Government of Karnataka

DEPARTMENT OF COLLEGIATE AND TECHNICAL EDUCATION

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| **Program** | **Electrical & Electronics Engineering** | **Semester** | **5** |
| **Course Code** | **20EE53I** | **Type of Course L: T:P** | **Integrated 104:52:312** |
| **Specialization** | **Renewable Energy** | **Credits** | **24** |
| **CIE Marks** | **240** | **SEE Marks** | **160** |

**Introduction:**

Renewable energy provides reliable power supplies and fuel diversification, which enhance energy security, lower the risk of fuel spills, and reduce the need for imported fuels. Renewable energy also helps conserve the nation's natural resources. Renewable energy is a term for clean, sustainable energy that's derived from naturally regenerating sources. Using a combination of these natural sources and intelligent technology, we can generate enough heat and electricity for all our homes, businesses, and production needs. This specialisation course is taught in Boot camp mode. Boot camp are 12 weeks, of intense learning sessions designed to prepare the student for practical world – ready for either industry or becoming an entrepreneur. Students will be assisted through the course, with development-based assessments to enable progressive learning.

**Pre-requisite**

Before the start of this specialisation course, the students shall have prerequisite knowledge gained in the first two years on the following subjects:

1st year – Engineering Mathematics, computer Aided Engineering Graphics, Fundamentals of Electrical and Electronics Engineering and Basics of Electrical power system, Communication Skills, Statistics & Analysis, Basic IT Skills, Project Management skills and Residential wiring.

2nd year- Transformers and Alternators, Transmission and Distribution, Switchgear and Protection, Analog and Digital Electronics, Electrical motors, Power Electronics, Fundamentals of Automation Technology ,and Computer-Aided Electrical Drawing.

In the third year of study, student shall be applying previous years learning along with specialised field of study into projects and real-world applications.

**Course Cohort Owner**

A Course Cohort Owner is a faculty from the core discipline, who is fully responsible for one specialized field of study and the cohort of students who have chosen to study that specialised field of study.

**Guidelines for Cohort Owner**

1. Each Specialized field of study is restricted to a Cohort of 20 students which could include students from other relevant programs.

2. One faculty from the Core Discipline shall be the Cohort Owner, who for teaching and learning in allied disciplines can work with faculty from other disciplines or industry experts.
3. The course shall be delivered in boot camp mode spanning over 12 weeks of study, weekly developmental assessments and culminating in a mini capstone.
4. The industry session shall be addressed by industry subject experts (in contact mode/online / recorded video mode) in the discipline only.
5. The cohort owner shall be responsible to identify experts from the relevant field and organize industry sessions as per schedule.
6. Cohort owner shall plan and accompany the cohort for any industrial visits.
7. Cohort owner shall maintain and document industrial assignments, weekly assessments, practices and mini-project.
8. The cohort owner shall coordinate with faculties across programs needed for their course to ensure seamless delivery as per time table
9. The cohort owner along with classroom sessions can augment or use supplementally teaching and learning opportunities including good quality online courses available on platforms like Karnataka LMS, Infosys Springboard, NPTEL, Unacademy, SWAYAM, etc.

**Course outcome:**

*On successful completion of the course, the students will be able to:*

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| **CO1** | **Design and install a solar PV system.** |
| **CO2** | **Test, Commission, maintain, and monitor electrical and weather parameters for a solar PV system.** |
| **CO3** | **Install and test solar EV charging station.** |
| **CO4** | **Design and install small wind and biogas power plants.** |
| **CO5** | **Perform feasibility study to suggest appropriate sustainable energy and energy storage solutions for an educational institute/commercial building/industry.** |

