College of Engineering
Electrical Engineering Department
EE 492 - Capstone Project 2
2023-2024 - Spring Semester

University of Prince Mugrin

Capstone Project II

DESIGN AND IMPLEMENTATION OF A FLOATING PV POWER PLANT FOR MADINAH REGION

By:

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Under the Supervision of:

Dr. Hadeed Sher

May 16 , 2024

Outlines

01 Introduction

02 Literature Analysis

03 Project Design

04 Experimentation & Implementation

05 Results & Discussion

06 Conclusion

01

INTRODUCTION

Problem Statement

Energy Demand

Low Efficiency Of PV Panels

High Cost

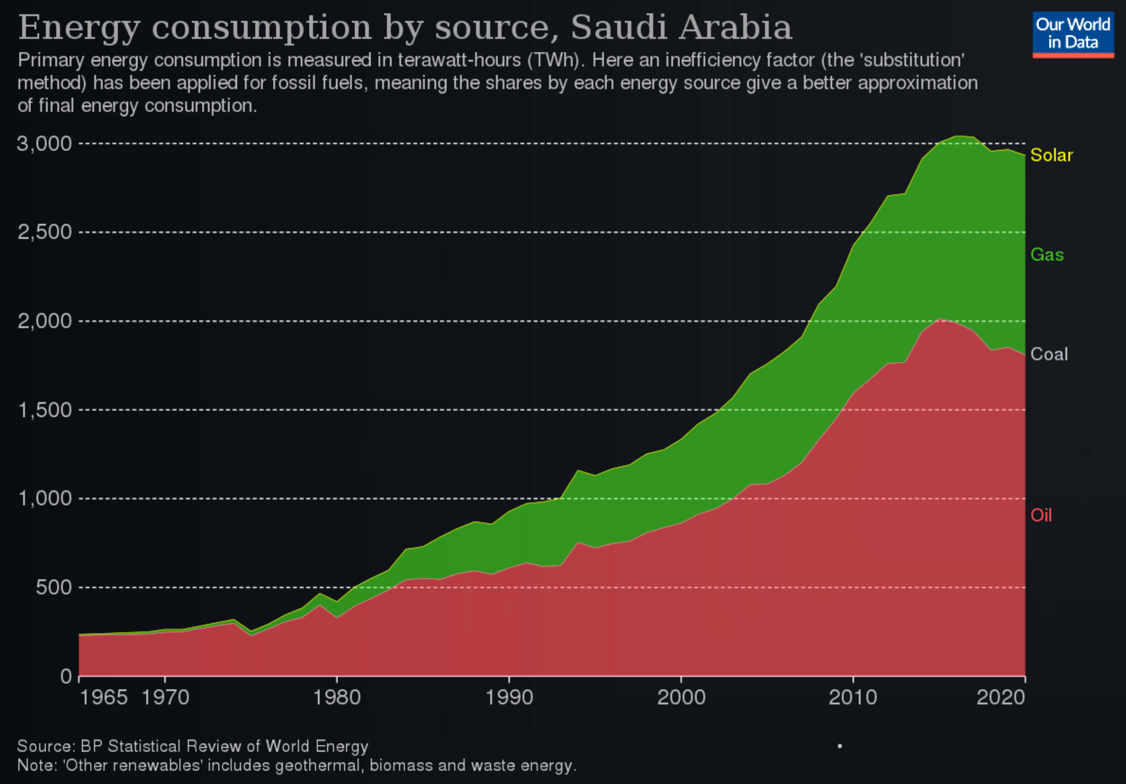


Figure 1

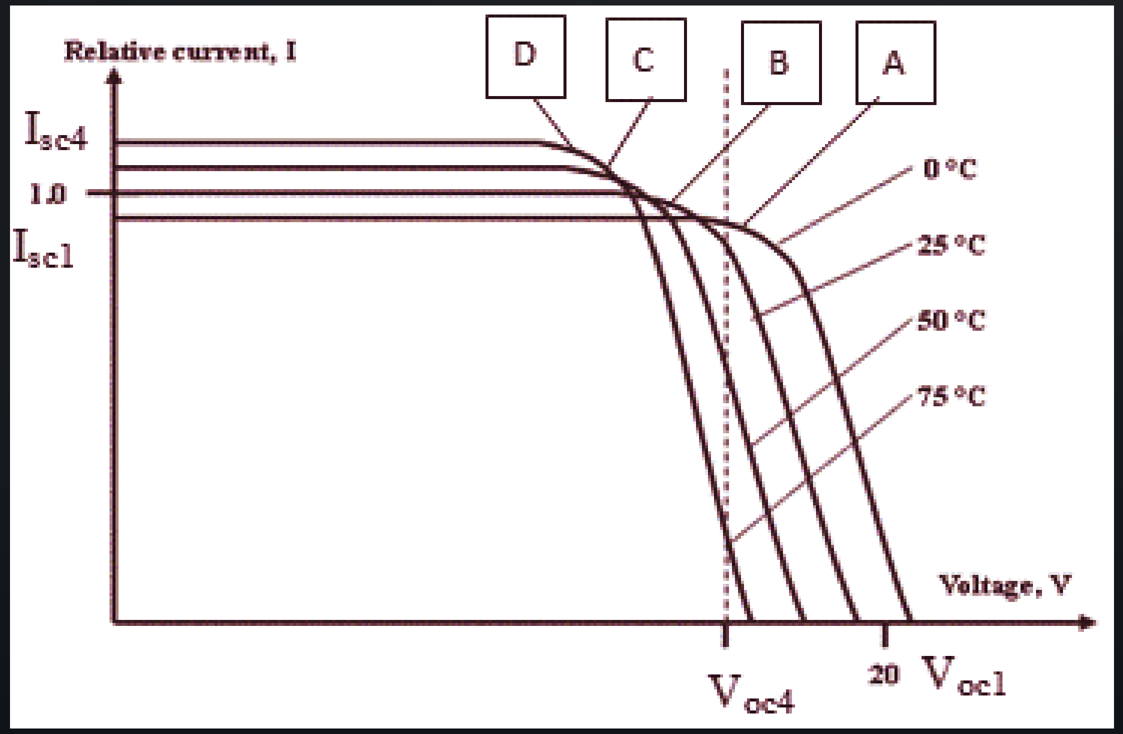


Figure 2

Figure 3

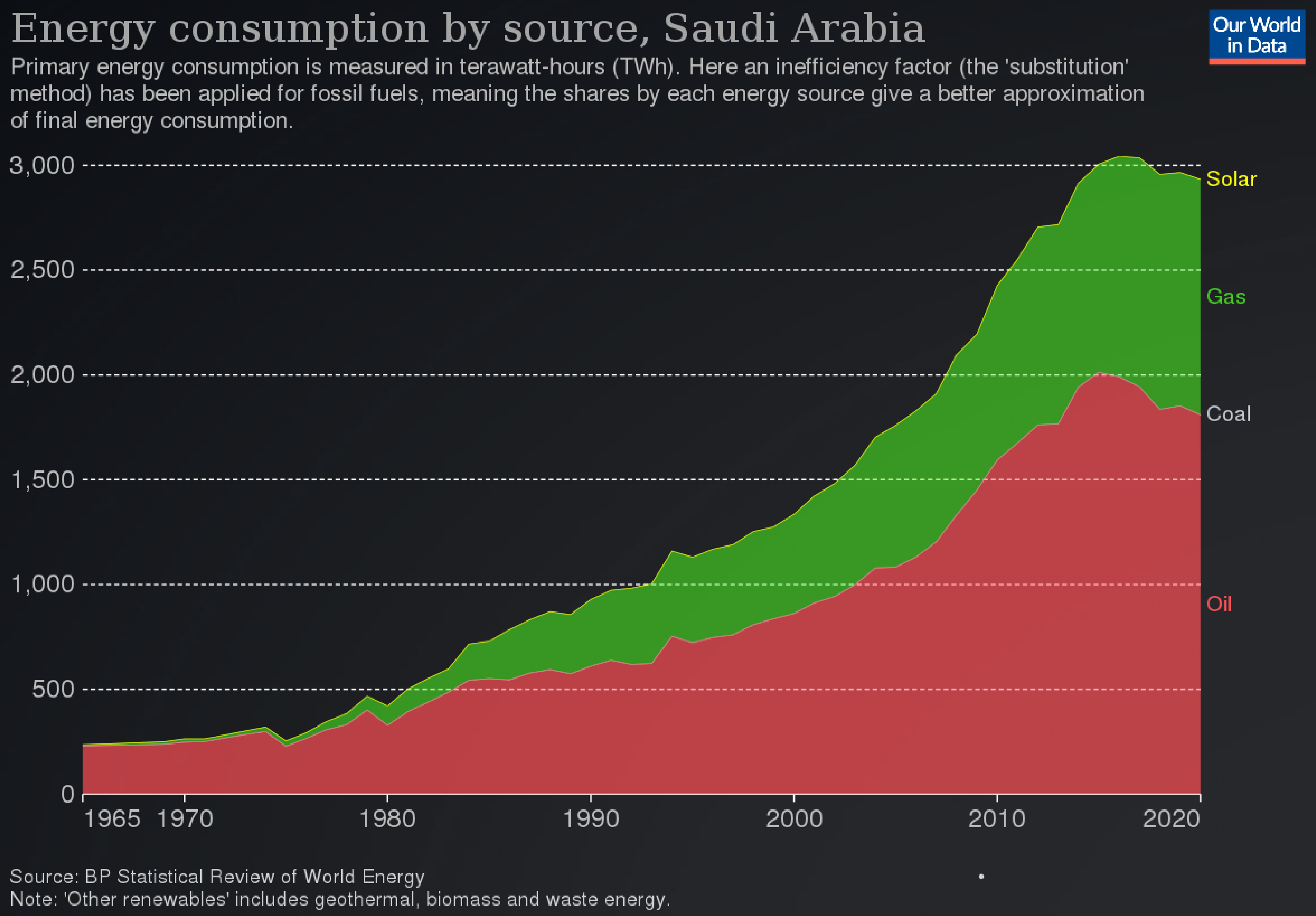


Figure 1. Energy Demand

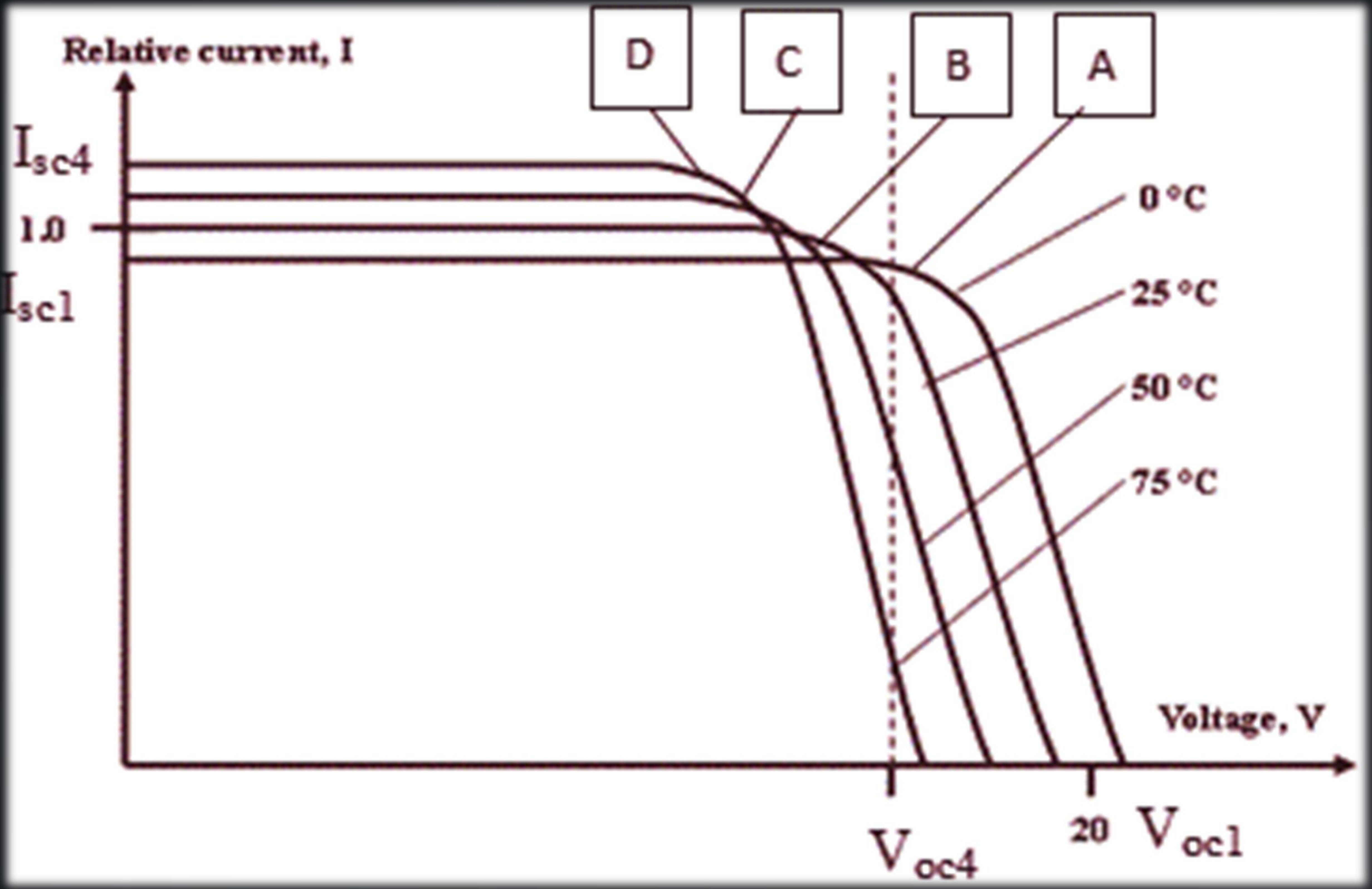


Figure 2. Low Efficiency Of PV Panels

Figure 3. High Cost

Current Methods
(PV Systems)

Figure 4. On Land

Figure 5. On Rooftop

Proposed Solution

Design and Implementation of a Floating PV Power Plant for Madinah Region (Al-Aqoul Lake)

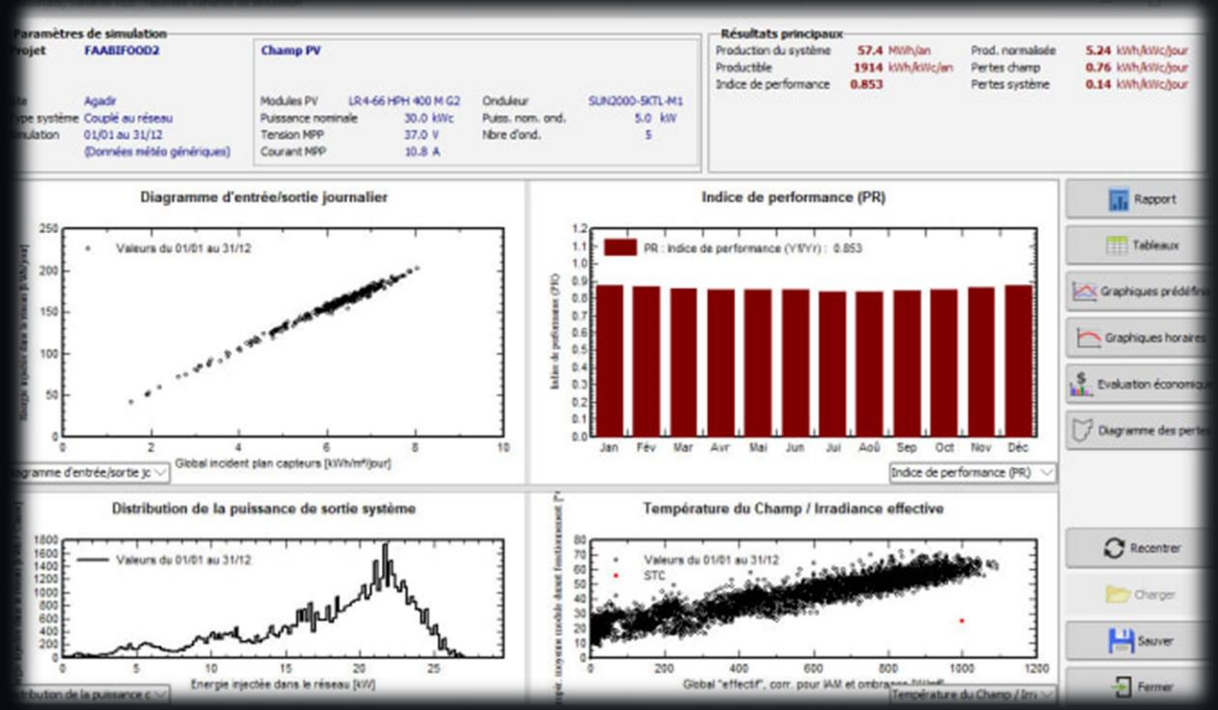
Objectives:

