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Solar Energy Education: Curriculum Framework Development

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Solar Energy Education: Curriculum Framework Development

Agenda

- Introduction
- Objectives
- Existing solar education programme
- Industry demands & gaps
- Proposed curriculum framework
- Pilot programme and results.

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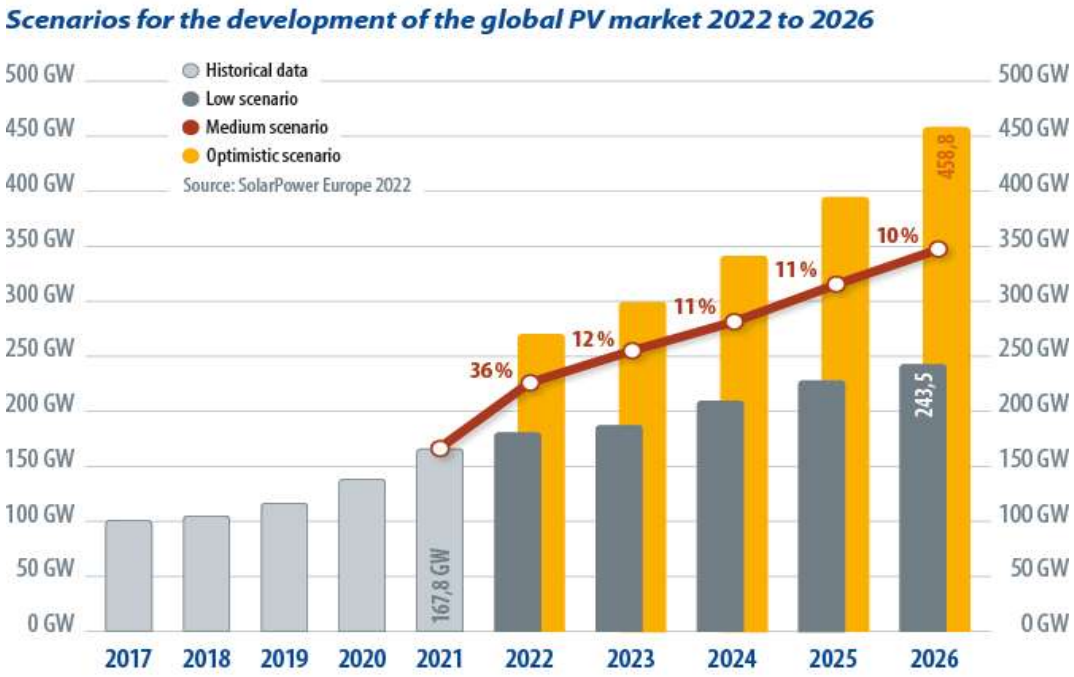
Solar Energy Education: Curriculum Framework Development

Introduction

- Solar energy has witnessed tremendous growth globally, playing a pivotal role in achieving net-zero targets.
- By 2023, global solar capacity rose by 350 GW, with China leading the growth (148.9 GW).
- According to solar power Europe, the workforce in solar industry in 2021 was about 466000 and grew staggeringly by 39% to 648000 by the end of 2023.
- **Major obstacle – Lack of skilled solar manpower.**

