed soil at 30 degree angles
2. Tarp with rolled solar panel attached laid overtop mounds
3. Tarp staked down at multiple points over 60 degree portion
4. Single mound in front of first row for dust protection
5. Gas discharge tubes at the end of each row
6. Lightning rods with every module
7. Microcontroller for system monitoring
8. Motorized brushes to sweep panels

Concept Reference

Topaz Solar Farm [1]

- Individual panels connected together
- Sections are supported by vertical I-beams
- Wiring located on underside of panels

Concept Screening Matrix

Needs	Concept A	Concept B	Concept C	Concept D	Concept E	Concept F	Reference
Electric Safety	+	+	0	+	+	+	0
Material Cost	-	+	-	-	+	+	0
Electric Production	0	0	0	0	+	0	0
Scalability	0	+	0	0	-	+	0
Heat Dissipation	0	-	0	+	-	-	0
System Monitoring	+	+	+	0	0	+	0
Durability	+	-	+	+	0	-	0
Installation Cost	-	+	-	-	+	+	0
Lead Time	-	+	-	0	0	+	0
Ease of Installation	-	+	-	-	-	+	0
Ease of Maintenance	+	+	0	0	0	+	0
Weight of Structure	-	+	-	-	-	+	0
Sum of +'s	4	9	2	3	4	9	0
Sum of 0's	3	1	5	5	4	1	12
Sum of -'s	5	2	5	4	4	2	0
Net Score	-1	7	-3	-1	0	7	0
Rank	5	1	7	5	3	1	3

Concept Scoring Matrix

Needs	Weights	Concept A		Concept B		Concept C		Concept D		Concept E		Concept F	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Scalability	18.0%	4	0.72	5	0.9	4	0.72	4	0.72	4	0.72	5	0.9
Material Cost	14.0%	2	0.28	4	0.56	2	0.28	2	0.28	3	0.42	4	0.56
Installation Cost	14.0%	2	0.28	4	0.56	2	0.28	3	0.42	4	0.56	4	0.56
Ease of Installation	14.0%	2	0.28	5	0.7	2	0.28	2	0.28	2	0.28	5	0.7
Electric Safety	8.0%	5	0.4	4	0.32	3	0.24	4	0.32	3	0.24	4	0.32
Heat Dissipation	8.0%	4	0.32	1	0.08	4	0.32	5	0.4	2	0.16	1	0.08
Durability	8.0%	3	0.24	2	0.16	4	0.32	3	0.24	3	0.24	1	0.08
Weight of System	6.0%	1	0.06	5	0.3	1	0.06	2	0.12	2	0.12	5	0.3
System Monitoring	4.0%	5	0.2	4	0.16	5	0.2	5	0.2	4	0.16	4	0.16
Ease of Maintenance	4.0%	3	0.12	3	0.12	2	0.08	3	0.12	2	0.08	3	0.12
Energy Efficiency	1.0%	1	0.01	2	0.02	3	0.03	3	0.03	5	0.05	1	0.01
Lead Time	1.0%	1	0.01	4	0.04	2	0.02	2	0.02	2	0.02	4	0.04
	100%												
	Net Score	2.91		3.88		2.81		3.13		3.03		3.79	
	Rank	5		1		6		3		4		2	