1. Developing Renewable Source
2. Environmental and Economical Advances

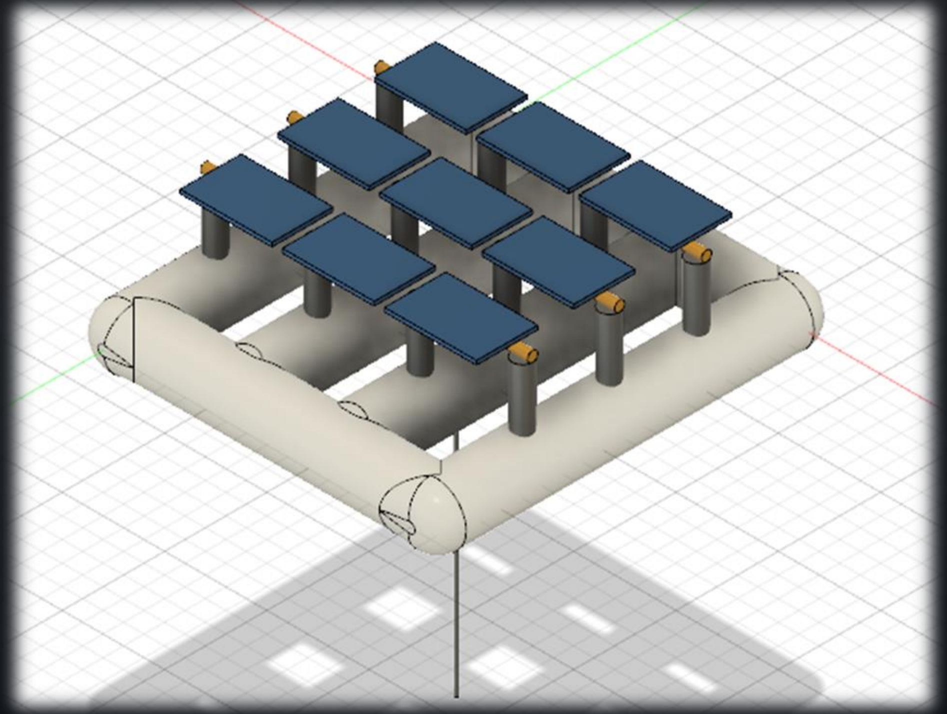
Figure 6. FPV Power Plant

Deliverables

Mega FPV Power Plant Simulation



Prototype Construction

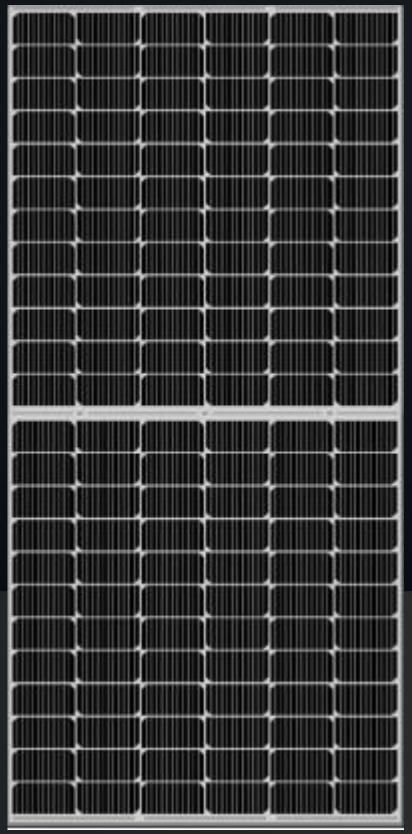


Detailed Financial Analysis

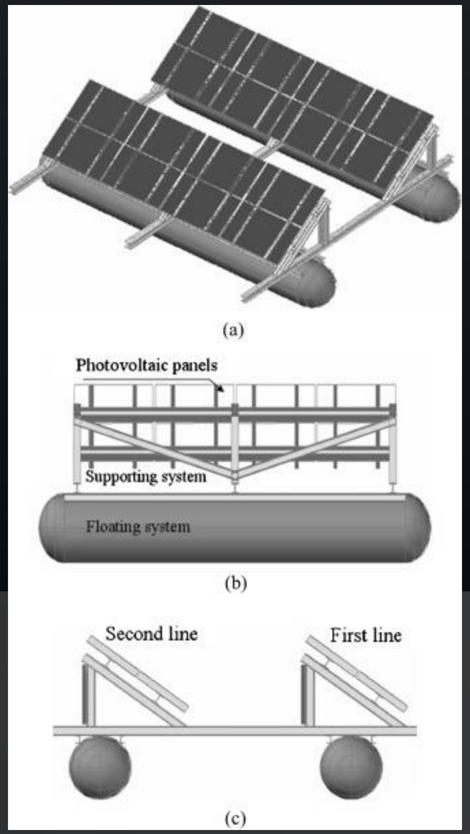
02

Literature Analysis

Design Parameters & Specifications



Panel Type
and Efficiency

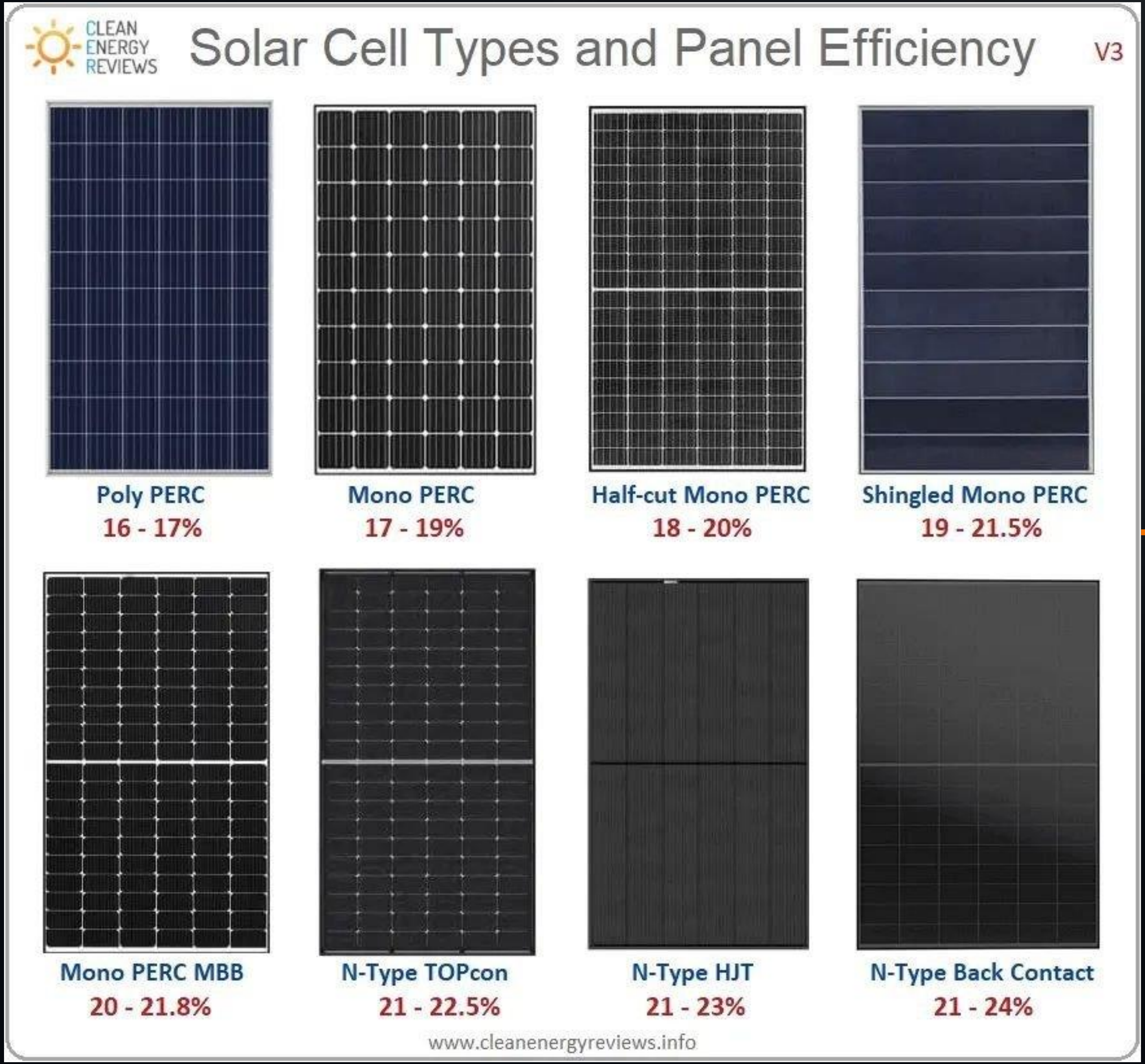


Floating System
Design

Components	Qty	Unit Cost GH¢	Cost GH¢
Bulbs	1	1	1
Diodes, Resistor, Capacitor, Led	1	1	30
Transformer	2	5	10
Crystal	1	2.50	2.50
Relay	2	10	20
Construction board	1	1	1
Lamp holder	1	1.50	1.50
Photocell	1	20	20
Screws	1 box	2	2
(At mega 328P)	1	20	20
UPS	1	110	110
Arduino Uno	1	80	100
Consultation	Once	100	100
13 amp Plug	2	1.50	3
Transportation			40
Communication	10	2.0	20
Mica case	1	50	50
Cable	3 yards	3	9
Rechargeable Batteries	2	20	40
Internet Bundle	1 Month	30	30

Electrical
Layout

Panel Type and Efficiency



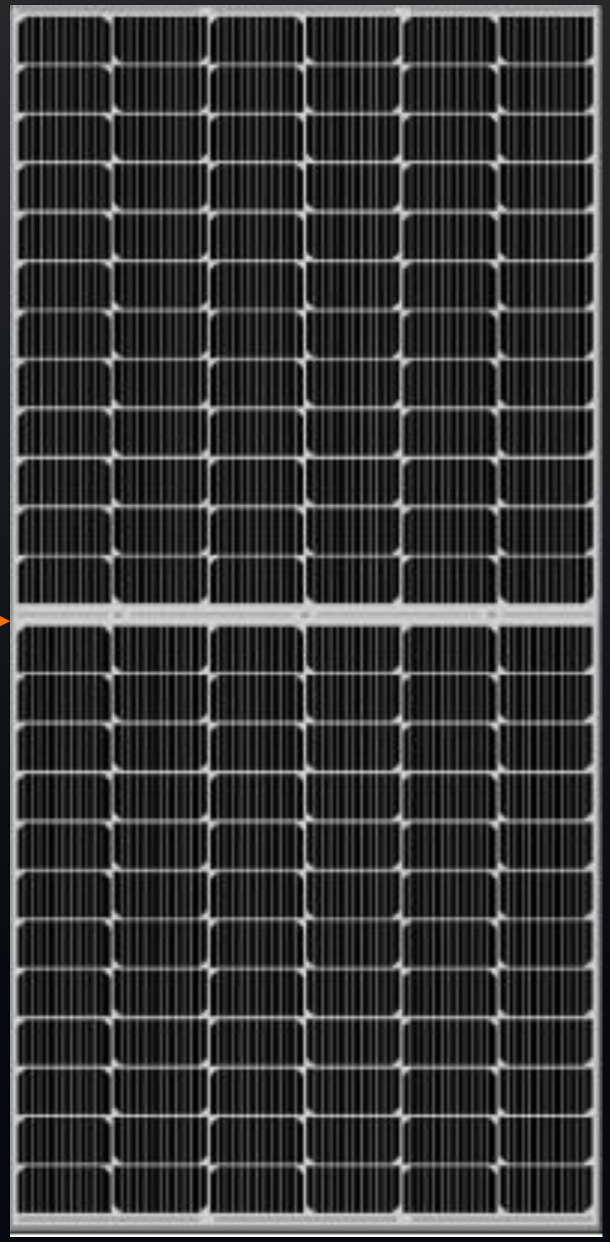


Figure 9. JA Solar 545W Mono PERC MBB Panel

Source:
A. Amer, H. Attar, S. As'ad, S. Alsaqoor, I. Colak, A. Alahmer, M. Alali, G. Borowski, M. Hmada, and A. Solyman, "Floating Photovoltaics: Assessing the Potential Advantages and Challenges of Harnessing Solar Energy on Water Bodies," Journal of Ecological Engineering, vol. 24, no. 10, pp. 324–339, Aug. 2023. [Online]. Available: https://doi.org/10.12911/22998993/170917

Floating System Design

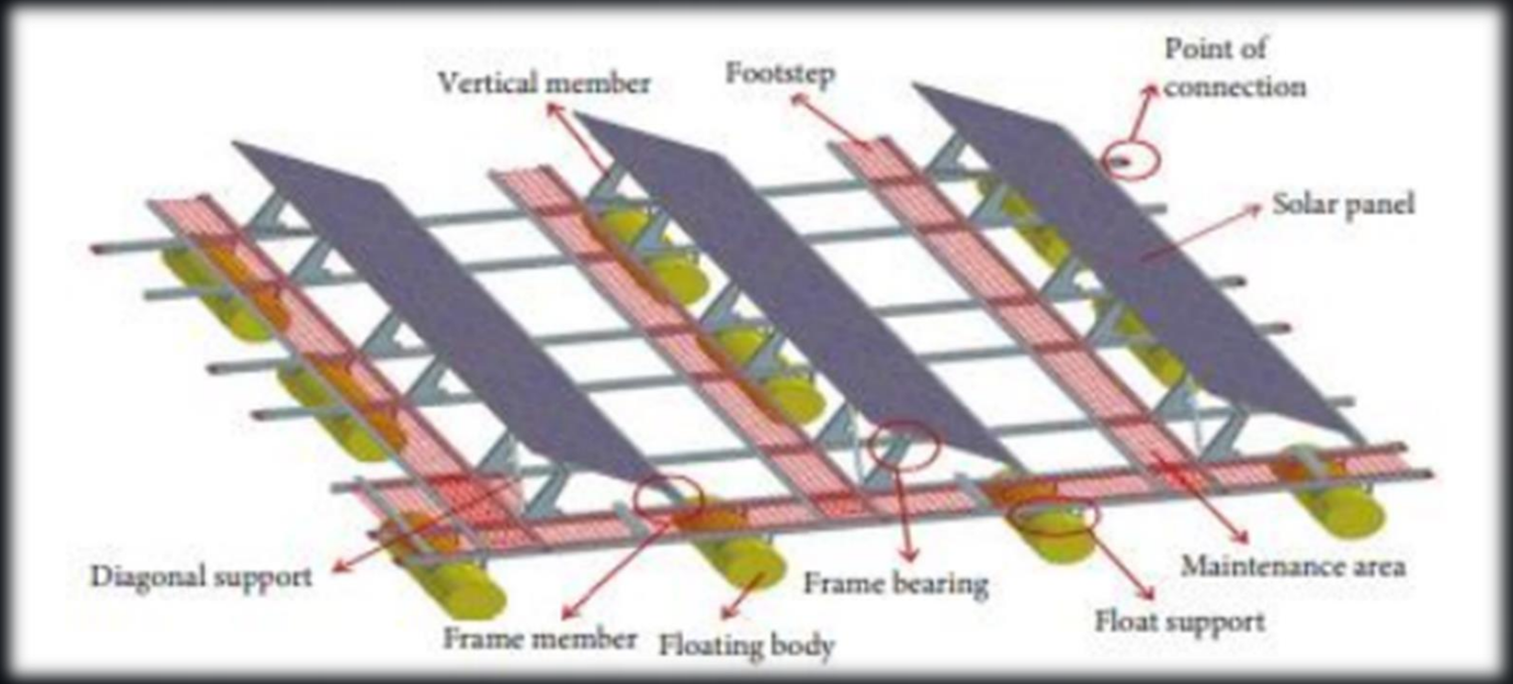


Figure 10. Frame Array Design

Figure 11. Independent Floating Modular Design

Source:
M. Elshafei et al., "Study of Massive Floating Solar Panels over Lake Nasser," Journal of Energy, vol. 2021, Article ID 6674091, 17 pages, 2021. [Online]. Available: https://doi.org/10.1155/2021/6674091

