B.VOC. RENEWABLE ENERGY COURSE STRUCTURE

THIRD YEAR (NEP 2020 Implemented from 2023-24

Semester V

Sr. No.	NEP Course Category	Course Code & Title	No. of Credits
1	Major Core	RE 301 MJ Roof Top & Grid Connected PV System	2
2	Major Core	RE 302 MJ Solar Energy in India: Policies, Innovations & Future	2
3	Major Core	RE 303 **MJ Mathematics for Solar PV Systems**	2
4	Major Core Practical	RE 304 MJP Introduction to Solar PV Software	2
5	Major Core Practical	RE 305 MJP Practical Based on Theory	2
6	Major Elective	RE 310 MJ Climate Change	2
7	Major Elective practical	RE 311 MJP Climate Change Project	2
8	Vocational Skills Course	RE 321 VSC Solar Home Décor Craft Studio	2
9	Field Project	RE 331 FP	2
10	Minor Theory	RE 341 MN Entrepreneurship Skills	2
11	Minor Practical	RE 342 MNP Computer Applications for Business Automation	2
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Semester VI

Sr. No.	NEP Course Category	Course Code & Title	No. of Credits
1	Major Core	RE 351 MJ Solar PVS Operation & Maintenance	2
2	Major Core	RE 352 MJ Site Survey and Feasibility Study	2
3	Major Core	RE 353 MJ Solar Thermal Applications	2
4	Major Core Practical	RE 354 MJP Core Skills & Professional Skills	2
5	Major Core Practical	RE 355 MJP Practical Based on Theory	2
6	Major Elective	RE 360 MJ Battery Technologies	2
7	Major Elective Practical	RE 361 MJP Practical Based on Battery Technologies	2
8	Vocational Skills Course	NA	0
9	On Job Training	RE 381 OJT	4
10	Minor Theory	RE 391 MN Net Zero Energy Building Design Strategies	2
11	Minor Practical	RE 392 MNP Case Study (NZEB)	2
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SEMESTER- V

1. Course Code: RE 301 MJ Roof Top & Grid Connected PV System

By the end of this course:

1. **Student explains** the fundamental structure and functioning of rooftop solar PV systems along with relevant policies and business models.
2. **Student differentiates** between off-grid, on-grid, and hybrid system configurations including battery backup and anti-islanding features.
3. **Student identifies** the major components of a grid-connected PV system and describes their roles and interconnections.
4. **Student estimates** system size for small-scale applications and evaluates its suitability based on regulatory and technical parameters.

Unit 1: Introduction to Rooftop Solar PV *(10 hours)*

1. Basics of rooftop solar PV systems
2. Types of solar business models
3. System sizing (small-scale)
4. Policies, regulations, and case studies

Unit 2: Grid Connectivity and Configurations *(10 hours)*

1. Off-grid vs. on-grid systems
2. Grid-tied system working and applications
3. System configurations: with/without battery backup
4. Captive systems, support systems, and anti-islanding

Unit 3: Components of Grid-Connected Systems *(10 hours)*

1. Solar PV array and combiner box
2. DC/AC cabling and distribution boxes
3. Grid-connected inverter
4. Overview of other essential components

References Books/links:

1. Solar Photovoltaics: Fundamentals, Technologies and Applications, Solanki Chetan Singh, PHI Learning Pvt. Ltd. (EEE) Delhi.

2. Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, Solanki Chetan Singh, PHI Learning Pvt. Ltd. (EEE) Delhi.

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2. Course Code: RE 302 MJ Solar Energy in India: Policies, Innovations & Future

Learning Outcomes

1. **Student describes** key national and state-level solar policies, MNRE guidelines, and regulatory mechanisms including net metering.
2. **Student examines** recent technological advancements in solar PV systems, storage, and their integration with smart grids.
3. **Student analyzes** the challenges in solar project implementation related to land, grid connectivity, and policy frameworks.
4. **Student evaluates** future strategies, innovations, and collaborative efforts necessary to achieve India's 2030 solar energy targets.