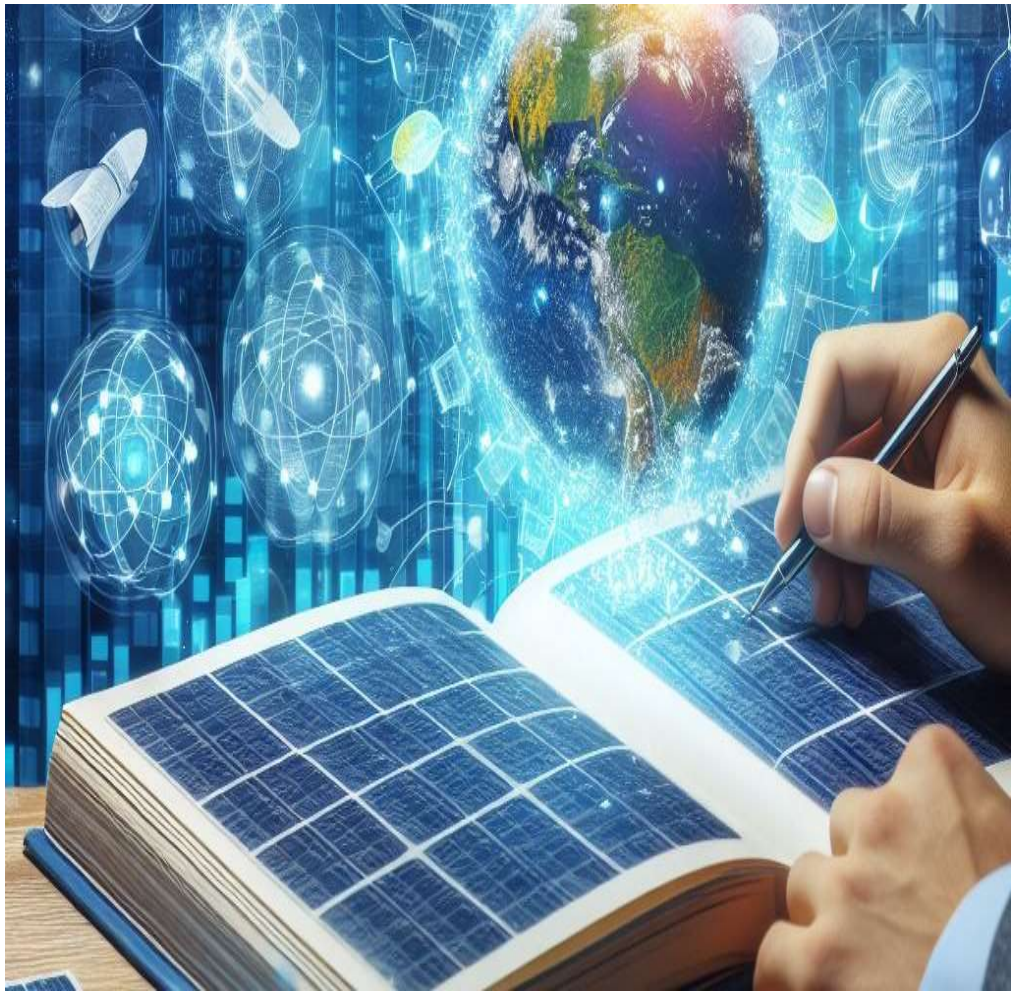


PV market growth prediction till 2026

Solar Energy Education: Curriculum Framework Development

Objectives

- Develop a curriculum framework that integrates both academic rigor and practical, industry-relevant training for solar professionals.
- Equip students with the necessary skills for PV system design and installation.
- Emphasis on hands-on training with solar technologies, energy storage, and power electronics.
- Upscaling and rescaling the learners with the solar energy system.
- Inclusion of industry internships, site visits, and project-based learning for real-world application.



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Existing solar education program.

- Current solar energy curricula focus too heavily on theoretical aspects, lacking practical, hands-on experience.
- Rely on mostly MATLAB/SIMULINK software.
- Few programmes integrate the latest solar technologies, such as bifacial modules or perovskite cells.
- Global online platform Coursera offers wide range of courses on PV. However, limited to online learning without practical experience or hands on training.

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Industry Demands & Gaps

Key Skills Sought by Employers in the Solar Power Sector:

- Site Visits: Conducting Site visits and effectively applying professional skills on-site.
- Analysis: Performing cost, requirements, and efficiency analysis.

Technical understanding on the followings:

- Roof top, grid-connected, and utility/industrial scale PV systems.
- Knowledge of solar panel types.
- Good understanding on inverters, converters, and battery energy storage systems.
- Planning and Implementation which includes Electrical Installations for PV systems.
- Understanding on different installation standards i.e. BS7671, IEC61730, etc.
- Understanding grid codes for grid connected, utility/industrial PV installations.
- Software Proficiency in PVSyst, AutoCAD, PVSol, ETAP etc.