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Electrical Layout

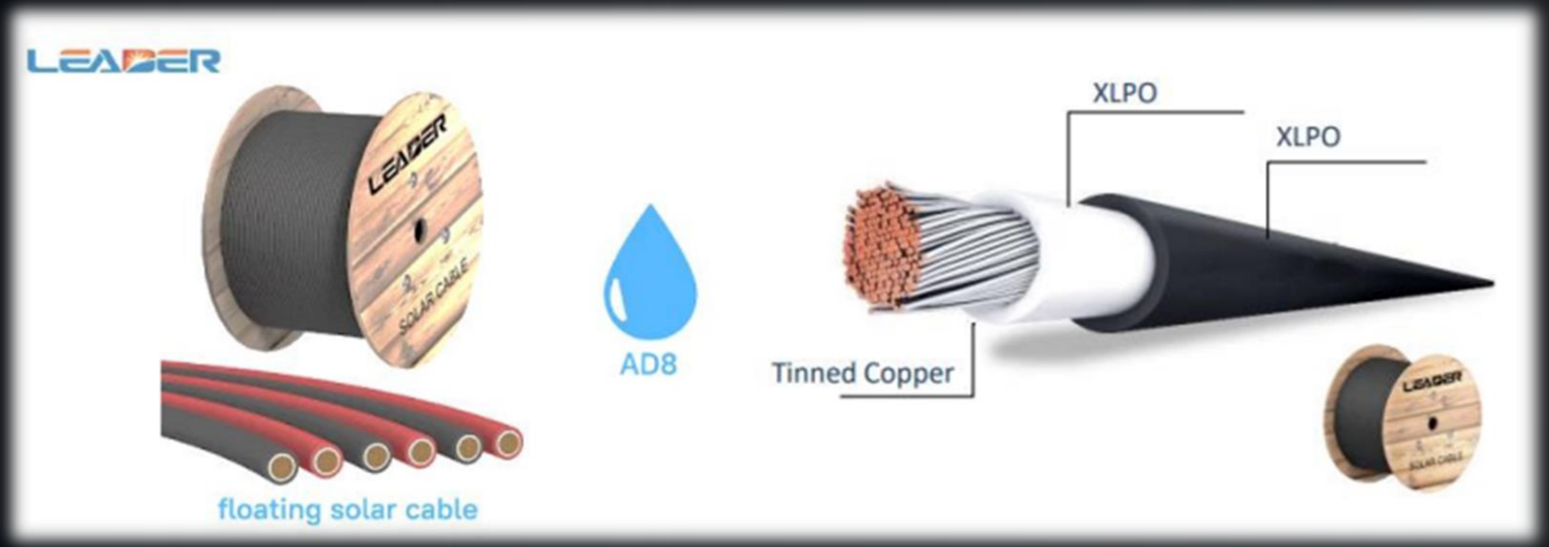

Figure 12. MC4 WiLEADER® Floating Solar Cable

Figure 13. Fronius's String Inverters

Source:
"JA Solar supplies modules for first floating PV plants," Energy Digital. [Online]. Available: https://energydigital.com/renewable-energy/ja-solarsupplies-modules-first-floating-pv-plants

Source:
"Why string inverters for PV systems," Fronius. [Online]. Available: https://www.fronius.com/en-us/usa/solar-energy/home-owners/blog/why-stringinverters-for-pv-system

FPV Power Plants Review

1) Small Size Power Plants
(up to 500 kWp)

2) Medium Size Power Plants
(500 to 1500 kWp)

3) Large Size Power Plants
(above 1500 kWp)

Source:
S. S. Patil (Desai), M. M. Wagh, and N. N. Shinde, "A Review on Floating Solar Photovoltaic Power Plants," in International Journal of Scientific and Engineering Research, June 2017.

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FPV Power Plants Review

Figure 14. California, USA, 175 kWp

Source:
"Floatovoltaics: Far Niente Wynery's floating solar power," Inhabitat. [Online].
Available: https://shorturl.at/mwAR5

Figure 15. Inami Town, Japan, 1428 kWp

Source:
Ciel et Terre, "Floating solar system," [Online].
Available: http://www.ciel-et-

Figure 16. Walton-on-Thames, UK, 6338 kWp

Source:
Ciel et Terre, "QE-2 Project," [Online].
Available: https://ciel-et-terre.net/project/qe-2/

03

Project Design

Perimeter
15,772.53 m

Area
3,609,849.04 m²

Figure 17-a. Site Data By Google Earth
(Al-Aqoul Lake)

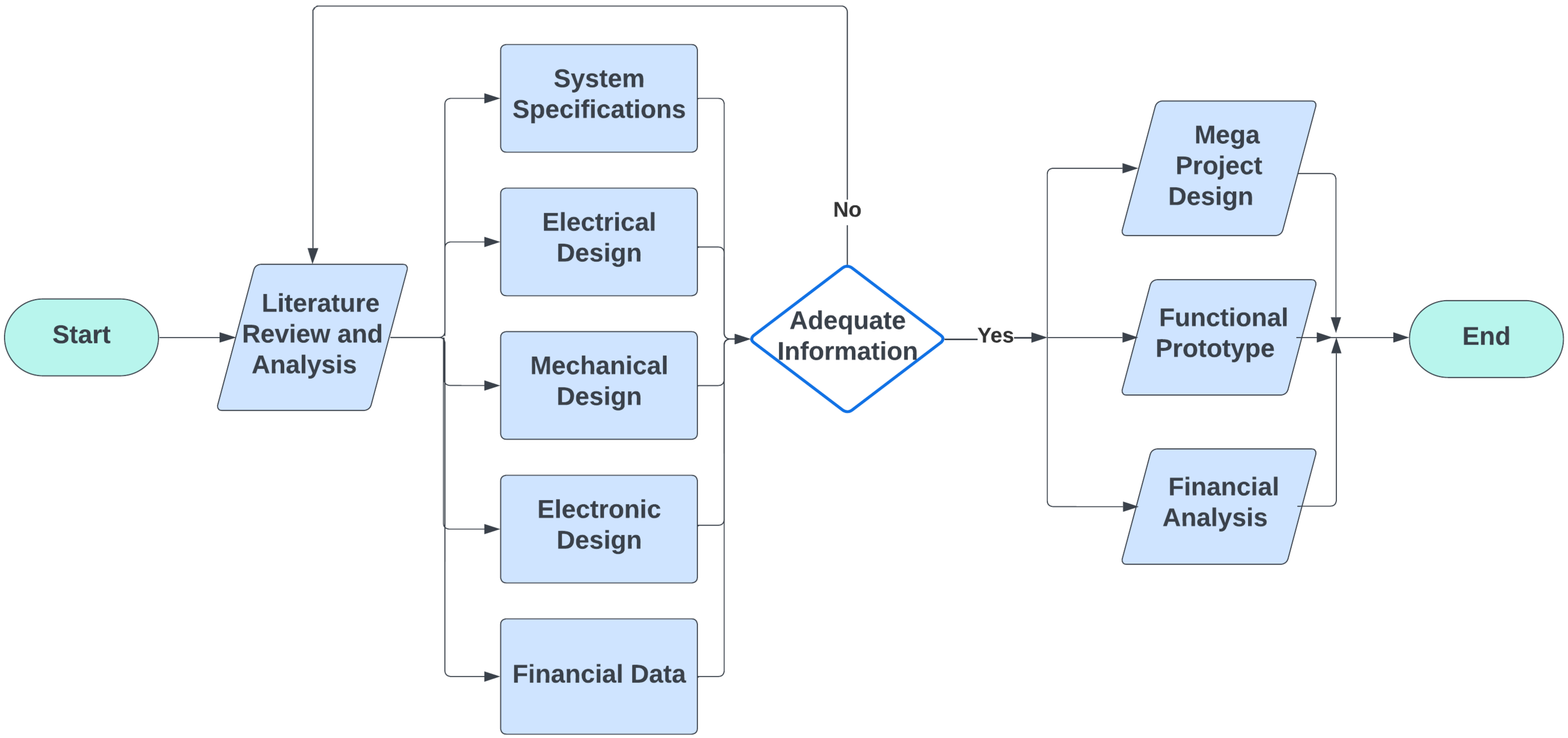
Site Analysis

Site Analysis

Figure 17-b. Site Photo, by us ☺
(Al-Aqoul Lake)

Site Analysis

Figure 17-c. Another Site Photo, by us ☺
(Al-Aqoul Lake)



Project Flow Chart

Mechanical Designs

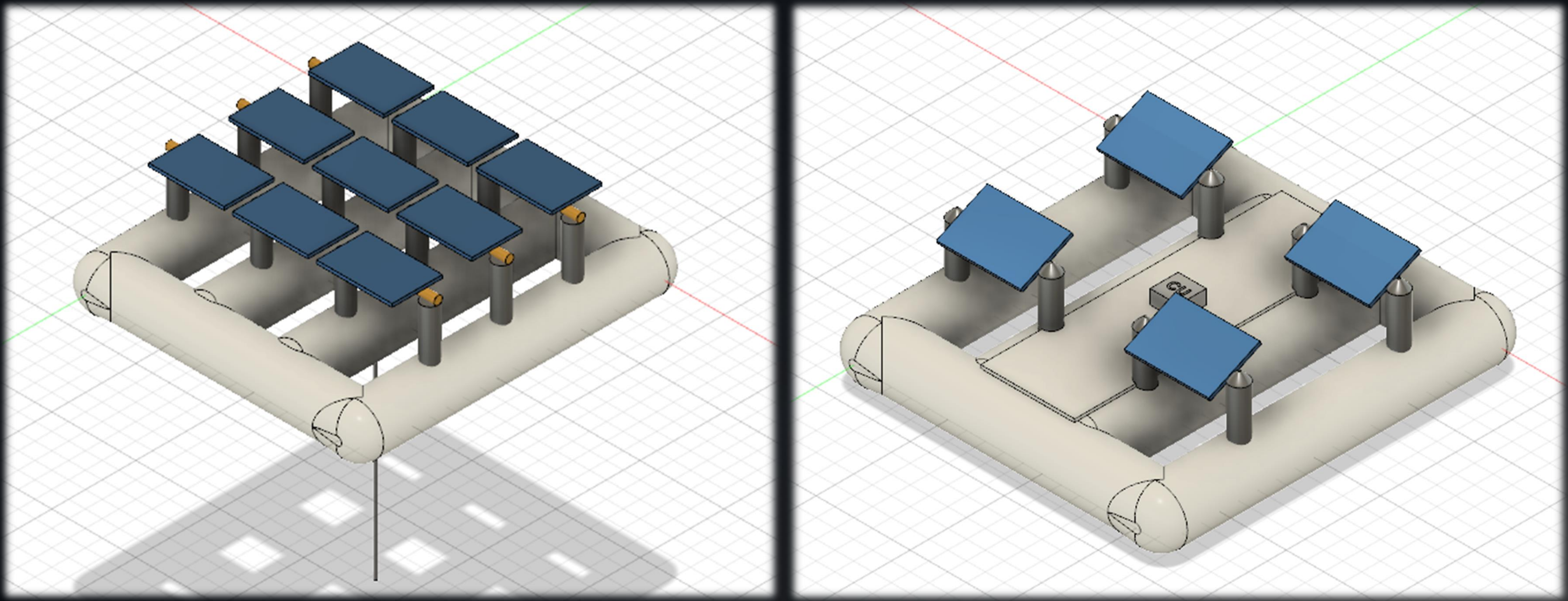


Figure 18. Mechanical Structures
(Fusion-360 Program)

Depth Warning System

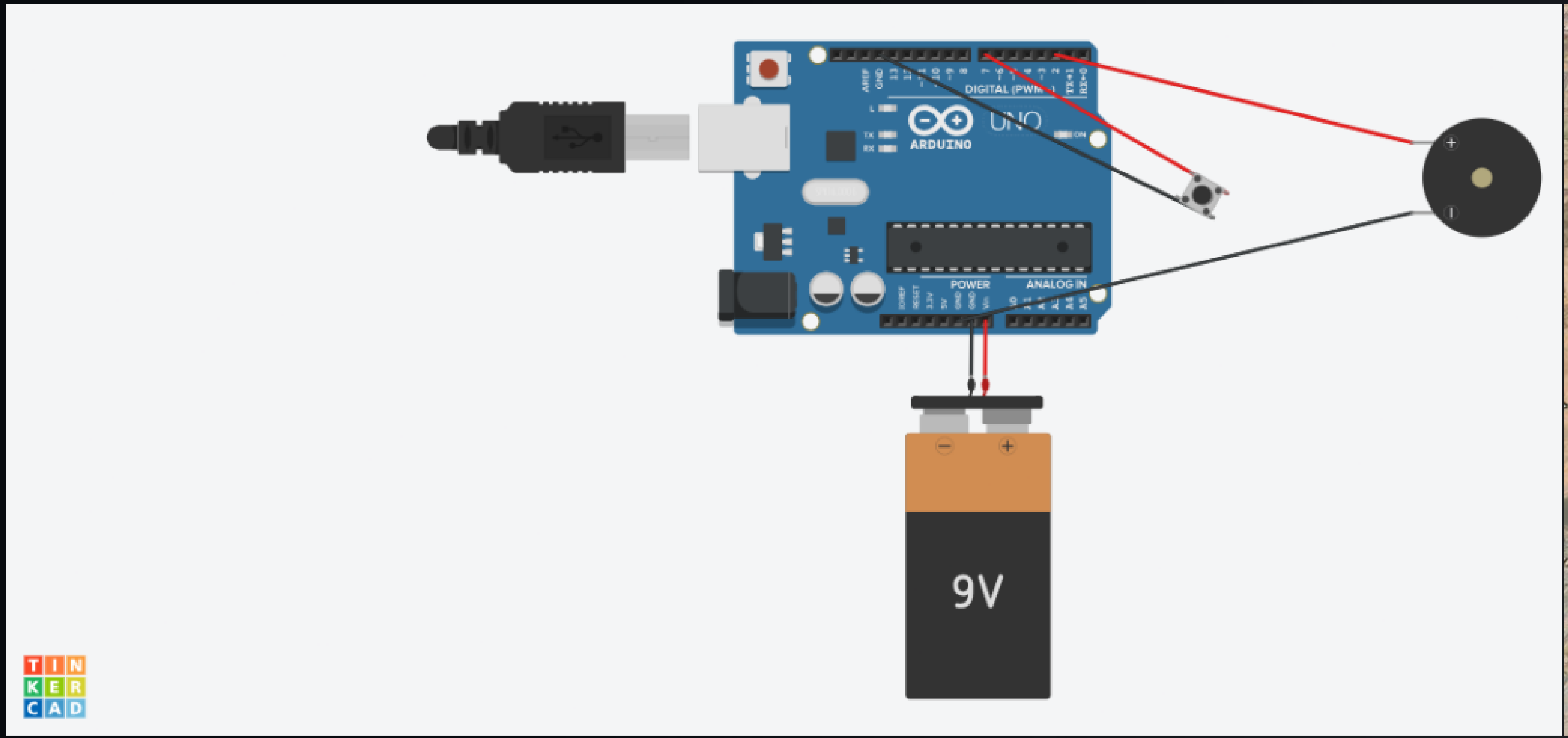


Figure 19. Electronic Design
(TINKERCAD Program)