Preliminary Concept Design

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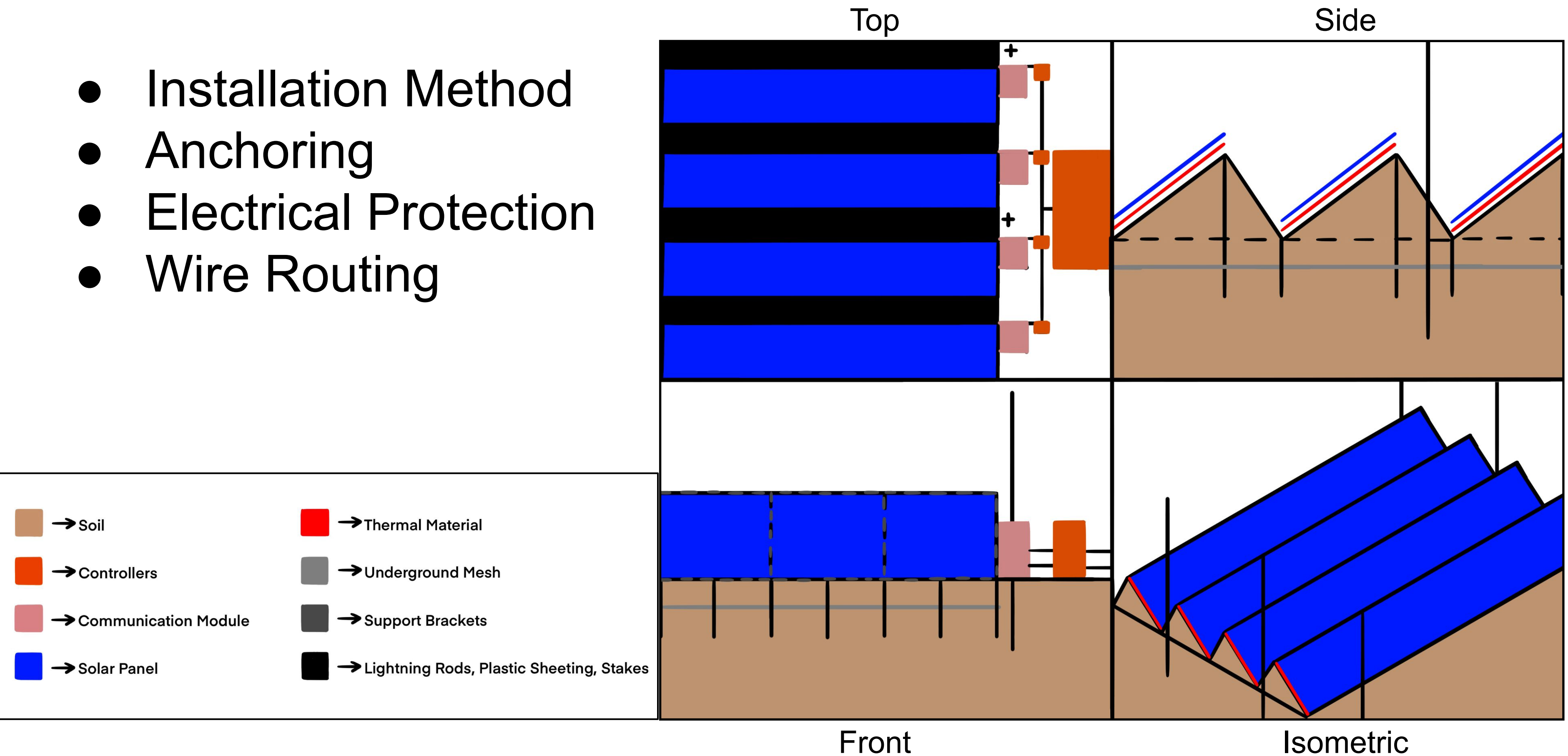
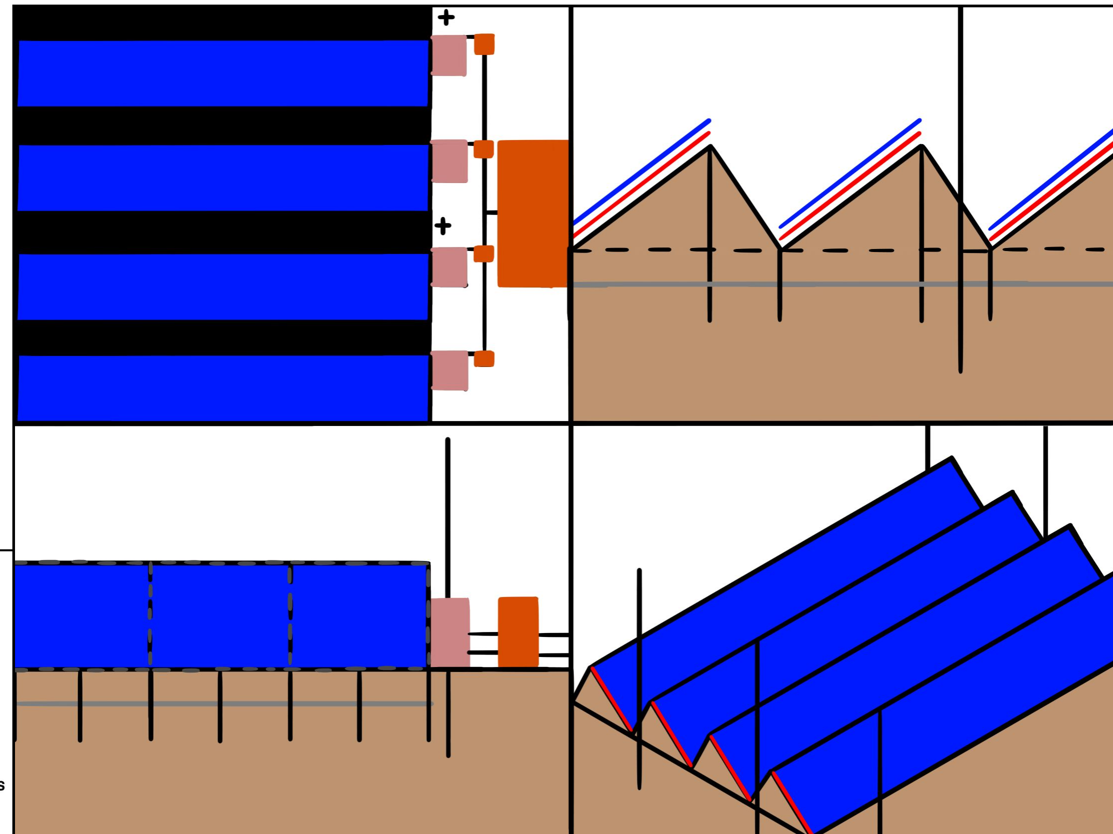
Overview