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Industry Demands & Gaps

Aspect	Industry Need	Current Academic Training
Hands-on-Experience	Practical training in PV System design and installation. Essential to have understanding on site analysis, roof assessments, shading affects, panel spacing and location, utility/industry scale PV installation etc.	Mostly theoretical learning with limited practical exposure.
Hardware and Software Skills	Use of shading analysis tool for example, Pathfinder tool. Proficiency in PVSyst, PVSol, AutoCAD	Minimal training on specialised software. Mostly done on MATLAB.

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Industry Demands & Gaps

Key Areas Needing Improvement in Solar Education Programmes:

- **Lack of Practical Application-Based Learning:**
  - Heavy focus on theoretical aspects with limited hands-on experience.
  - Students miss opportunities to apply knowledge in real-world design scenarios.
  - Insufficient use of industry-standard software tools (e.g., PVSyst).
- **Inadequate Integration of Emerging Technologies:**
  - Rapid advancement in PV technologies (e.g., perovskite cells, bifacial modules) are not fully integrated into curricula.
  - Limited exposure to cutting-edge innovations like solid-state batteries and floating solar panels.
- **Limited Focus on Economic and Policy Aspects:**
  - Courses often overlook financial feasibility, incentive schemes, and regulatory frameworks.
  - Lack of training on economic factors that influence the adoption of solar technologies.

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Proposed Curriculum Framework

The proposed curriculum aims to bridge the gap between academic education and industry demands in the solar energy sector:

- Focuses on providing students with a comprehensive understanding of photovoltaic (PV) systems, energy storage, and power electronics, while incorporating practical, hands-on learning experiences.
- Integrating industry-standard tools like PVSyst, and real-world applications such as site visits, internships, and project-based learning.
- Addressing key areas such as emerging technologies, economic and policy considerations, and safety practices in solar installations.

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Proposed Curriculum Framework

Photovoltaic Systems

- Covers the basics of renewable energy, solar PV system applications, and solar cell technologies.
- Focuses on key concepts like solar radiation, maximum power point, load calculations, and site assessments.
- Includes practical topics like battery sizing, panel placement, safety devices, and PV installation codes.

Energy Storage Systems

- Explores battery technologies, including lead-acid and lithium-ion, as well as their differences and applications.
- Discusses energy storage connections, charge controllers (PWM and MPPT), and new advancements in battery technology.

Application of Power Electronic in PV

- Introduces DC-DC, AC to DC and DC-AC converters, their topologies, and bi-directional converters for PV systems.

Safety & Protection

- Emphasises safety standards, covering electrical and fire safety, battery energy storage systems (BESS), and environmental safety.
- Focuses on system installation, commissioning, operation, and maintenance safety protocols.

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Proposed Curriculum Framework

Module	Topics
PV System Design	Introduction to Photovoltaic System
	Photovoltaic system fundamentals
	PV design.
	Load calculations
	An overview of solar panel.
	Solar Panel based n-type and p-type materials
	Performance and Cost Analysis of Solar Panel Technology (PERC, TOPCON, and Heterojunction)
	New Solar Technology
	Introduction to web-based tool – PVGIS, PVWatts and PVsyst

Module	Topics
Application of Power Electronics in PV systems	Introduction to Power Electronics
	Types of Converters
	Application of power converters
	DC-DC converters and their topologies
	Voltage control
	Inverters and its application in PV systems
	Bi-directional inverters
	Charge controller and MPPT Controller
	Power optimiser

Module	Topics
Energy Storage for PV systems - Battery	Introduction to Battery
	Battery types
	Nominal Voltage and Capacity
	C-Rate, Energy and Power
	Battery life
	Battery conditions
	Battery connections
	System losses
	Battery sizing in PV system