Electrical Design Reasoning

Sembcorp FPV Farm

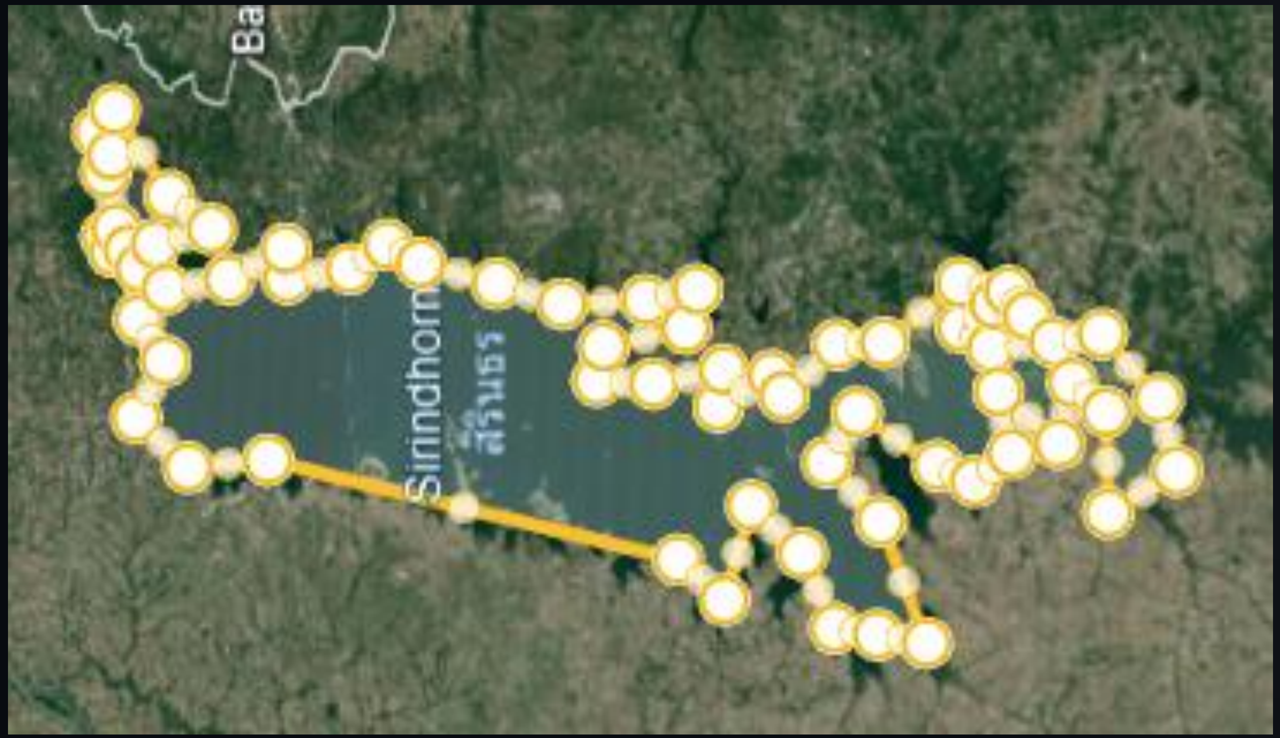
FPV of Queen Elizabeth II reservoir

Sirindhorn Dam Floating Solar Farm

FPV of Queen Elizabeth II reservoir

- ❑ Location: The UK’s largest floating solar farm is situated on the Queen Elizabeth II reservoir near Walton-on-Thames, Surrey.
- ❑ Number of Panels: It comprises more than 23,000 solar photovoltaic panels.
- ❑ Capacity: The total capacity of this floating solar farm is 6.3 megawatts (MW).
- ❑ Panels area = 57,500 m^2
- ❑ lake area = 1 279 000 m^2
- ❑ % of solar system = 4.50%

Sirindhorn Dam Floating Solar Farm



- ❑ **Location: Sirindhorn, Thailand.**
- ❑ **Number of Panels: 145,000 solar photovoltaic panels.**
- ❑ **Capacity: The total capacity of this floating solar farm is 45 megawatts (MW).**
- ❑ **Panels area = 121,000 m^2**
- ❑ **lake area = 2 000 000 m^2 (area taken manually, not available on internet)**
- ❑ **% of solar system = less than 1%**

Sembcorp FPV Farm

- ❑ Location: Singapore.
- ❑ Number of Panels: 122,000 solar photovoltaic panels.
- ❑ Capacity: The total capacity of this floating solar farm is 60 megawatts (MW).
- ❑ Panels area = 450,000 m^2
- ❑ lake area = 1 235 737 m^2 (area taken manually, not available on internet)
- ❑ % of solar system = 36.42%

Electrical Design Formulation

Due to:

1. Available water area

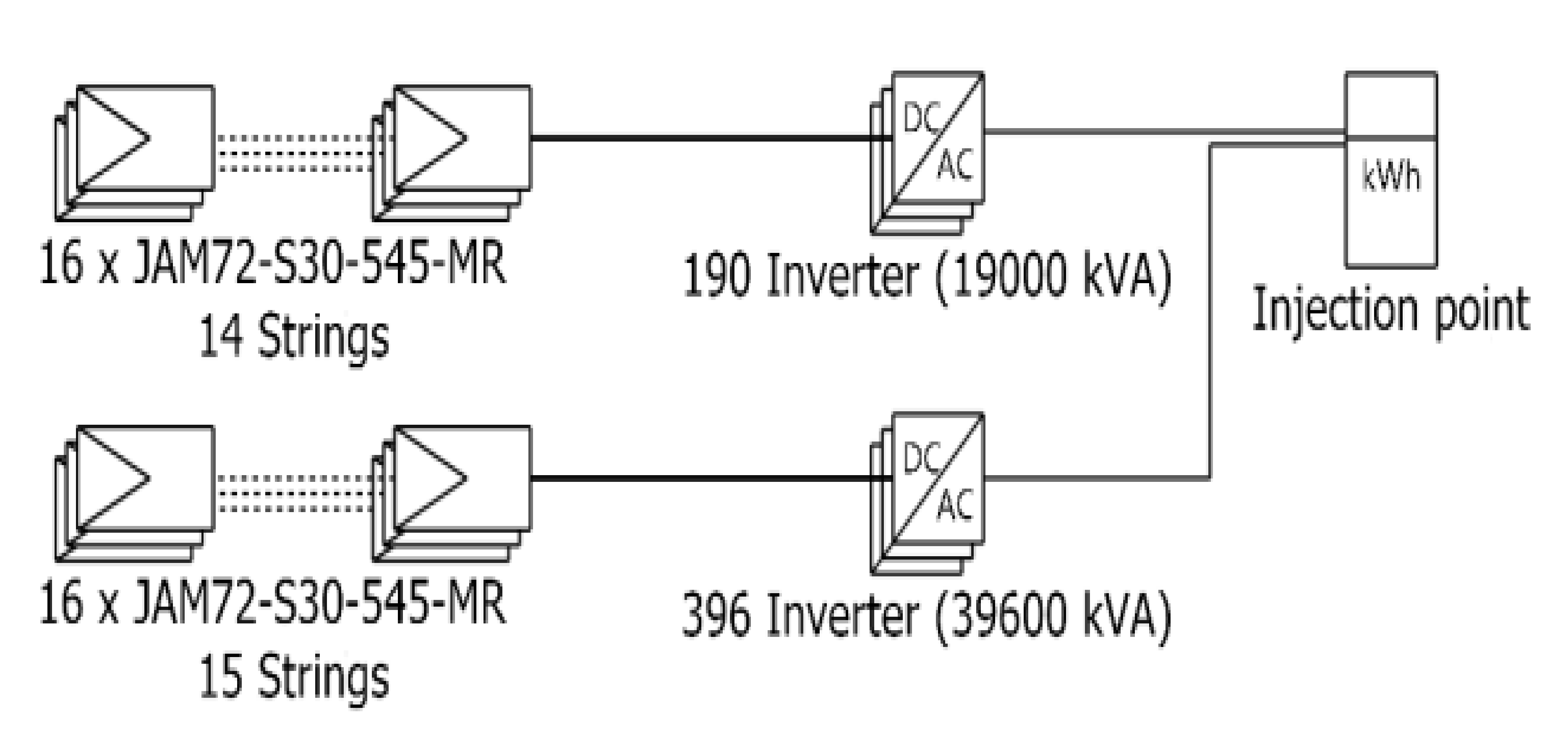
2. System design

3. Lake topography

The System Size:

- **10% of the lake’s Area**
- **The system’s area = 360,985 square meters**
- **137,600 Panels of 545W each**

Electrical Design



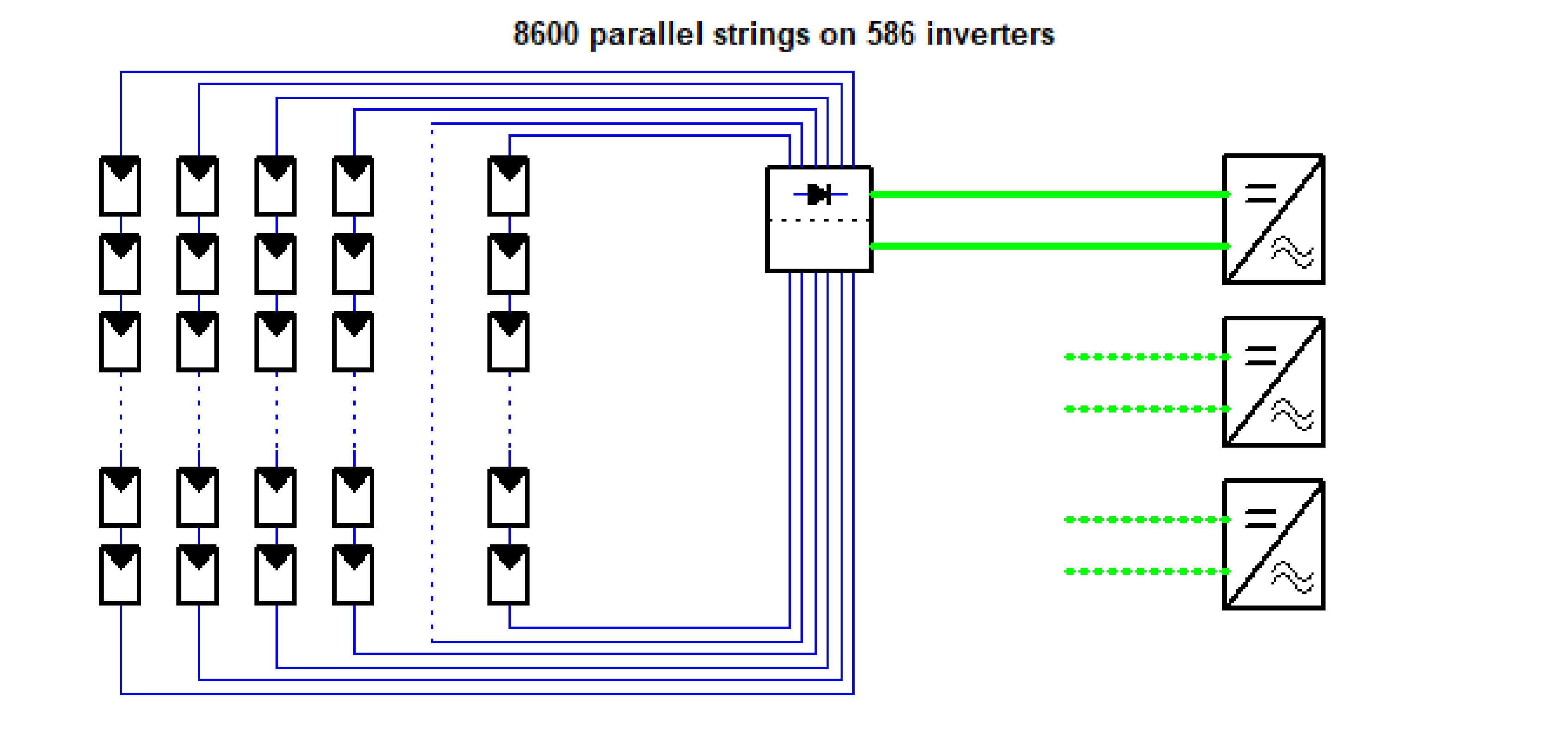


Figure 20. Electrical Design
(PVsyst Program)

Electrical Design Parameters

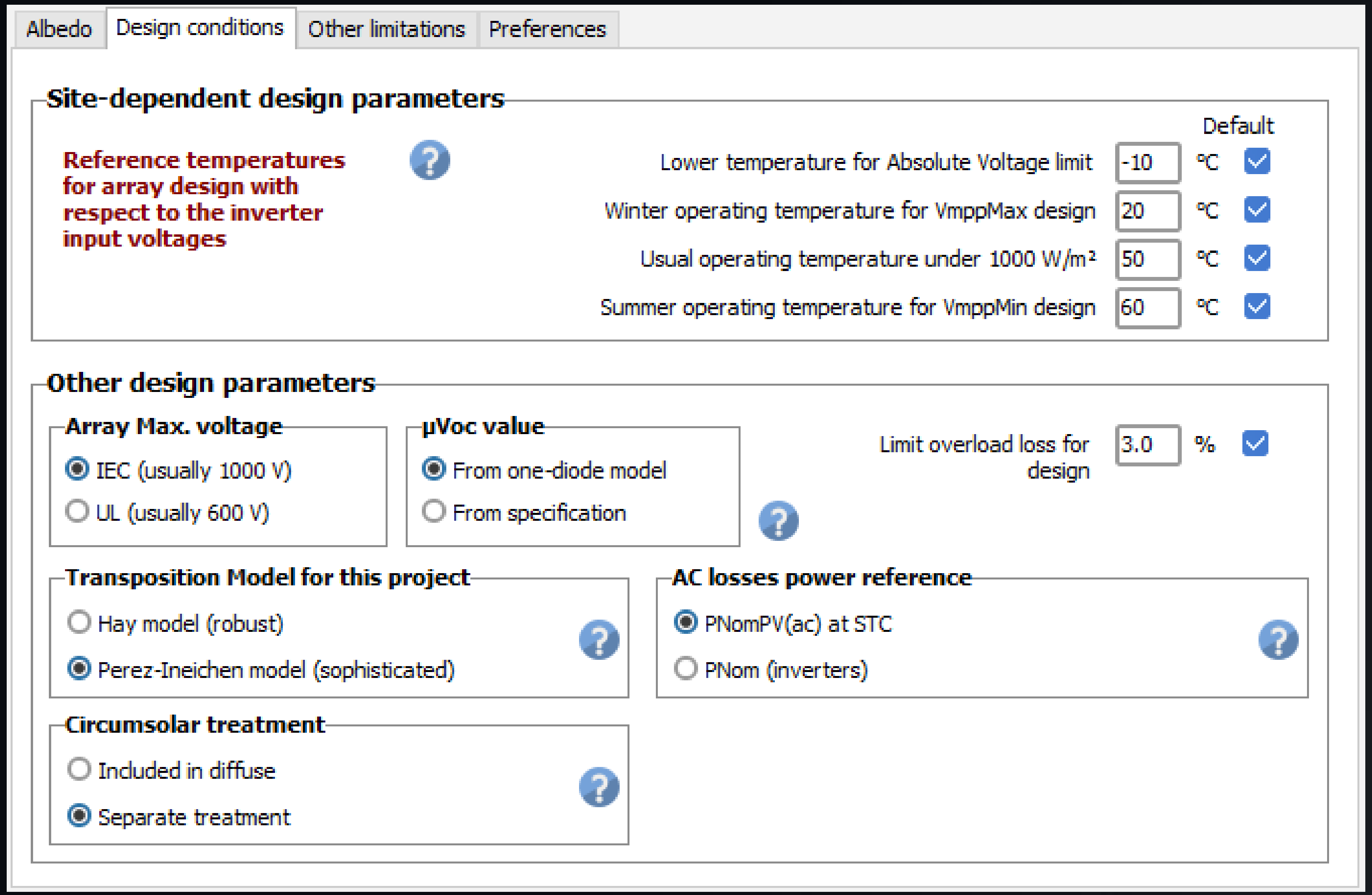


Figure 21. Main Parameters.