Unit 1: Solar Policies and Regulations (10 Hours)

1. National policies: MNRE guidelines, subsidies, bidding processes
2. State-level initiatives and net metering rules

Unit 2: Technology and Implementation Challenges (10 Hours)

1. Advances in solar PV and storage systems
2. Smart grid integration
3. Key challenges: land, grid, policy gaps

Unit 3: Future Outlook and Strategies (10 Hours)

1. Emerging trends and innovations
2. Achieving 2030 solar targets
3. Role of private sector and partnerships

References Books/links:

1) www.mahadiscom.in/

2) www.mnre.gov.in/

3) https://www.mahaurja.com/

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3. Course Code RE 303 MJ Mathematics for Solar PV Systems

Learning Outcomes

1. **Student applies** basic mathematical and electrical formulas, including Ohm's Law and power equations, to solve solar system-related problems.
2. **Student calculates** solar panel, battery bank, inverter, and cable requirements using data on energy output, load, and site conditions.
3. **Student interprets** solar meter readings, system layout charts, and performance data to assess efficiency and troubleshoot issues.
4. **Student estimates** rooftop solar project costs, savings, and payback periods using system sizing and usage data.

Unit 1: Basic Math and Electrical Formulae (10 Hours)

1. Numbers, percentages, decimals, ratios
2. Units and conversions (length, area, power, energy)
3. Area and volume (used for layout and mounting space)
4. Ohm's Law: Voltage, Current, Resistance
5. Power and Energy formulas (P = VI, kWh)
6. Series and Parallel Circuits

Unit 2: Solar System Sizing and Performance Math (10 Hours)

1. Solar irradiance and energy output
2. Tilt angle, direction, and shading (using basic trigonometry)
3. Calculating number of panels based on load and sunlight
4. Battery bank sizing for energy storage
5. Inverter and charge controller ratings
6. Cable sizing and voltage drop

Unit 3: System Layout, Meter Reading & Cost Estimation (10 Hours)

1. Roof layout and space planning
2. Calculating panel spacing to avoid shade

3. Reading multi meter, solar meters, and charts
4. Tracking energy generation and usage
5. Estimating system costs
6. Basic payback period and savings calculation
7. Make smart layout choices using simple math
8. Understand system data and troubleshoot issues
9. Do cost and savings calculations for small projects
10. Step-by-step problem solving
11. Hands-on practice with tools and meters

Practical Activities List:

1. **Measure and Calculate Rooftop Area**
    - Use measuring tape or a scale diagram to calculate usable panel space.
2. **Estimate Household Energy Consumption**
    - Use appliance ratings to calculate daily and monthly energy use in kWh.
3. **Size a Battery Bank**
    - Determine battery capacity required for backup based on load and autonomy.
4. **Calculate Cable Size and Voltage Drop**
    - Use cable length and current to estimate voltage drop and choose proper cable size.
5. **Use a Multimeter to Take Readings**
    - Measure voltage and current in a DC circuit and verify using Ohm's Law.
6. **Shadow Analysis for Panel Spacing**
    - Use simple tools or drawings to assess shading and calculate optimal spacing.

Reference Books

1. Duffie, J. A., & Beckman, W. A. (2013). *Solar engineering of thermal processes* (4th ed.). Wiley.
2. Garg, H. P., & Prakash, J. (2000). *Solar energy: Fundamentals and applications* (1st ed.). Tata McGraw-Hill.
3. Solanki, C. S. (2015). *Solar photovoltaics: Fundamentals, technologies and applications* (3rd ed.). PHI Learning Pvt. Ltd..

4. Course Code RE 304 MJP Introduction to Solar PV Software

Learning Outcomes

1. **Student explains** the features and functions of popular PV system design software, including PV*Sol, PVsyst, and HelioScope.
2. **Student demonstrates** the ability to create site profiles and input basic data for a solar PV system design.
3. **Student applies** system sizing and layout planning techniques, and selects appropriate inverters and modules for grid-connected PV systems.
4. **Student evaluates** system performance by analyzing results, identifying losses, and generating comprehensive reports for solar PV projects.