Module	Topics
Safety and Protection	Electrical Safety
	Fire safety
	Occupational safety
	Environmental safety
	System Installation and Commissioning
	Operations and Maintenance Safety

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Proposed Curriculum Framework

Integration of System Engineering

- Students will explore how various solar components (e.g., panels, inverters, storage) interact for enhanced system performance.
- Emphasis has been placed on system design, requirements analysis, and life cycle management.
- Real-world case studies have been utilised to illustrate the practical implications of component interactions in solar systems.
- Project-based learning will allow students to design and simulate interactions between different solar components in a controlled environment.

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Proposed Curriculum Framework

Continuing Professional Development (CPD) Courses

- Structured into two categories: one for graduates and solar engineers, and an advanced course for postgraduates, PhD candidates, and researchers.
- Both CPDs cover topics such as PV design, performance analysis and with additional focus on PV condition monitoring and maintenance.
- Advanced topics in – AI and Machine Learning, IoT and Distributed Energy Management.

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Pilot Programme & Results

The pilot programme began with a summer training programme at the University of Mosul.

A survey was conducted where students provided their opinions on various aspects of the training.

Total Participants: 130 students.

Week	Session	Topics	Date and time	Trainer
1	1	(Induction to solar cell technology, cleaning process and Lithography)	1/7/2024, 9 AM	Dr. Ahmed Suhail
	2	(Sputtering and Wet transfer of CVD graphene processes)	3/7/2024, 8 PM	Dr. Ahmed and Dr. Huda
2	1	Photovoltaic system and its fundamentals	10/7/2024, 9 AM	Dr. Omar Abdulwahid
	2	Designing PV system and Load Calculation	11/7/2024, 9 AM	Dr. Salwan Sabry
3	1	Solar panel and energy storage	17/7/2024, 9 AM	Dr. Omar Abdulwahid
	2	Application of Power Converters and Invertors in a PV system	18/7/2024, 9 AM	Dr. Salwan Sabry
4	1	Measure the I-V curves of solar cells under variable conditions	22/7/2024, 9 AM	Lab team
	2	Measure the I-V curves of solar cells under variable conditions	23/7/2024, 9 AM	Lab team
	3	Setup solar system	29/7/2024, 9 AM	Lab team
	4	Setup solar system	30/7/2024, 9 AM	Lab team

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Pilot Programme & Results

1. How satisfied are you with the knowledge you gained from the Summer training?

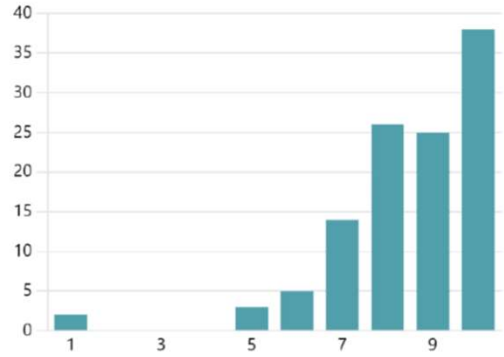
Very satisfied	56
Satisfied	52
Neither satisfied nor dissatisfied	4
Dissatisfied	2
Very dissatisfied	0