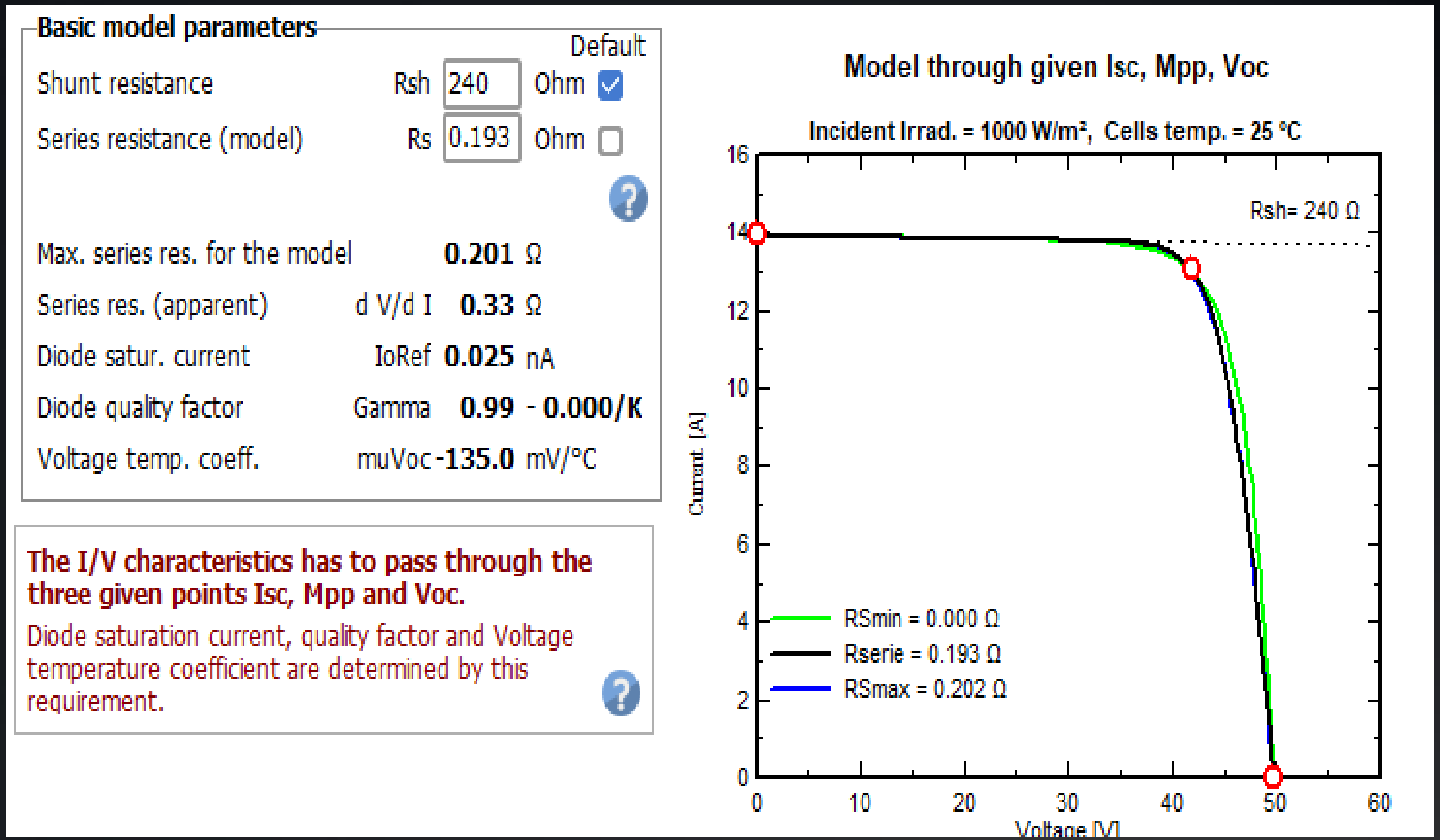


Figure 22. PV Panel Parameters.

Electrical Design Parameters

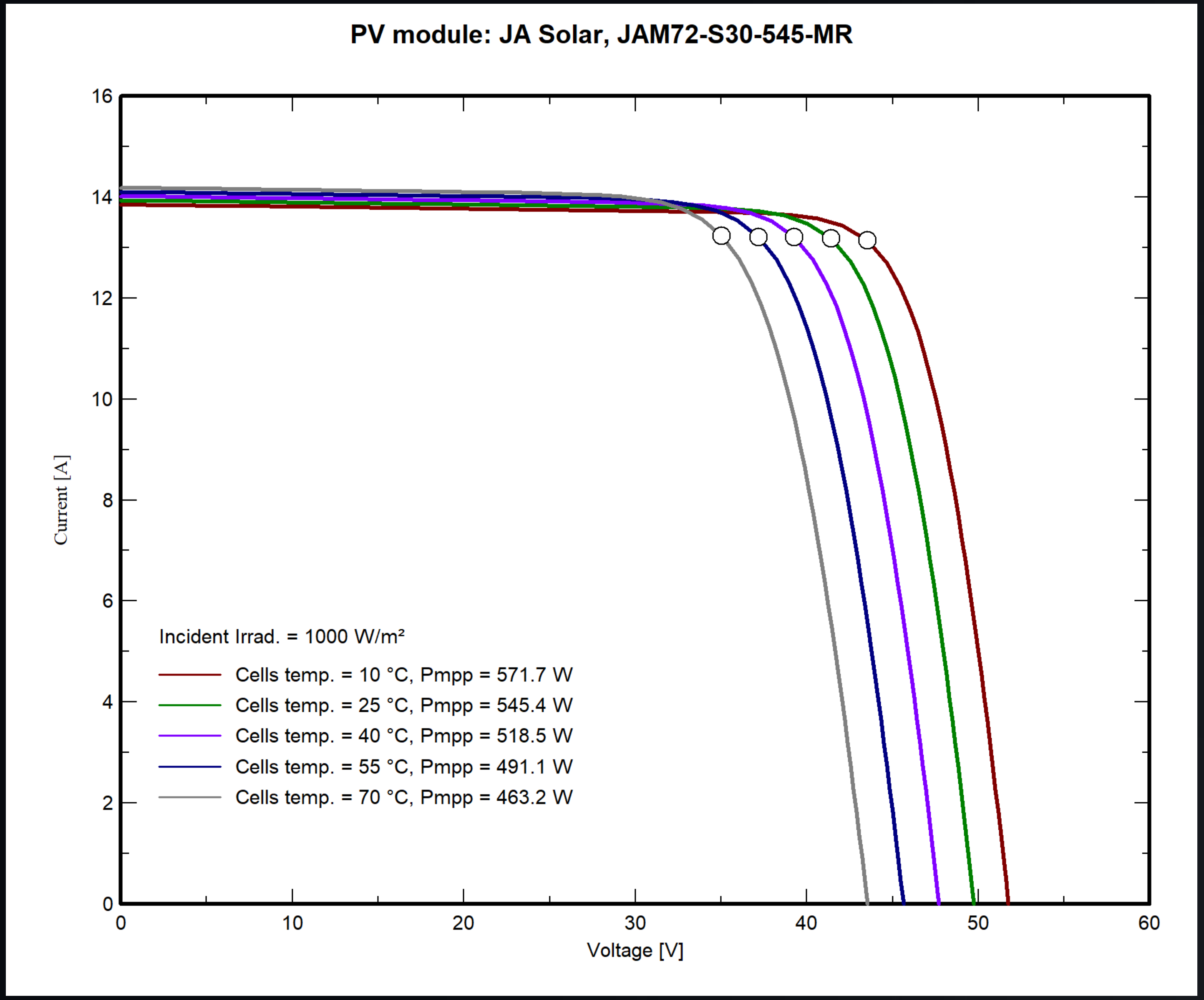


Figure 23. PV Panel V-I Curve with

Varying Temperature

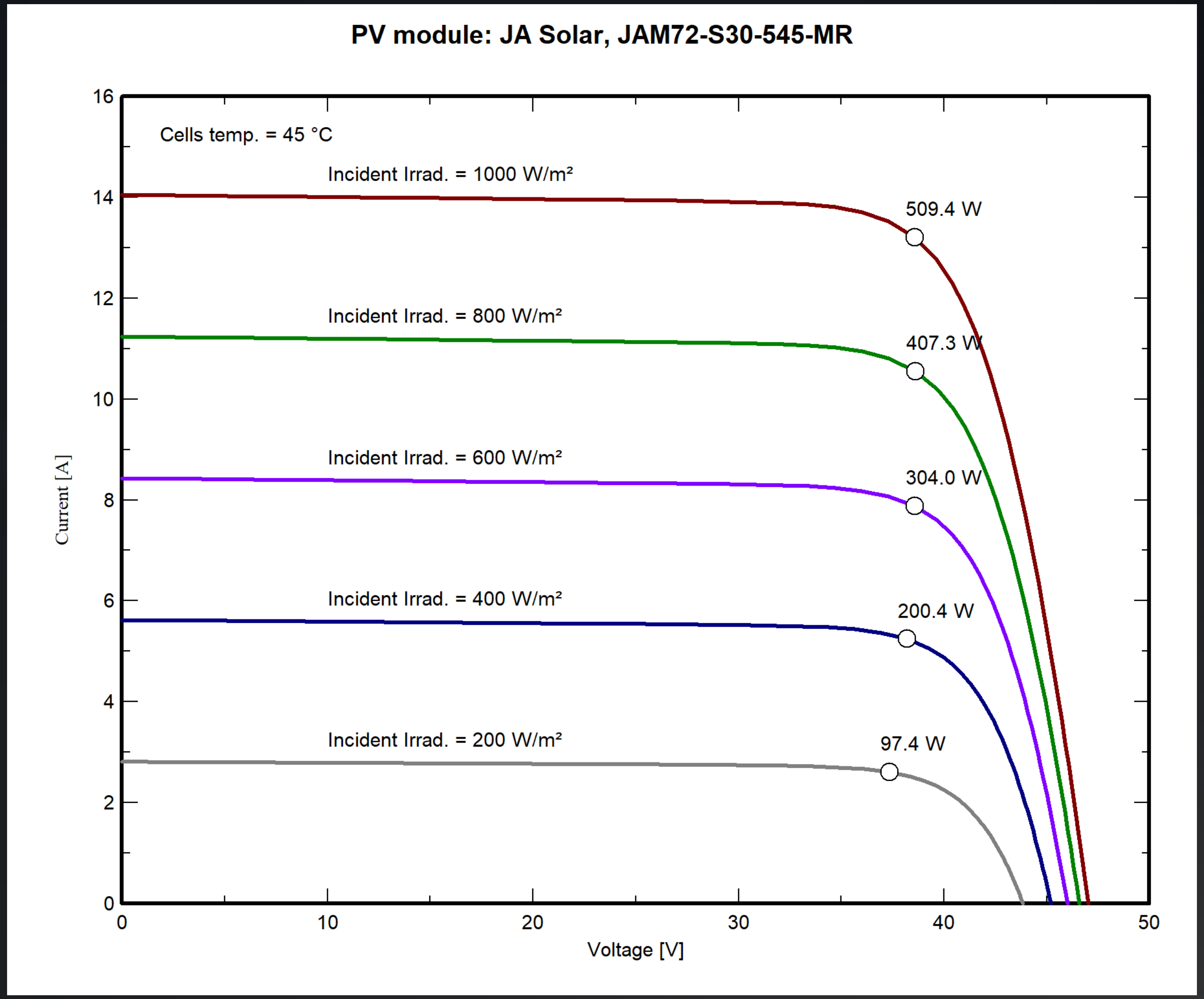


Figure 24. PV Panel V-I Curve with

Varying Irradiance

Electrical Design Parameters

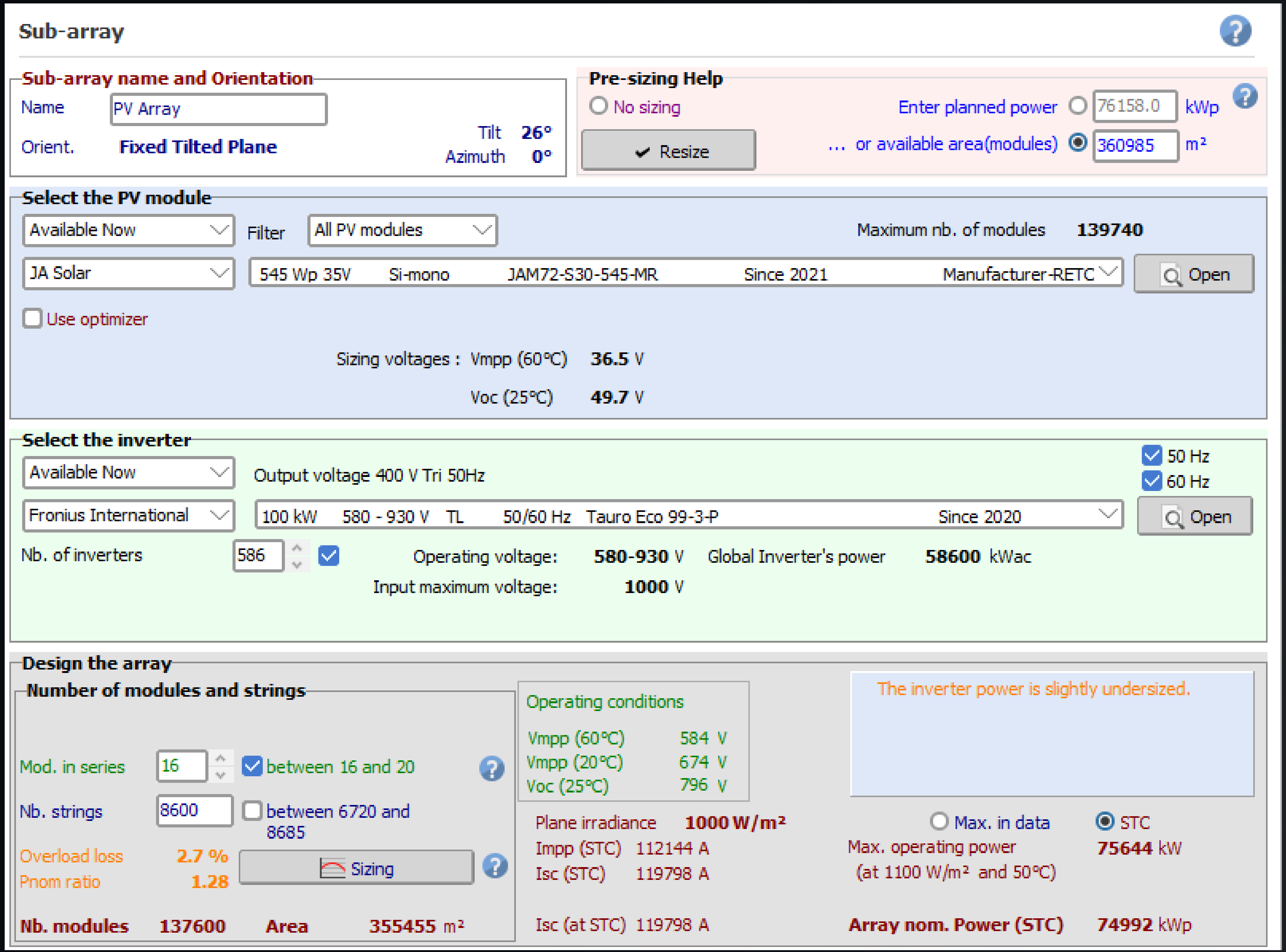


Figure 25. System Parameters.