Unit 1: Basics of PV System Design Software *(10 hours)*

- Overview of popular PV software (e.g., PV*Sol, PVsyst, HelioScope)
- Creating site profiles and inputting basic data
- Understanding solar resource data

Unit 2: Designing Grid-Connected PV Systems *(10 hours)*

- System sizing and layout planning
- Inverter and module selection
- Simulating energy output

Unit 3: Analysing Results and Reporting *(10 hours)*

- Performance analysis and losses
- Generating reports and interpreting results
- Exporting project documentation

Reference Books

1 Duffie, J. A., & Beckman, W. A. (2013). *Solar engineering of thermal processes* (4th ed.). Wiley.
2 Garg, H. P., & Prakash, J. (2000). *Solar energy: Fundamentals and applications* (1st ed.). Tata McGraw-Hill.
3 Solanki, C. S. (2015). *Solar photovoltaics: Fundamentals, technologies and applications* (3rd ed.). PHI Learning Pvt. Ltd..

5. Course Code RE 305 MJP Practical Based on Theory

Practical: To design small and large RTGC Solar PV Plants and prepare a report.

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6. Course Code: RE 310 MJ Climate Change

Learning Outcomes

1. **Student explains** the causes and evidence of climate change, including the role of greenhouse gases in global warming.
2. **Student evaluates** the global and regional impacts of climate change, particularly its effects on sea levels, extreme weather, and regional communities.
3. **Student identifies** the climate change challenges specific to India and Maharashtra, with a focus on agriculture, monsoons, and urban areas.
4. **Student explores** solutions for climate change, including mitigation strategies through renewable energy, adaptation measures, and youth/community involvement in local actions.

UNIT 1: Basics of Climate Change *(10 hours)*

1. What is Climate Change? – Causes and evidence
2. Greenhouse Gases and Global Warming
3. Global Climate Agreements – UNFCCC, IPCC, Paris Agreement

UNIT 2: Climate Change and Its Impact *(10 hours)*

1. Global and Regional Impacts – Sea level rise, extreme weather
2. Climate Change in India and Maharashtra – Monsoons, agriculture, cities
3. Vulnerable Communities and Climate Justice

UNIT 3: Climate Solutions and Local Action *(10 hours)*

1. Mitigation through Renewable Energy and Efficiency
2. Adaptation Strategies – Water, agriculture, infrastructure
3. Youth and Community Action – Local solutions and career opportunities

Reference Books

1. IPCC. (2021). *Climate change 2021: The physical science basis* (Sixth Assessment Report). Cambridge University Press. https://doi.org/10.1017/9781009157896
2. Dessler, A. E. (2021). *Introduction to modern climate change* (3rd ed.). Cambridge University Press.

3. Hulme, M. (2009). *Why we disagree about climate change: Understanding controversy, inaction and opportunity*. Cambridge University Press.

7. RE 311 MJP Climate Change Project

Students should conduct a project based on a given topic and prepare a report.

"Climate in Action: Assessing and Reducing Carbon Footprint on Campus" Students calculate the carbon footprint of their university and propose actionable mitigation strategies using renewables and efficiency.

8. RE 321 VSC Solar Home Decor Craft Studio

Learning Outcomes

1. **Student constructs** a solar garden light using an LDR sensor for automatic lighting functionality.
2. **Student creates** a decorative solar lantern by installing solar-powered LEDs into paper or cloth designs.
3. **Student assembles** a solar-powered table fan by connecting a DC motor to a solar panel and designing a mini fan.
4. **Student designs** a solar table lamp or centerpiece with rechargeable batteries, optional motion sensors, and decorative elements.

1. DIY Solar Garden Light

Make a cute solar stake light for your garden/balcony.

Use an LDR sensor for automatic lighting.

Materials Required: Mini solar panel | Rechargeable battery | LED | LDR (optional) | Plastic bottle | Paint

2. Decorative Solar Lantern

Craft beautiful lanterns from paper or cloth.

Install LED with solar power.

Materials Required: Solar panel | Battery | LED | Colored paper | Glue gun | Craft tools

3. Solar-Powered Table Fan

Connect DC motor to solar panel.

Design a working mini fan.