- Installation Method
- Anchoring
- Electrical Protection
- Wire Routing

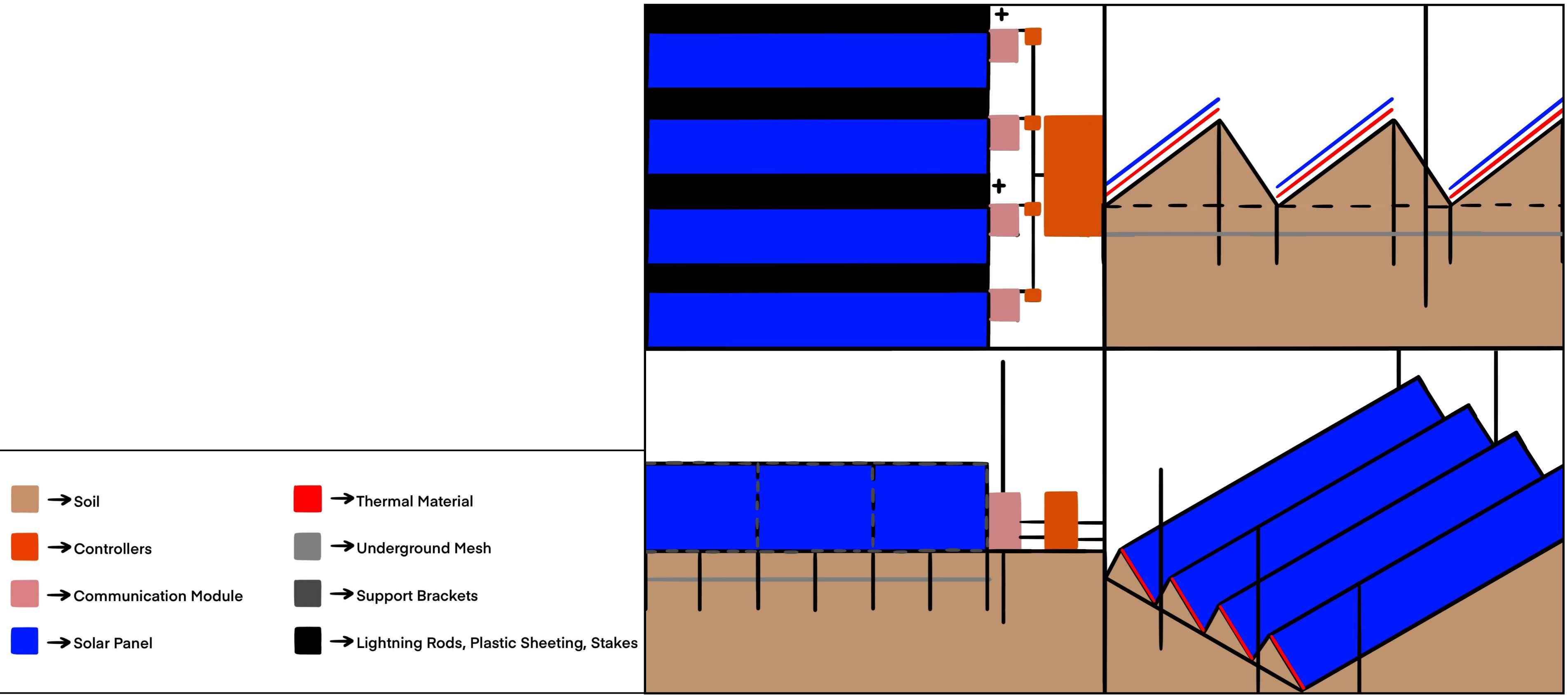


Installation Method / Anchoring

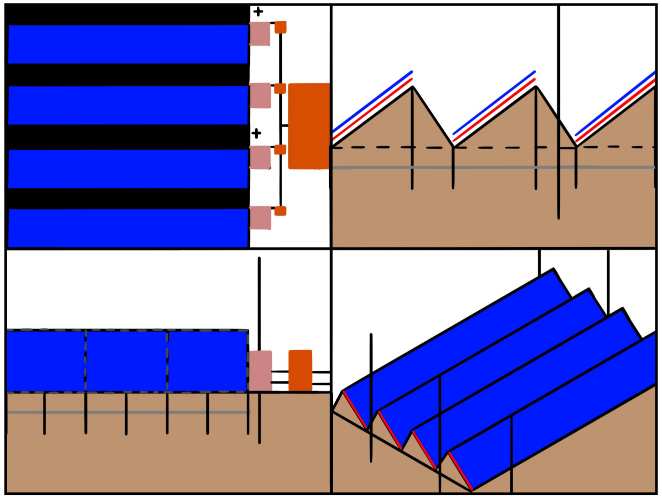


- → Soil
- → Controllers
- → Communication Module
- → Solar Panel
- → Thermal Material
- → Underground Mesh
- → Support Brackets
- → Lightning Rods, Plastic Sheeting, Stakes

Electrical Protection / Routing



Design Metrics



- Created measurable metrics based on design needs
- Based on current issues within the solar industry and needs with current design

User Need	Specific User Need	Design Requirement	Metric	Range	Goal
Cost	Material Cost	Cost Reduction	USD	5%-25%	15%
	Installation Cost	Cost Reduction	USD	10%-60%	0.3
Scalability	Installation	Installation Time	Months	1-3	3
	Weight of System	Weight Reduction	Pounds	10%-30%	20%
	Ease of Maintenance	Reduction in Labor	Hours	1%-10%	5%
System Performance	System Monitoring	Microcontrollers	Count	1-5	4
	Durability	Similar to Current Lifespan	Years	20 - 30	25
	Heat Dissipation	Temperature of Electronics	Degree Celsius	20-40	30
	Energy Efficiency	Similar to Current Efficiency	% Efficient	15%-23%	18%
Safety	Lightning Protections	Lighning Rods	Count	1-4	1
	Surge Protections	Gas Discharge Tubes	Count	1-5	4

Broader Impacts

- Environmental Impact
  - Reduction in greenhouse gases and air pollution produced by the energy industry

- Industrial Impact
  - Electric Power Industry
  - Electronics Industry
  - Fossil Fuel Industry

Broader Impacts

- Social Impact
  - Reduction of jobs in traditional fuel industries
  - Increase of jobs in manufacturing of solar panels and solar industry

- Political Impact
  - Decrease in tensions between countries due to fossil fuel needs
  - Increase in tensions whose exports involve fossil fuels
  - Improvement in energy production in 3rd world countries