Electrical Design Parameters

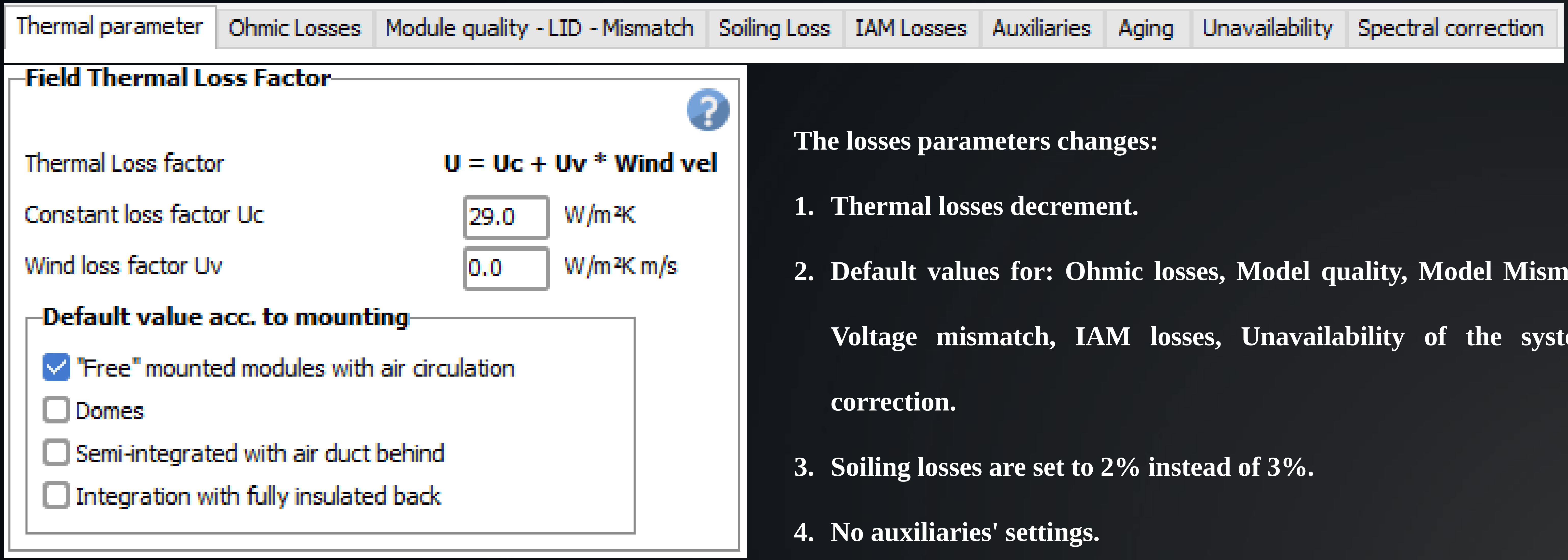


Figure 26. Losses settings

The losses parameters changes:

1. **Thermal losses decrement.**
2. **Default values for: Ohmic losses, Model quality, Model Mismatch losses, String Voltage mismatch, IAM losses, Unavailability of the system, and Spectral correction.**
3. **Soiling losses are set to 2% instead of 3%.**
4. **No auxiliaries' settings.**

04

Experimentation & Implementation

Software Selection

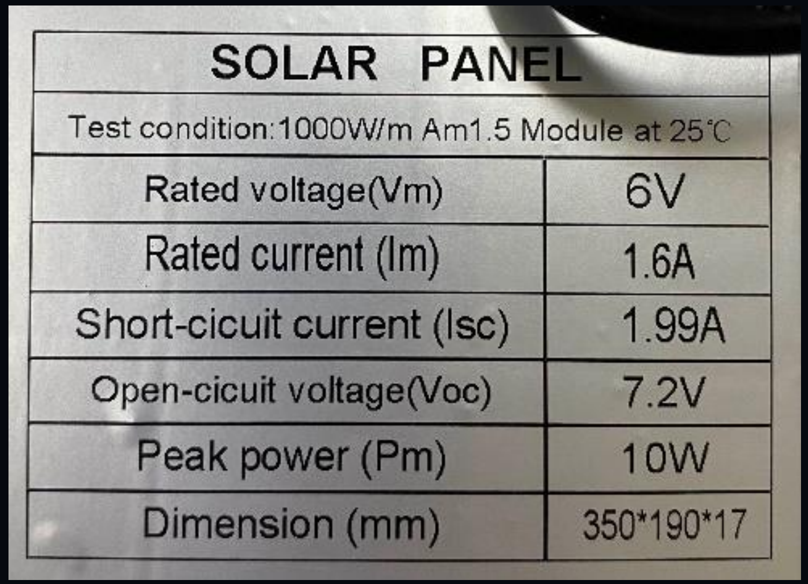
PVsyst

Fusion-360

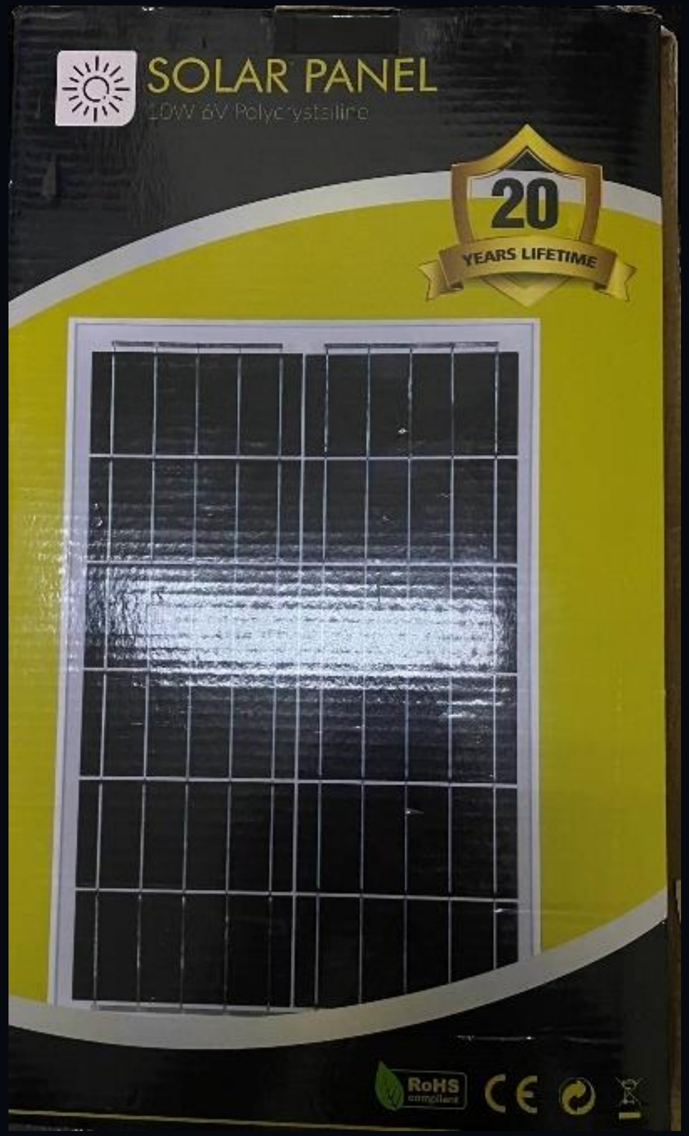
TinkerCAD

Hardware Selection
- Components -

Polycrystalline Solar Panel



SOLAR PANEL	
Test condition:1000W/m Am1.5 Module at 25℃	
Rated voltage(Vm)	6V
Rated current (Im)	1.6A
Short-cicuit current (Isc)	1.99A
Open-cicuit voltage(Voc)	7.2V
Peak power (Pm)	10W
Dimension (mm)	350*190*17



PVC Pipes

PVC Elbows and Connectors

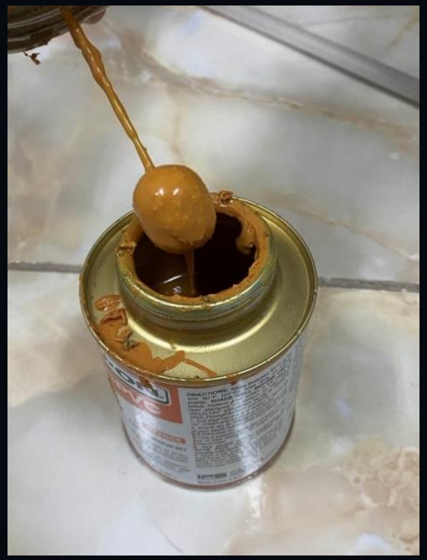
Hardware Selection
- Instruments -

Hacksaw

Digital Multimeter

Measuring Tape

CPVC Adhesive



Prototype Building Process

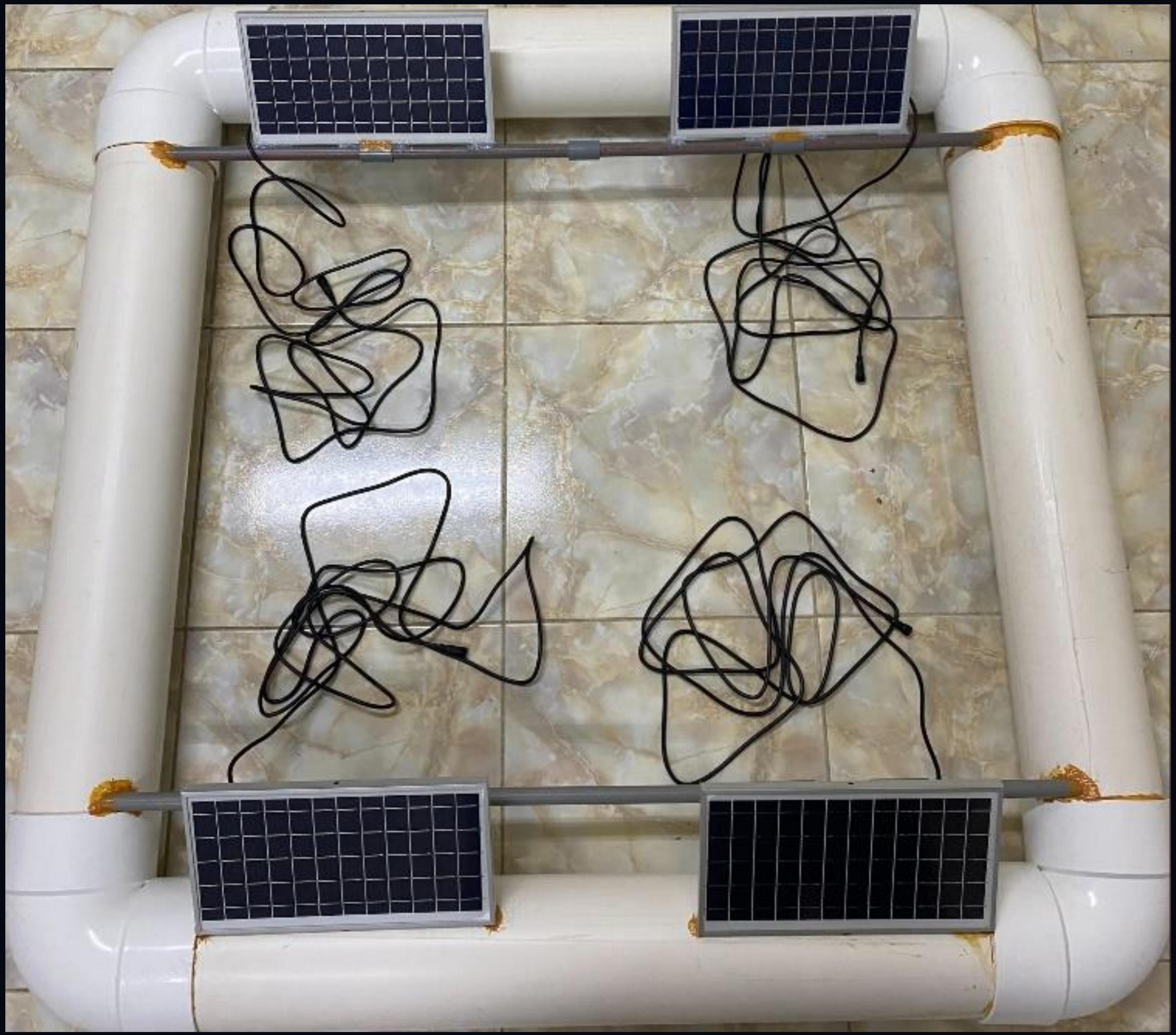
Stage 1: Frame Construction

- ✓ Cutting and Measuring
- ✓ Assembly
- ✓ Sealing and Waterproofing

Stage 2: Structural Reinforcement for Solar Panel Installation

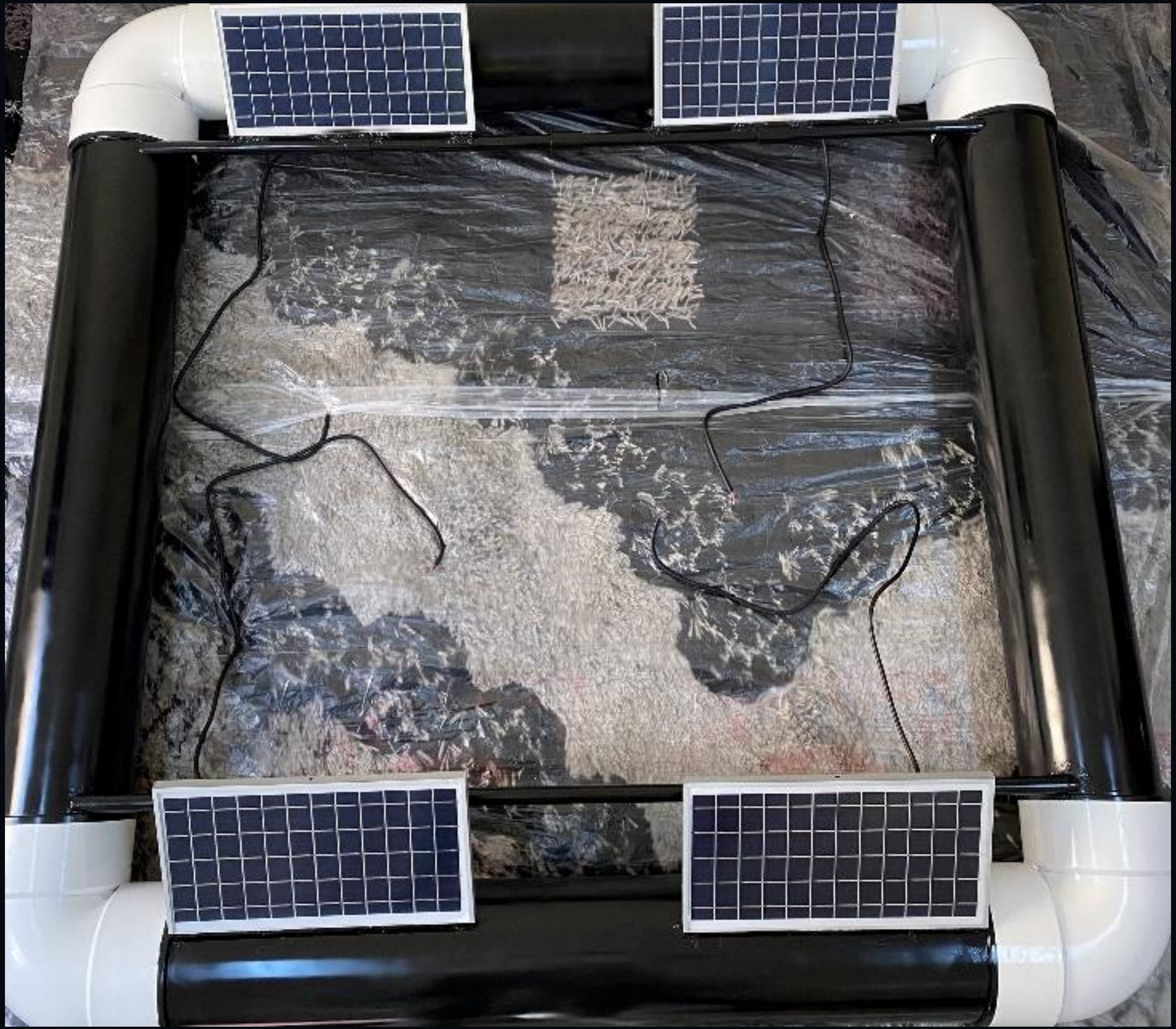
- ✓ Installation of Support Rods
- ✓ Securing the Rods
- ✓ Load Testing

