B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VIII

OPERATION AND MAINTENANCE OF SOLAR ELECTRICSYSTEMS (Professional Elective)

Subject Code	15EE832	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

Credits - 03

Course objectives:

- To discuss basics of solar resource data, its acquisition and usage.
- To discuss PV technology, buying the PV modules and connecting the modules to form arrays.
- To discuss inverters, system components, cabling used to connect the components and mounting methods of the PV system.
- To explain site assessment, design process of the grid connected system and its sizing.
- To explain installation, commissioning, operation and maintenance of PV systems.
- To explain the types of financial incentives available, calculation of payback time. ■

Module-1	**Teaching Hours**
Solar Resource and Radiation: Solar resources, Quantifying solar radiation, The effect of the Earth's atmosphere on solar radiation, Sun geometry, Geometry for installing solar arrays. **PV Industry and Technology:**Semiconductor devices,Mainstream technologies,Monocrystalline silicon,Multicrystalline/polycrystalline silicon,Thin film solar cells,Contacts,Buying solar modules,Standards,Certifications,Warranties,Emerging technologies,Dye-sensitized solar cells,Sliver cells,Heterojunction with intrinsic thin layer (HIT) photovoltaic cells,III-V Semiconductors,Solar concentrators. **PV Cells, Modules and Arrays:**Characteristics of PV cells,Graphic representations of PV cell performance,Connecting PV cells to create a module,Specification sheets,Creating a string of modules,Creating an array,Photovoltaic array performance,Irradiance,Temperature,Shading.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying.	
Module-2	
Inverters and Other System Components: Introduction, Inverters,Battery inverters,Grid-interactive inverters,Transformers,Mainstream inverter technologies,String inverters,Multi-string inverter,Central inverter,Modular inverters,Inverter protection systems,Self-protection,Grid protection,Balance of system equipment: System equipment excluding the PV array and inverter,Cabling,PV combiner box,Module junction box,Circuit breakers and fuses,PV main disconnects/isolators,Lightning and surge protection,System monitoring,Metering,Net metering,Gross metering. Mounting Systems:Roof mounting systems,Pitched roof mounts,Pitched roof mounts for tiled roofs,Pitched roof mounts for metal roofs,Rack mounts,Direct mounts,Building-integrated systems,Ground mounting systems,Ground rack mounts,Pole mounts,Sun-tracking systems,Wind loading,Lightning protection.■	**08**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing.	
Module-3	
Site Assessment: Location of the PV array,Roof specifications,Is the site shade-free?,Solar Pathfinder,SolmetricSuneye,HORIcatcher,iPhone apps,Software packages,Available area,Portrait installation,Landscape installation,Energy efficiency initiatives,Health, safety and environment (HSE) risks,Local environment,Locating balance of system equipment,Site plan. **Designing Grid-connected PV Systems:**Design brief,Existing system evaluation,Choosing system components,Modules,Mounting structure,Inverters,Cabling,Voltage sizing,Current sizing,Monitoring,System protection,Over-current protection,Fault-current protection,Lightning and surge protection,Grounding/earthing,Mechanical protection,Array protection,Sub-array protection,Extra low voltage (ELV) segmentation. **Sizing a PV System:**Introduction, Matching voltage specifications,Calculating maximum voltage,Calculating minimum voltage,Calculating the minimum number of modules in a string,Calculating the maximum voltage,Calculating the maximum number of modules in a string,Calculating the	**08**

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SEMESTER - VIII

15EE832 OPERATION AND MAINTENANCE OF SOLAR ELECTRICSYSTEMS
(Professional Elective)(continued)

Module-3 (continued)		**Teaching Hours**
minimum voltage,Calculating the minimum number of modules in a string,Matching current specifications,Matching modules to the inverter's power rating,Losses in utility-interactive PV systems,Temperature of the PV module,Dirt and soiling,Manufacturer's tolerance,Shading,Orientation and module tilt angle,Voltage drop,Inverter efficiency,Calculating system yield.■		
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-4		
Installing Grid-connected PV Systems:PV array installation, DC wiring, Cabling routes and required lengths,Cable sizing, PV combiner box,System grounding/earthing, Inverter installation, Installation checklist,Interconnection with the utility grid,Required information for installation,Safety. **System Commissioning:**Introduction, Final inspection of system installation,Testing,Commissioning, System documentation. **System Operation and Maintenance:**System maintenance, PV array maintenance, Inverter maintenance, System integrity, Troubleshooting, Identifying the problem, Troubleshooting PV arrays, Troubleshooting underperforming systems,Troubleshooting inverters,Other common problems. ■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	
Module-5		
Marketing and Economics of Grid-connected PV Systems:Introduction, PV system costing,Valuing a PV system,Simple payback and financial incentives,Simple payback,Feed-in tariffs,Rebates,Tax incentives,Loans,Renewable portfolio standards and renewable energy certificates,Marketing,Insurance. **Case Studies:**Case studies A to G.■		**08**
Revised Bloom's Taxonomy Level	L_1 – Remembering, L_2 – Understanding.	

Course outcomes:

At the end of the course the student will be able to:

- Discuss basics of solar resource data, its acquisition and usage.
- Explain PV technology, buying the PV modules and connecting the modules to form arrays.
- Explain the use of inverters, other system components, cabling used to connect the components and mounting methods of the PV system.
- Assess the site for PV system installation.
- Design a grid connected system and compute its size.
- Explain installation, commissioning, operation and maintenance of PV systems.
- Explain the types of financial incentives available, calculation of payback time■

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem Analysis, Design/ Development of Solutions, Conduct investigations of complex problems, Modern Tool Usage, The Engineer and Society, Environment and Sustainability, Ethics, Individual and Team Work, Communication, Project Management and Finance, Life-long Learning.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.■

B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - VIII				
15EE832 OPERATION AND MAINTENANCE OF SOLAR ELECTRICSYSTEMS (Professional Elective)(continued)				
Textbook				
1	Grid-connected Solar Electric Systems, The Earthscan Expert Handbook for Planning, Design and Installation	Geoff Stapleton and Susan Neill	Earthscan	1st Edition, 2012