2. Do you feel you achieved your desired learning outcome?

Yes	94
No	7
Not sure	14

3. How would you rate the instructor's overall teaching performance?

8.48
Average Rating



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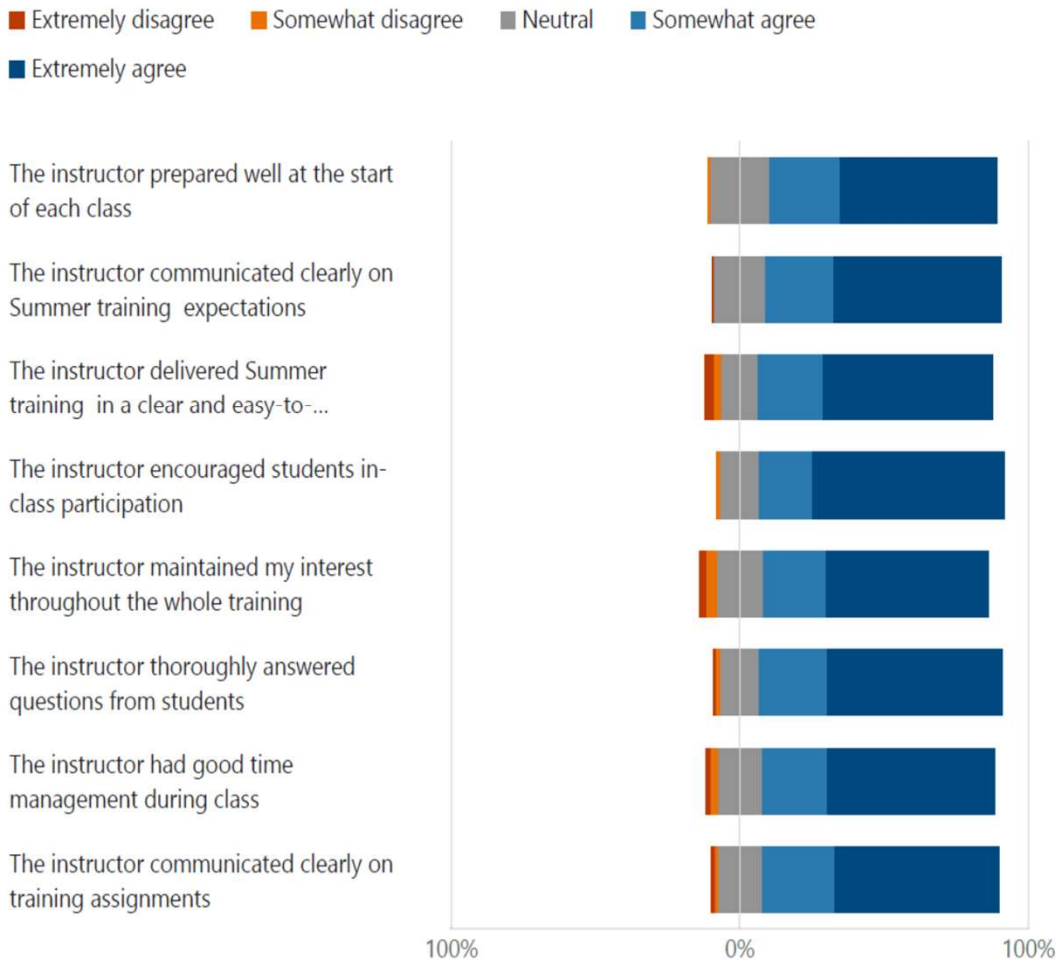
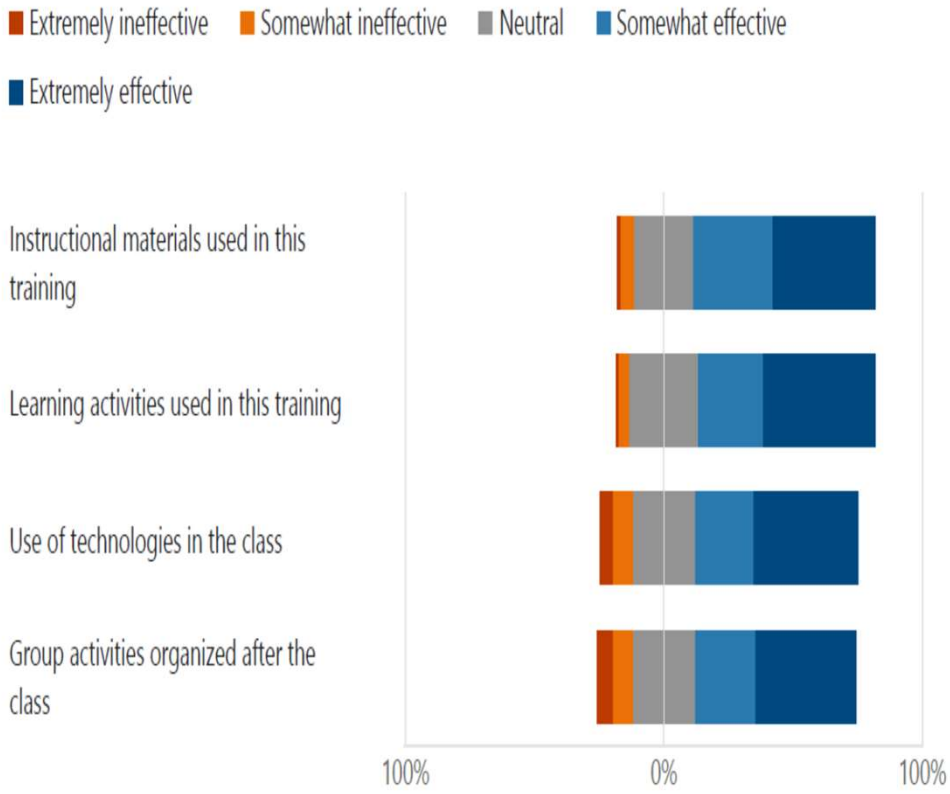
4. How do you agree with the following statements?