Stage 3: Solar Panel Installation



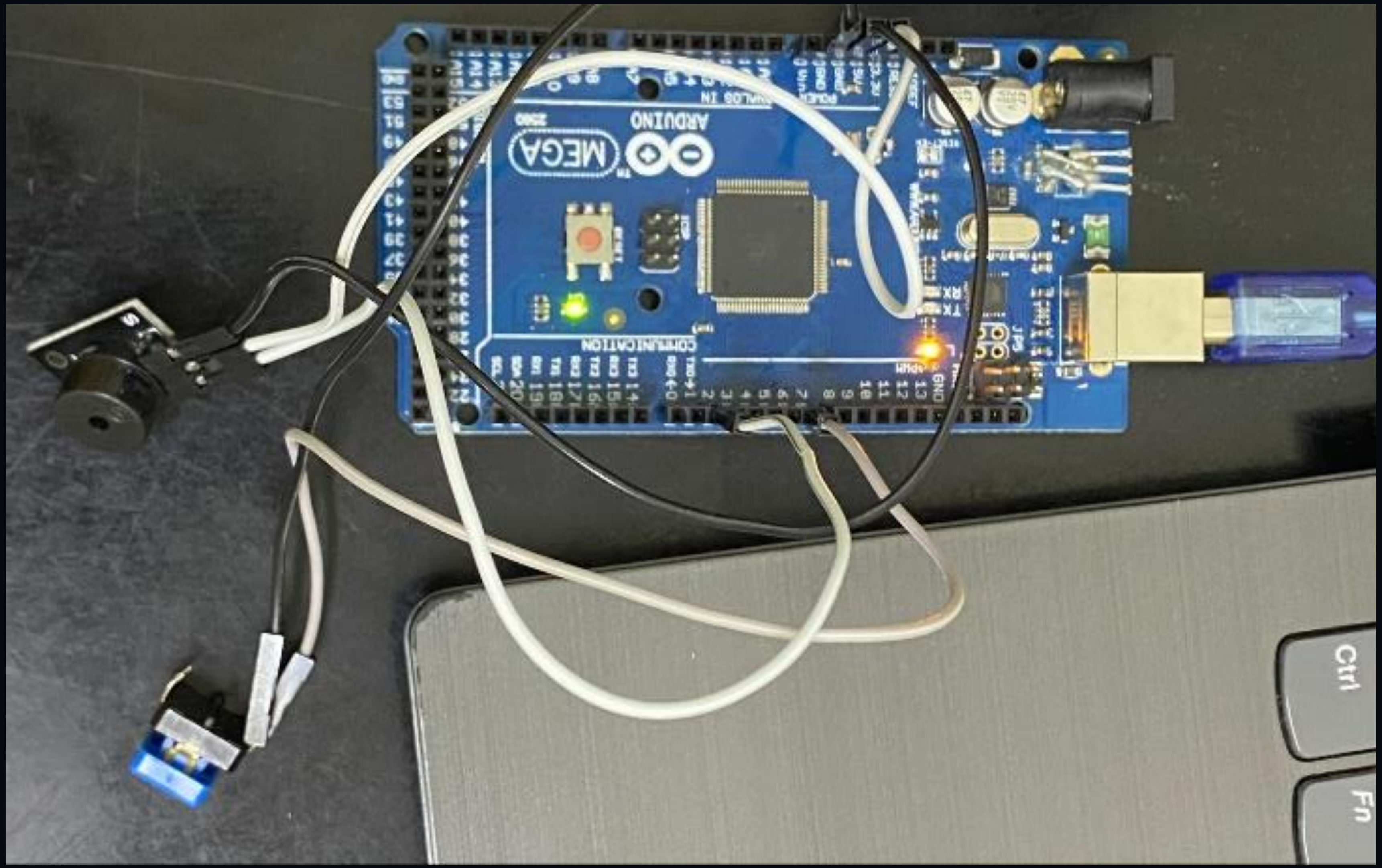
- ✓ Mounting the Solar Panels
- ✓ Ensuring Durability

Stage 4: Aesthetic Enhancement and Wiring Preparation



- ✓ Color Change of PVC Frame
- ✓ Preparing for Final Connections

Additional Setups



Arduino Setup

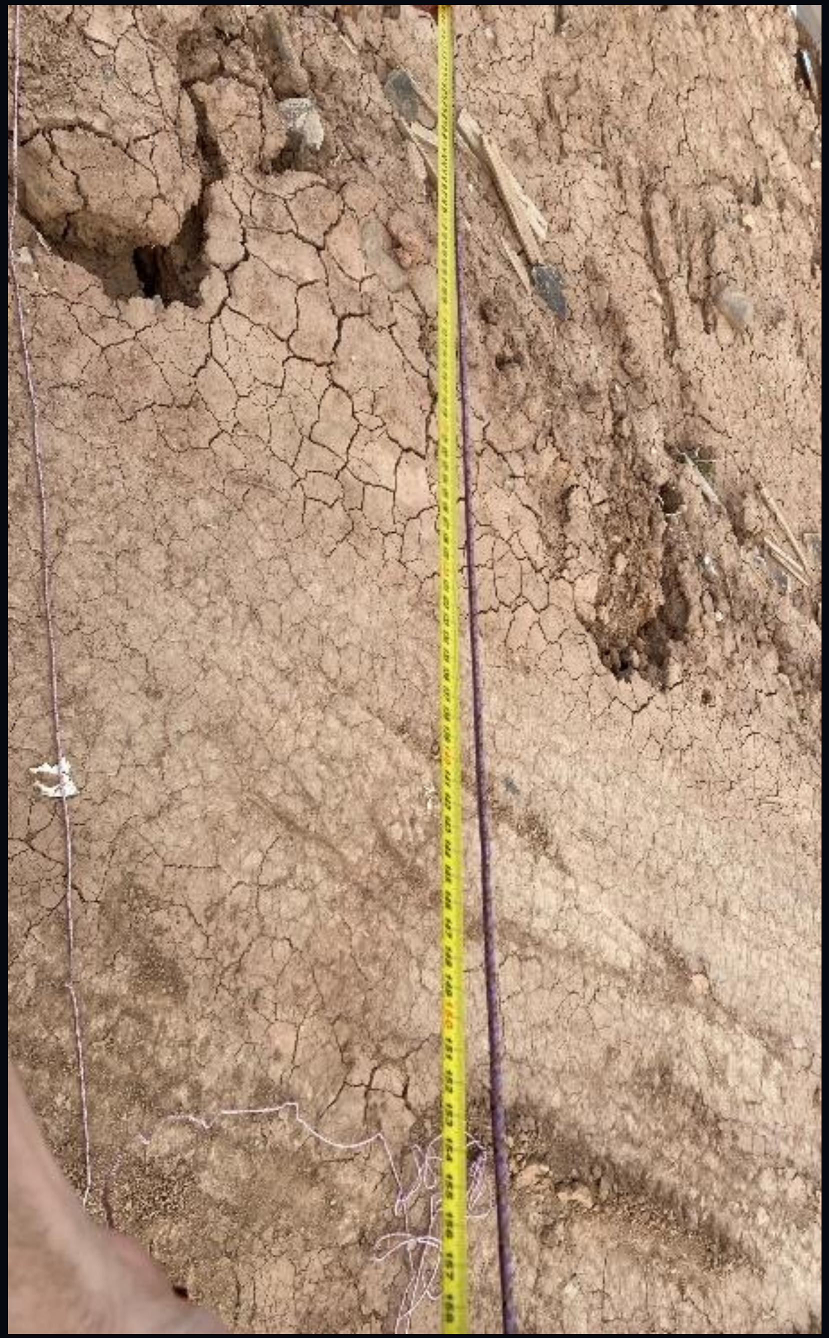
Water Level Sensor

Final Stage: Installation of Control Unit and Final Assembly

- ✓ Installation of the Cork Base
- ✓ Building the Control Unit

Lake Depth Measurement

Step-1



Step-2

Step-3

Budget

No.	Item	Quantity	Cost (SAR)	Total Cost (SAR)
1	Waterproof Glue	1	25	25
2	Plastic Rods (for the bottom)	4	-	56.67
3	Plastic Joints	4	-	92
4	Plastic Rods (for holding panels)	4	-	22.02
5	PV Solar Panels (10W each)	4	40 each	160
6	Control Unit Plastic Box	1	5	5
7	Cork Plate (70*150)	2	10 each	20
8	A3 Cover Paper	1	10	10
9	Reflecting Tape	1	5	5
10	Black Color Spray	7	-	68
11	Arduino Uno	1	45	45
12	Buzzer	1	5	5
13	Push Button	1	5	5
14	9V Battery	1	4	4
	Total Cost			522.69