Materials Required: Solar panel | DC motor | Fan blade | Switch | Battery | Cardboard or frame

4. Solar Table Lamp / Centerpiece

Make a glowing table décor piece.

(Add optional motion sensors.)

Materials Required: Solar panel | LED string | Rechargeable battery | Jar or dome | Craft paint

Website Links for Learning Solar Home Décor Projects

1. **Instructables – Solar Projects**
   🛠 DIY step-by-step tutorials with images and videos
   🔗 https://www.instructables.com/solar/
   (Search for "solar lamp," "solar garden light," etc.)

2. **YouTube – DIY Solar Projects**
   Visual learning of solar craft and electronics projects
   https://www.youtube.com/results?search_query=DIY+solar+lamp+project
   https://www.youtube.com/c/Techiesms *(Indian creator – solar + electronics projects)*

3. **Pinterest – Solar Craft Ideas**
   For creative solar home décor inspirations
   https://www.pinterest.com/search/pins/?q=solar%20home%20decor%20diy

4. **Open Green Energy – DIY Solar Projects Blog**
   Focused on clean energy, DIY solar tutorials
   https://www.opengreenenergy.com

5. **Science Buddies – Solar STEM Projects**
   STEM-based solar experiments and models
   https://www.sciencebuddies.org/search?q=solar+energy

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9. RE 331 FP Field Project

Write a report of field visit. Filed visit can be planned for any type of Renewable Energy Project.

10. RE 341 MN Entrepreneurship Skills

Learning Outcomes

1. **Student explains** the process of setting up a new venture and identifies key components of a business plan.
2. **Student distinguishes** between fixed and working capital needs and outlines the components of a loan application.

3. **Student demonstrates** professional etiquette, time management, and leadership in workplace communication.
4. **Student identifies** company policies related to safety, customer service, and documentation, and recognizes departmental functions within an organization.

Unit 1: Setting up a New Venture (10 Hours)

1. Process for setting up a new venture
2. Key ingredients of a business plan
3. Distinguishing between fixed and working capital requirements
4. Components of a loan application for fundraising
1. Definition of entrepreneurship from different perspectives
2. Importance of entrepreneurship: Enhances creativity and innovation, Builds self-confidence, Tool for nation building, Engine of economic growth

Unit 2: Communication and Professional Etiquette (10 Hours)

1. Demonstrating good etiquettes and manners while communicating with clients
2. Demonstrating the importance of time management
3. Demonstrating leadership skills and effective resource management techniques

Unit 3: Company Policies and Organizational Structure (10 Hours)

1. Understanding the company's safety policy
2. Company's customer support policy
3. Company's documentation policy
4. Obtaining authorization from specified field safety officer and supervisor
5. Familiarization with the company's different departments

References Books/links:

Solar Photovoltaics: Fundamentals, Technologies and Applications, Solanki Chetan

Singh, PHI Learning Pvt. Ltd. (EEE) Delhi.

11. RE 342 MNP Computer Applications for Business Automation

Learning Outcomes

1. **Student identifies** key business processes and understands the need for automation in enhancing productivity.
2. **Student demonstrates** proficiency in using office productivity tools (Word, Excel, and PowerPoint) and automating tasks with formulas, macros, and pivot tables in spreadsheets.
3. **Student applies** AI tools for improving writing, communication, data analysis, and workflow automation using platforms such as ChatGPT, Microsoft Excel Copilot, and Zapier.
4. **Student creates** automated reports and dashboards, and utilizes project management and digital collaboration tools to improve team communication and task efficiency.

Unit 1: Fundamentals of Business Automation (10 Hours)

1. Overview of business processes and automation needs
2. Introduction to Office productivity tools (Word, Excel, PowerPoint)
3. Automating tasks using spreadsheets (formulas, macros, pivot tables)

Unit 2: AI Tools for Business Efficiency (10 Hours)

1. Using AI tools for writing, summarizing, and communication (e.g., **ChatGPT**, **Grammarly**)
2. AI tools for data handling and analysis (e.g., **ChatGPT with Code Interpreter**, **Microsoft Excel Copilot**)
3. Automating workflows with AI-based platforms (e.g., **Zapier**, **IFTTT**, **Notion AI**)