Budget and Preliminary Parts List

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Budget & Materials

Total Budget

- $3,500

Material Groups

- Electrical
- Mechanical
- Installation

Preliminary Parts List		
Electrical Components	Mechanical Components	Installation Equipment
Microcontrollers	Metal Mesh	Backhoes
Lightning Rods	Metal Sheeting	Tractors
Gas Discharge Tubes	Tarps	
Wire Routing	Metal Anchoring Rods	
Transformers	90° Metal Bracketing	
Capacitor Banks	Thermal Material	
DC to AC converters	Plywood	
	Fasteners	
	Stakes	

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Project Risk and Abatement Plan

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Temperature

- Day temperatures exceeding 110F
- Night temperatures below 0F
- Possible material degradation due to thermal cycling and solar radiation
    - Plan: Careful selection of materials
- Possible localized heat island effect
    - Plan: Account for effect in simulations

Dust, Soil, and Erosion

- Dust covering panels reduces efficiency
  - Plan: Incorporate a dust removal system

- Incompatibility of anchoring method with soil composition
  - Plan: Test the anchoring method with the various soil compositions found in the American Southwest.

- Erosion destroys the sloped land dunes
  - Plan: Plastic sheeting laid to reduce erosion and exposure to weather

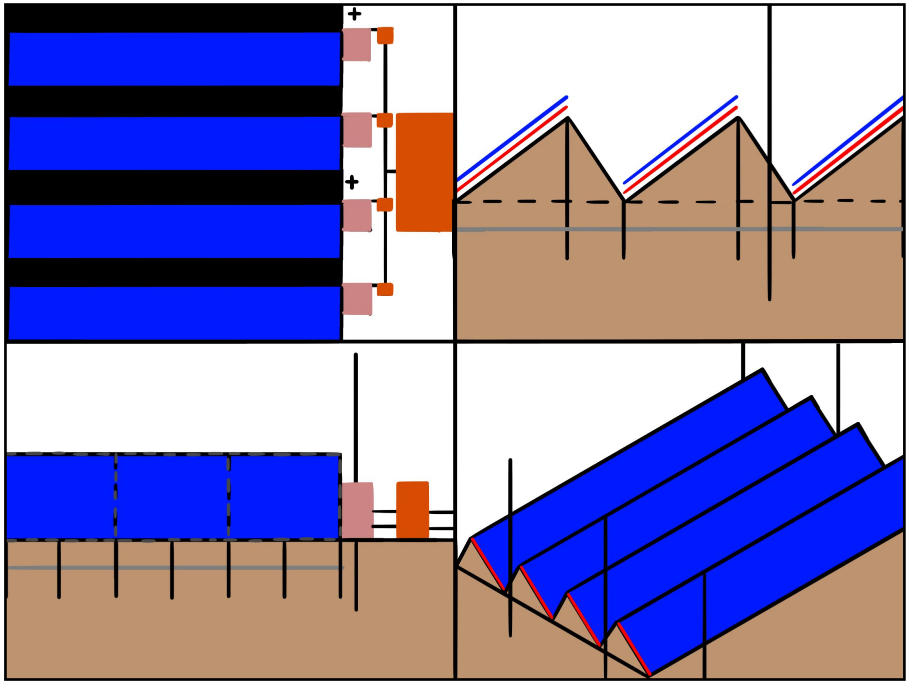
Electrical Malfunction

- Destruction of electrical components from lightning
  - Installation lightning rods to ground lightning strikes
- Electrostatic discharge shorting electrical components
  - Installation of gas discharge tubes to each panel section
- Panels operating outside of expected parameters
  - Microcontrollers monitoring panel and system outputs

Conclusion

Conclusion

- The team considered various attributes needed within a final design
- Each member created their own individual concept
- These concepts were all considered, and a preliminary design concept was created
- A preliminary budget and parts were created based on this design
- Various risks and abatement plans to the project were considered as well



Questions?

Sources

[1] “The world's biggest solar power plants,” Power-Technology.com. https://www.power-technology.com/features/the-worlds-biggest-solar-power-plants/attachment/1-image-topaz-solar-farm/ (accessed 15-Nov-2020).