Timeline

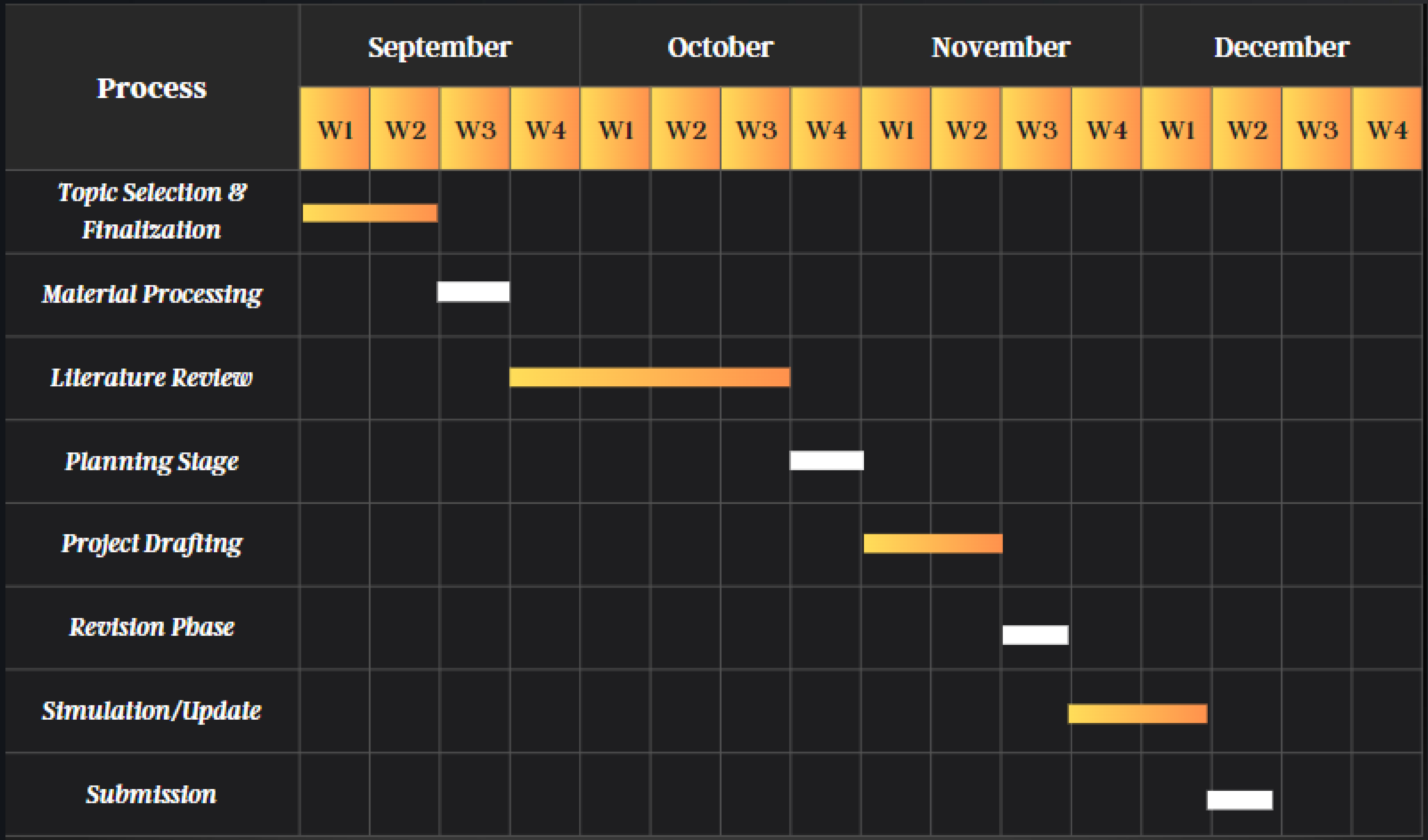


Figure 27. Gantt Chart of Capstone I

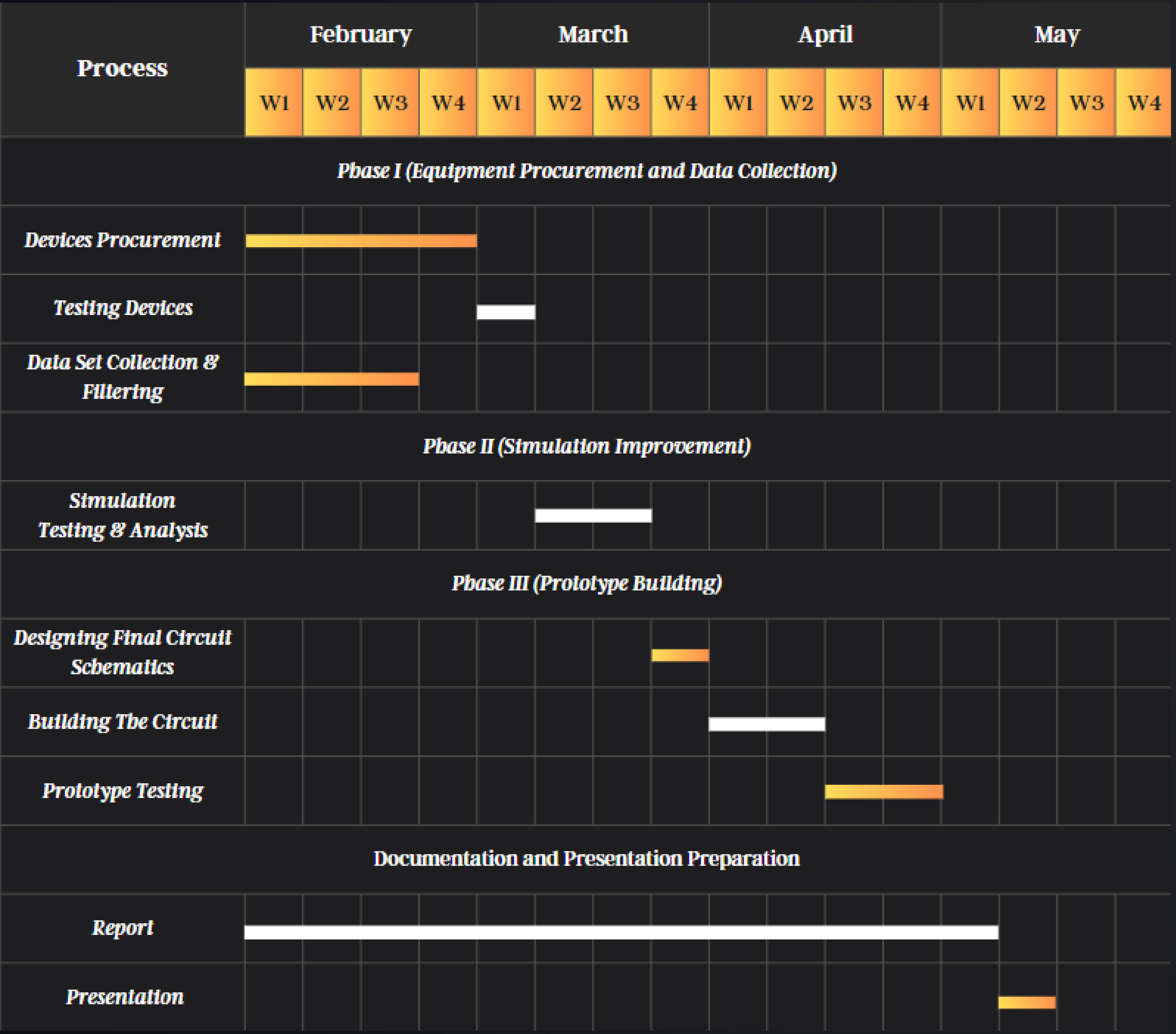


Figure 28. Gantt Chart of Capstone II

05

Results & Discussion

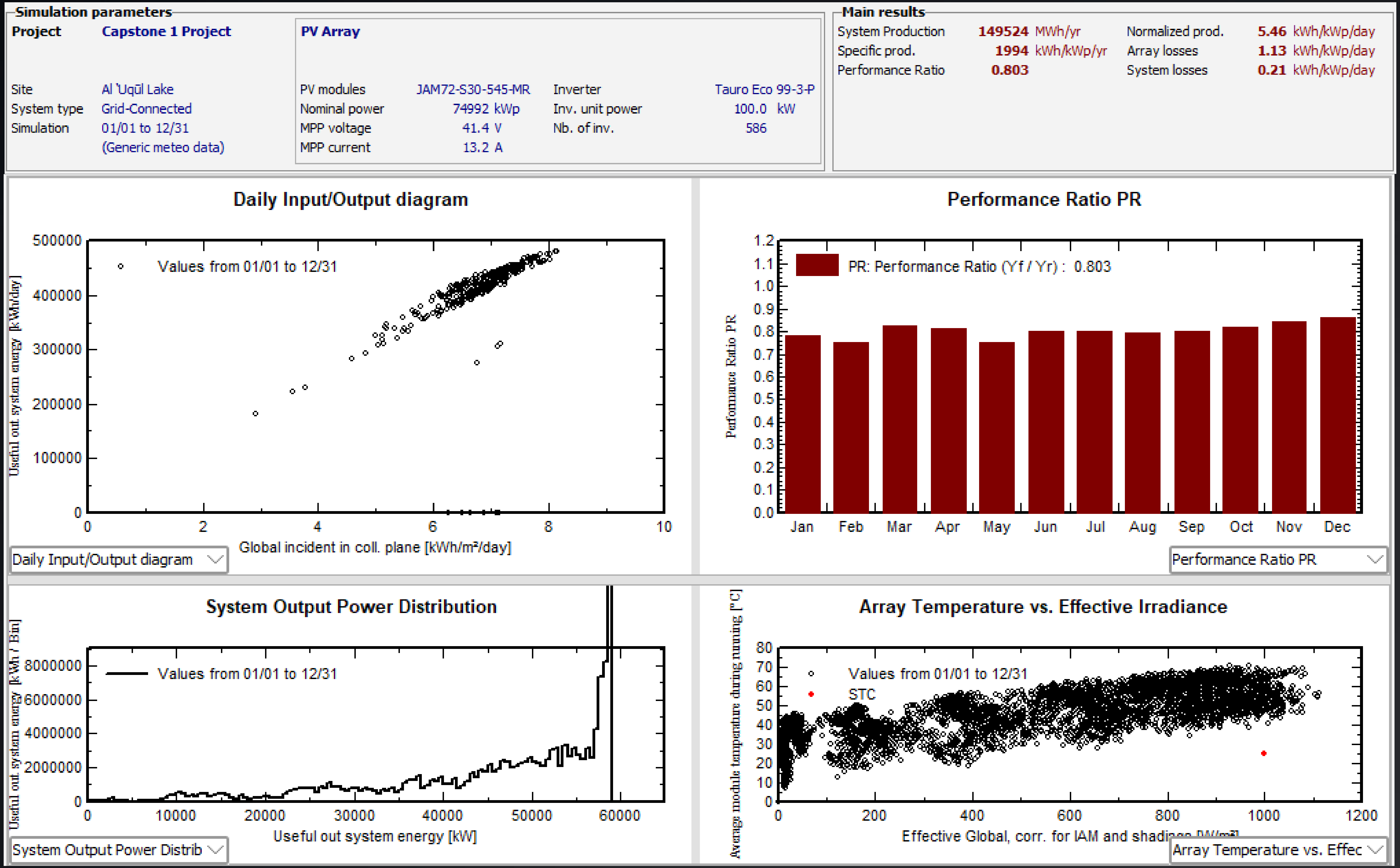


Figure 29. PVsyst Results

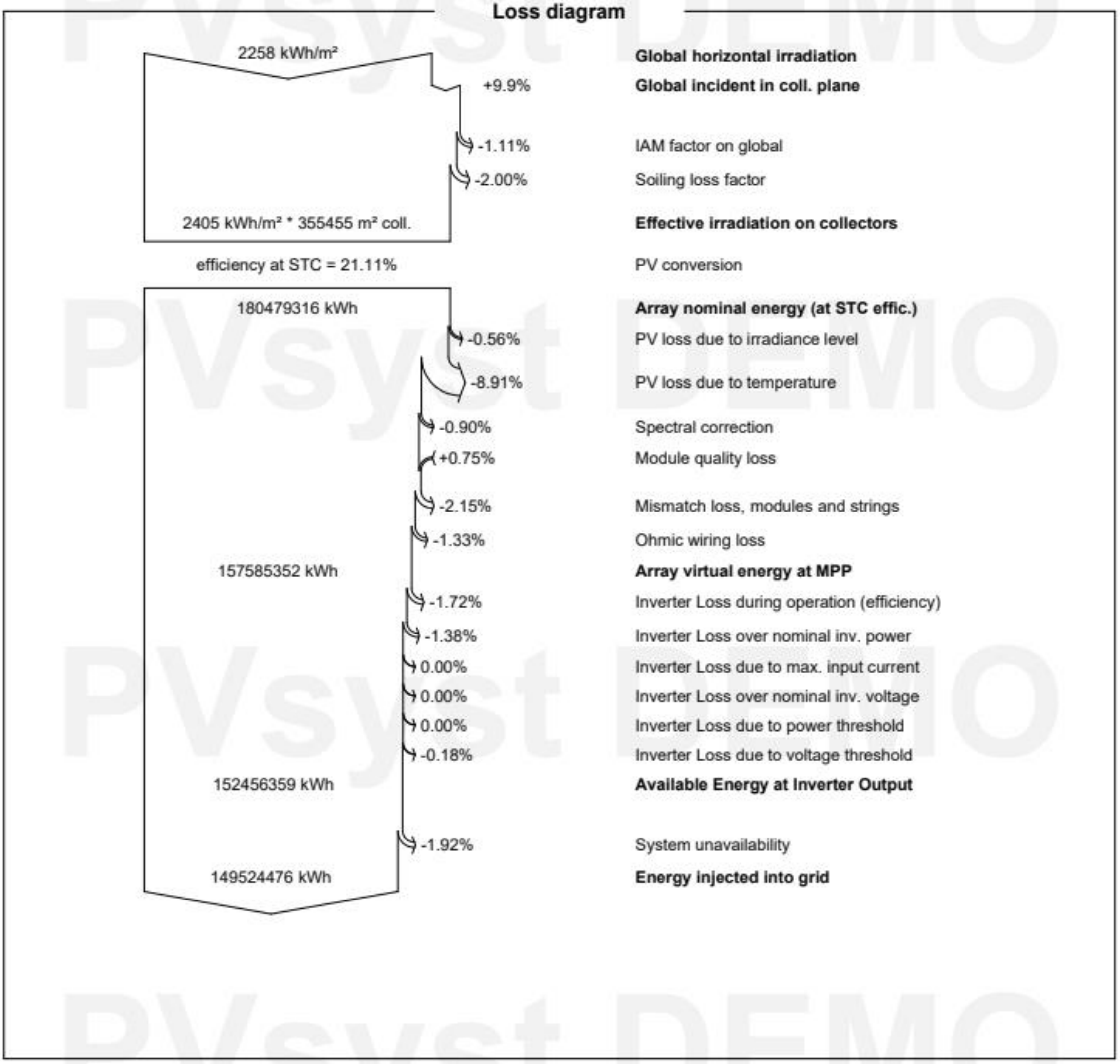
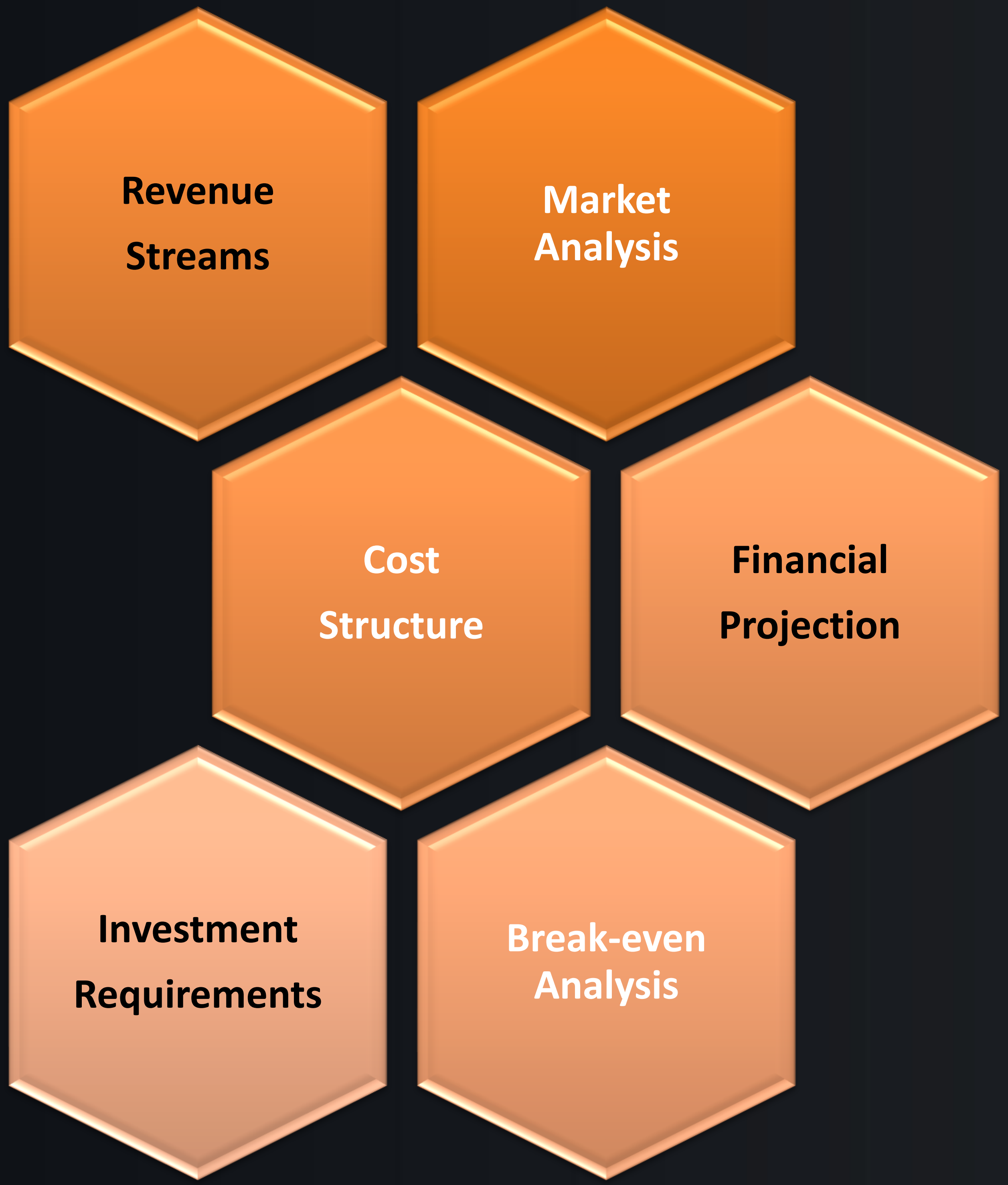


Figure 30. Results of Loss Diagram

Financial Study



Initial Capital Investment

318,836,800 SAR

Annual Revenue

26,914,320 SAR

Break-even Point (kWh)

122,659,333 kWh

Prototype Presentation

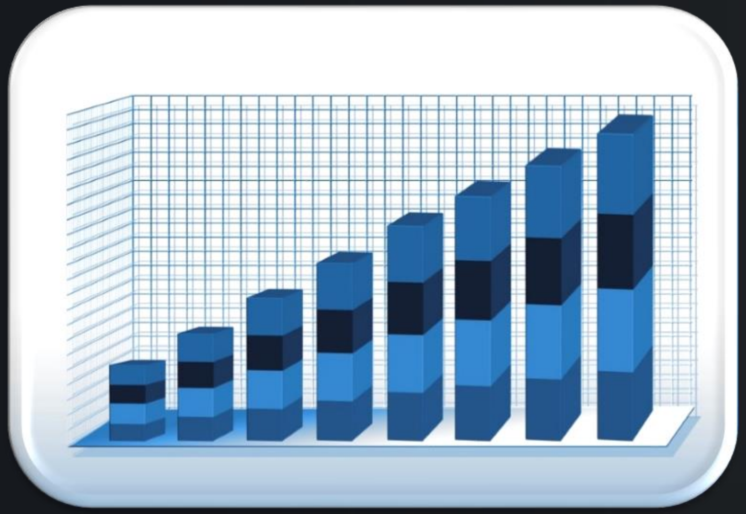
Prototype Presentation

Discussion

Skills and Knowledge Required for the Project

Learning Processes and Techniques

Application of Knowledge and Skills



Final Observations and Statistics

Results evaluation

06

Conclusion

Summary

Project Importance:

- ❑ Sustainability and Environment
- ❑ Vision 2030
- ❑ Enhancing Efficiency

Project Outcomes:

- ➢ Functional Prototype
- ➢ Real Mega Project Design
- ➢ Financial Analysis

Important Results:

- ✓ 149,524 MWh/year
- ✓ Performance ratio of 0.803
- ✓ Break-Even pt. 122,659,333 kWh/yr

Future Recommendations

- Integration of AI-Driven Technologies
- Scalability and Expansion

Relevant EE Courses

- EE-459 Renewable Energy
- EE-404 Solar Cells & Photovoltaic Systems

Work Division

Task	Person
Literature Review	Most Literature: Hamza
Mechanical Design	3D Design: Marwan
PVsyst Design and Analysis	Hamza and Marwan (Marwan Most)
Report Writing	Hamza and Marwan (equal tasks)
Presentation Slides Preparation	Design: Hamza. Content: Marwan.
Financial Study	Hamza and Marwan (Hamza Most)
Prototype Building Components	Marwan
Work Instruments	Hamza

Table 2. Work Division

Acknowledgment

References

[1]. "Saudi Vision 2030 - Environment & Nature," Vision 2030, [Online]. Available: https://www.vision2030.gov.sa/en/progress/environment-nature/. 2023

[2]. A. Amer, H. Attar, S. As’ad, S. Alsaqoor, I. Colak, A. Alahmer, M. Alali, G. Borowski, M. Hmada, and A. Solyman, "Floating Photovoltaics: Assessing the Potential Advantages and Challenges of Harnessing Solar Energy on Water Bodies," Journal of Ecological Engineering, vol. 24, no. 10, pp. 324–339, Aug. 2023. [Online]. Available: https://doi.org/10.12911/22998993/170917

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[8]. Ciel et Terre, "Floating solar system," [Online]. Available: http://www.ciel-et-terre.net/essential_grid_category/floating-solar-system/

[9]. Ciel et Terre, "QE-2 Project," [Online]. Available: https://ciel-et-terre.net/project/qe-2/


College of Engineering
Design and Implementation of a Floating PV Power Plant
Organic Pigments
Factory

THANK YOU

Any Questions?