Unit 3: Business Process Management & Communication (10 Hours)

1. Creating automated reports and dashboards (Google Sheets + AppScript, Power BI basics)
2. Tools for task and project management (e.g., **Trello**, **ClickUp**, **Asana**)
3. Digital collaboration and communication tools (e.g., **Google Workspace**, **Slack**, **Microsoft Teams**)

SEMESTER VI

1. RE 351 MJ Solar PVS Operation & Maintenance

Learning Outcomes

1. **Student distinguishes** between various types of maintenance practices such as preventive, corrective, and condition-based monitoring.
2. **Student identifies** key O&M focus areas across different solar PV plant subsystems including modules, electrical, structural, and communication components.
3. **Student explains** common operational challenges in solar PV maintenance including manpower, logistics, weather conditions, and warranty claims.
4. **Student prepares** basic O&M strategies by integrating technical, logistical, and budgetary considerations for remote solar installations.

Unit I: Types of Maintenance

1. Preventive Maintenance (PM), Corrective Maintenance (CM) or breakdown Maintenance (BM),
2. Condition-Based Monitoring (CBM)

Unit II: O&M focus areas

1. A solar photovoltaic power plant has several components and each of the sub-system requires
2. Different O&M skill sets.
3. Examples: Module, Electrical sub-systems, Civil and Structural sub-systems, Communication,
4. Warranty Management, Spare Parts Inventory Management, Design Debugging and maintenance.

Unit III: Challenges

1. Skilled Manpower, Local Labour, O & M Budget, Availability of water,
2. Theft of materials, Documentation, Warranty claim management, Spares management and response time, Weather related issues like rain, sand movement
3. Remote location - execution challenges such as communication connectivity, logistics for repairs, and deployment of manpower.

References Books/links:

1. Solar Photovoltaics: Fundamentals, Technologies and Applications, Solanki ChetanSingh, PHI Learning Pvt. Ltd. (EEE) Delhi.

2. Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, Solanki Chetan Singh, PHI Learning Pvt. Ltd. (EEE) Delhi.

3. http://www.nrel.gov/docs/fy17osti/67553.pdf

4. A Practical Guide for Total Engineering of MW capacity Solar PV Power, by A.S.Kapur

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2. RE 352 MJ Site Survey and Feasibility Study

Learning Outcomes

1. **Student identifies** suitable installation sites by evaluating mounting options, shading issues, and site conditions.
2. **Student assesses** client energy requirements by preparing load profiles and estimating battery backup needs.
3. **Student performs** data collection and shading analysis for feasibility studies using standard solar software tools.
4. **Student prepares** a complete feasibility report including energy generation estimates and risk assessment.

Unit I: Site Visit (10 Hours)

- Identify best location for installation
- Check mounting type and placement
- Inspect shading and obstacles
- Prepare a simple site map

Unit II: Understanding Client Requirements (10 Hours)

- Assess load and prepare load profile
- Estimate plant capacity
- Decide on battery backup needs

Unit III: Feasibility Study and Report (10 Hours)

- Collect site data: GHI, DNI, temp, wind
- Do shading analysis
- Estimate energy generation using PV*Sol® / PVsyst
- Identify project risks
- Prepare feasibility report using software

References Books/links:

1. Solar Photovoltaics: Fundamentals, Technologies and Applications, Solanki Chetan Singh, PHI Learning Pvt. Ltd. (EEE) Delhi.

2. Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, Solanki Chetan Singh, PHI Learning Pvt. Ltd. (EEE) Delhi.

3. QP- 6, SECTOR: GREEN JOBS, REFERENCE ID: SGJ/Q0104

4. A Practical Guide for Total Engineering of MW capacity Solar PV Power, by A.S.Kapur

3. RE 353 MJ Solar Thermal Applications

Learning Outcomes

1. **Student explains** the principles of solar radiation, thermal energy conversion, and different types of solar thermal systems.
2. **Student identifies** the design, installation, and functional aspects of solar thermal devices such as water heaters, cookers, and dryers.
3. **Student designs** basic solar thermal systems for household or industrial applications, considering component selection and sizing.
4. **Student performs** maintenance and safety checks on solar thermal systems and applies troubleshooting methods for optimal performance.