5. How effective were the following aspects regards to your experience in this training?



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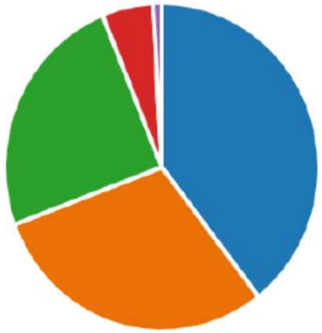
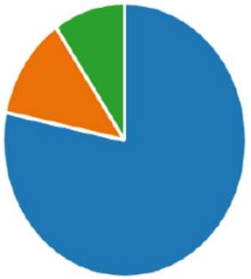
6. How effective were the instructional materials used in this training?

Extremely effective	45
Very effective	34
Somewhat effective	28
Not so effective	6
Not at all effective	1



8. Did the training meet your expectation?

Yes	90
No	14
Not sure	11

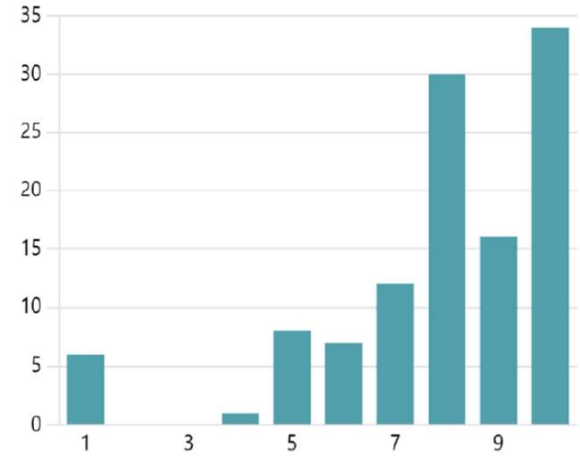


9. How likely are you to recommend this training to a friend or classmate?

7. How effective were the learning activities used in this training?

Extremely effective	46
Very effective	29
Somewhat effective	30
Not so effective	8
Not at all effective	2