Unit 1: Basics of Solar Thermal Energy *(10 hours)*

- Principles of solar radiation and thermal energy conversion
- Types of solar thermal systems (active and passive)
- Overview of solar collectors (flat plate, evacuated tube, concentrating)

Unit 2: Solar Thermal Devices and Applications *(10 hours)*

- Solar water heaters – types, design, and installation
- Solar cookers and dryers – construction and usage
- Industrial and commercial applications (process heating, solar cooling)

Unit 3: System Design, Maintenance & Safety *(10 hours)*

- Sizing and designing a basic solar thermal system
- Operation, maintenance, and troubleshooting
- Safety practices and efficiency optimization

Reference Books

1 Duffie, J. A., & Beckman, W. A. (2013). *Solar engineering of thermal processes* (4th ed.). Wiley.
2 Sukhatme, S. P., & Nayak, J. K. (2008). *Solar energy: Principles of thermal collection and storage* (3rd ed.). Tata McGraw-Hill Education.
3 Garg, H. P., & Prakash, J. (2000). *Solar energy: Fundamentals and applications* (1st ed.). Tata McGraw-Hill.

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4. RE 354 MJP Core Skills & Professional Skills

Learning Outcomes

1. **Student applies** reading, writing, and oral communication skills to understand instructions, maintain documentation, and interact effectively in the workplace.
2. **Student demonstrates** decision-making, teamwork, and time management abilities during task planning and execution.
3. **Student solves** routine work-related problems using analytical thinking, structured approaches, and customer-centric practices.
4. **Student handles** workplace communication, customer service, and feedback management with professionalism and clarity.

Unit I: Core/Generic Skills *(10 Hours)*

- **Writing Skills:** Maintain documentation
- **Reading Skills:** Understand manuals, safety instructions, signage, and codes
- **Oral Communication:** Express clearly, participate in discussions, and respond to queries.

Unit II: Professional Skills *(10 Hours)*

- **Decision Making:** Follow rules, take structured decisions
- **Planning & Organization:** Manage schedules, work in teams
- **Customer Centricity:** Follow code of conduct, ensure service satisfaction
- **Problem Solving:** Identify issues, choose best solutions
- **Analytical Thinking:** Use data and domain knowledge
- **Critical Thinking:** Evaluate information for daily tasks

Unit III: Workplace Application *(10 Hours)*

- Apply communication skills on the job
- Demonstrate planning, teamwork, and problem-solving in real tasks
- Handle customer interactions and feedback effectively

5. RE 355 MJP Practical Based on Theory

1. Pre-Survey Checklist Preparation

- Identify customer requirements (load, budget, space)
- Prepare a customized site survey checklist (roof type, orientation, shading, access, etc.)

2. On-Site Physical Inspection

- Measure rooftop area and angle using tape, inclinometer
- Observe sun path and shading (use compass/sun path app)
- Check roof condition, material, and structural strength

3. Electrical System Assessment

- Locate main electrical panel and load meter
- Check existing wiring, earthing, and inverter space availability
- Note backup systems (if any)

4. Data Collection & Photographic Evidence

- Take photos of roof, shade obstructions, and electrical points
- Record all measurements and observations in checklist format

5. Prepare Site Feasibility Report

- Analyse collected data: suitability, limitations, orientation
- Suggest PV capacity and layout
- Include summary, recommendations, and visuals.

Open-Access & Commonly Used Software for Solar PV Site Survey

Google Earth / Google Maps (Free)

- Used for initial site viewing and measuring rooftop area
- Helps assess surroundings, orientation, and access

PVGIS (Photovoltaic Geographical Information System – Free)

- Developed by the EU; commonly used in India

- Estimates solar energy potential and system performance
- Website: https://re.jrc.ec.europa.eu/pvg_tools/en/

Sun Surveyor Lite (Free Mobile App)

- Visualizes sun path, azimuth, and solar window
- Useful for shading analysis on-site (Lite version is free)

MS Excel / Google Sheets (Free)

- To record measurements, analyse data, and prepare feasibility reports

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6. RE 360 MJ Battery Technologies

Learning Outcomes

1. **Student explains** the types, specifications, and key operational concepts of batteries used in renewable energy systems.
2. **Student demonstrates** correct configuration and connection of battery banks for solar PV systems, including safe handling practices.
3. **Student performs** routine maintenance, safety checks, and basic troubleshooting of batteries and Battery Management Systems (BMS).
4. **Student evaluates** the suitability of various battery technologies and emerging trends for renewable energy storage applications.

Unit 1: Basics of Battery Technology *(10 hours)*

- Introduction to batteries and their role in renewable energy
- Types of batteries: Lead-acid, Lithium-ion, NiMH
- Basic terms: voltage, capacity, charge/discharge, efficiency
- Battery ratings and specifications

Unit 2: Battery Operations and Applications *(10 hours)*

- Charging and discharging process
- Battery banks and their configuration (series/parallel)
- Applications in solar PV systems (off-grid & hybrid)
- Safe handling, Do's and Don’ts in battery usage

Unit 3: Maintenance, Safety & Emerging Trends *(10 hours)*

- Battery maintenance and troubleshooting
- Storage and disposal of used batteries
- Battery Management Systems (BMS) – basics
- Future technologies: Solid-state, flow batteries (overview only)

7. RE 361 MJP Practical Based on Battery Technologies

1. **Identify and Compare Different Types of Batteries (Lead-acid vs. Lithium-ion)**
2. **Measure Battery Voltage, Current, and State of Charge using Multimeter**
3. **Assemble a Small Battery Bank (Series and Parallel Connections)**
4. **Demonstrate Charging and Discharging of a Battery with Solar Panel Setup**
5. **Perform Basic Battery Maintenance and Record Safety Checklist**

8. RE 381 OJT

9. RE 391 MN Net Zero Energy Building Design Strategies

Learning Outcomes

1. **Student explains** the concept, goals, and national relevance of NZEBs, along with associated green building codes and energy policies.
2. **Student identifies** key design principles of NZEBs, including passive strategies and energy-efficient systems used in building planning.
3. **Student describes** the integration of rooftop solar PV and battery storage for meeting energy demands in NZEBs.
4. **Student analyzes** energy performance data and case studies to evaluate the effectiveness of NZEB strategies in real-world scenarios.

Unit 1: Introduction to NZEB *(10 hours)*

- What is NZEB? – Concept and goals
- Key components: Energy efficiency + Renewable energy
- Importance of NZEB in Indian context (climate, energy demand)

- National policies and green building codes (BEE, ECBC)

Unit 2: Design Principles of NZEB *(10 hours)*

- Site planning and building orientation
- Passive design strategies: day lighting, ventilation, insulation
- Energy-efficient systems: lighting, appliances, HVAC
- Introduction to energy modelling tools (overview only)

Unit 3: Renewable Integration & Performance *(10 hours)*

- Sizing and integrating rooftop solar PV
- Battery storage basics and energy backup
- Monitoring and optimizing energy use
- Case studies of NZEBs in India

Reference Books:

1. Torcellini, P., Pless, S., Deru, M., & Crawley, D. (2006). *Zero energy buildings: A critical look at the definition*. National Renewable Energy Laboratory.
2. Majumdar, M. (Ed.). (2002). *Energy-efficient buildings in India*. The Energy and Resources Institute (TERI).
3. Kwok, A. G., & Grondzik, W. T. (2018). *The green studio handbook: Environmental strategies for schematic design* (3rd ed.). Routledge.
4. Yudelson, J. (2008). *The green building revolution*. Island Press.

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10. RE 392 MNP Case Study (NZEB)

Case Study Title:

"Analysis of a Net Zero Energy Building in the Indian Climate: Design, Energy Systems, and Performance"

Suggested Focus Areas:

- Select a real or proposed NZEB OR local institutional buildings with green features
- Study building orientation, passive design elements
- Analyze integration of solar PV, lighting, HVAC, and energy efficiency
- Evaluate performance using simple tools or checklists

- Include suggestions for NZEB implementation in Pune's climate