7.89
Average Rating



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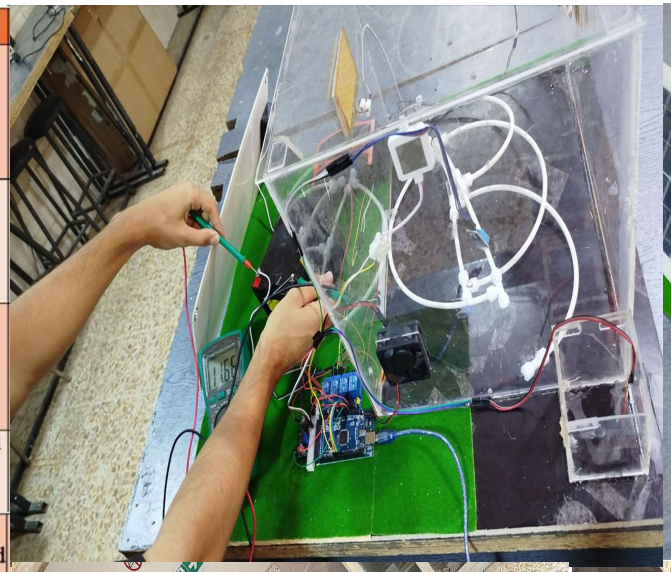
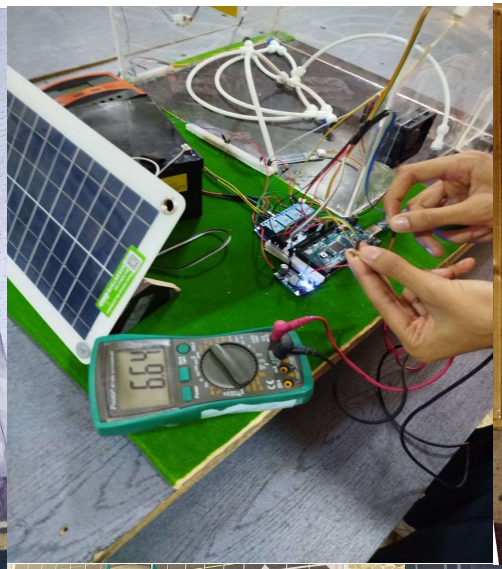
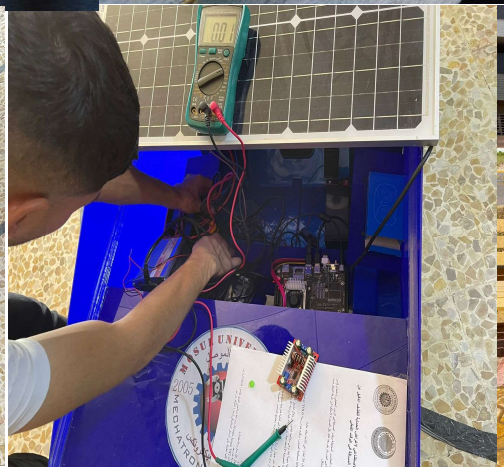
Pilot Programme & Results

No	Project	Supervisor
1	Producing electrical energy based on the combination of a hydropower source with solar cells	Dr. Ahmed Muneer
2	Solar water pumping systems for agricultural application	Dr. Ahmed Muneer
3	Producing electrical energy from recycling materials	Dr. Ahmed Muneer
4	Using carbon-based materials to produce transparent electrodes that is suitable for solar cells	Dr. Huda Mohammed
5	Sustainable development of smart car	Dr. Ahmed Muneer Dr. Omar Abdulwahid Dr. Salwan S. Sabry
6	Design and implementation of a controlled greenhouse-based solar power system	Dr. Omar Abdulwahid Dr. Salwan S. Sabry Dr. Ahmed Muneer
7	Design and Implementation of AI Driven Vehicle Powered by Solar Energy for Security Applications	Dr. Omar Abdulwahid Dr. Mohammed Yassen
8	Design and Analysis of a Large-Scale Solar Power Station to Support the University Grid Utility	Dr. Salwan S. Sabry Dr. Omar Abdulwahid Dr. Ahmed Muneer
9	Designing a Charging Station for Scooters and Electric Bikes at the University of Mosul	Dr. Salwan S. Sabry Dr. Ahmed Muneer Dr. Omar Abdulwahid







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Materials Design and Development

5- Sputtering process:

6- Wet transfer process of CVD graphene:

[Project Site](#) [Handbook](#) [Setup Guide](#) [Video Recording](#)

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Thank You