**Detailed Course Plan**

| Week | CO | PO | Days | 1st session (9 am to 1 pm) | L | T | P | 2ND session (1.30 pm to4.30 pm) | L | T | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 5 | 1,5 | 1 | **Introduction to Renewable energy**<br>**Introduction to sustainability:**<br>-Meaning of sustainability<br>-Components of sustainability **Ref:1**<br><br>6Rs of sustainability<br>-Rethink, Refuse, Reduce, Reuse, Recycle, Repair<br>-Examples<br><br>-Seventeen Sustainable Development Goals?<br>**Ref:2**<br>-Video demonstration 6Rs of sustainability | 1 | | 3 | **Decarbonization :**<br>-How Does Decarbonisation Work?<br>-Why is Decarbonisation Important?<br>-How do we Decarbonise?<br><br>**NetZero:**<br>-Meaning of NetZero,<br>-Difference between NetZero and zero.<br>Video demonstration of decarbonisation<br><br>**Sustainability Carbon footprint calculator:**<br>**Ref:3**<br>-Calculate your family's carbon footprint and analyze | 1 | | 2 |
| | 5 | 1,5 | 2 | • **Sustainable Manufacturing for India's Low-Carbon Transition**<br>**Ref:4**<br>• **Power Positive**<br>**Ref:5**<br>• Video demonstration of Sustainable Manufacturing<br>• Video demonstration on Power Positive<br><br>**Agrovoltaics**<br>• Advantages and disadvantages of agrovoltaic energy<br>• Applications of agrovoltaics<br>• Benefits of agrovoltaics<br>**Ref:8**<br>Video demonstration agrovoltaic | 1 | | 3 | **Global Energy scenario**<br>**Indian Energy Scenario**, Energy Policy<br>• **Prepare table:** (All India): Installed capacity for thermal, hydro, nuclear, and Renewable energy sources.<br>• **Prepare table: (Karnataka)**: Installed capacity for thermal, hydro, nuclear, and Renewable. **Ref:6a**<br>• **Electricity Price & Availability**<br>**Ref: 6b**<br><br>**Renewable Energy Sources:** | 1 | | 2 |

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| | | | | | | | | • -Hydro<br>• -Solar<br>• -Wind<br>• -Biomass<br>• -Hydrogen<br>• -Geothermal<br>• -Ocean<br>The basic principle of working, its benefits and disadvantages.<br>• Video Demonstration of Renewable Energy technologies. | | | |
| | 1,5 | 3 | Design thinking<br>What is design thinking?<br>5 steps of Design Thinking.<br>**Ref.7a.b**<br>Why is design thinking so important?<br>**Ref.7c** | 1 | | 3 | Examples of design thinking<br>**Ref.7d,e,f** | | | 3 |
| | 1,5 | 4 | Applying Design Thinking to Sustainable Energy<br>**Ref.7.i** | 1 | | 3 | How can 'Design Thinking' help utilities prepare for a new energy future? **Ref.7.g**<br>Reinventing solar energy supply for rural Africa **Ref.7.h.** | 1 | | 2 |
| | | **5** | **Developmental Assessment** | - | - | | **Assessment Review and corrective action** | | | **3** |
| | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | |

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| **2** | 1 | 1,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | **Introduction to solar energy:**<br>• Solar Irradiance Concepts:<br>• DNI(Direct normal irradiance ).<br>• Global horizontal radiance (GHI),<br>• Diffuses horizontal radiation (DHI),<br>• Relation between GHI, DNI and DHI.<br>• Global Tilted Irradiance (GTI).<br>**Practice**<br>• Compass (Direction of solar panel)<br>• Calculation of tilt angle.<br>• Lumen meter or Lux meter<br>• Solar radiation measurement | 1 | | 2 |
| | 1 | 1,5 | 2 | **Understand Terminology used in the Solar Industry:**<br>• Photovoltaic (PV) cell<br>• Module<br>• Array<br>• Balance of system,<br>• Efficiency of solar panel<br>• Electrical (or electric or utility) grid<br>• Ground-mounted Solar<br>• Interconnection agreement<br>• Mounting hardware<br>• Net metering<br>• Operations and maintenance<br>• Solar batteries (or storage)<br>• Solar canopies<br>• Solar carports<br>• Solar dealer | 2 | | 2 | **Solar PV Systems**<br>• Identify and understand the working, advantages, and efficiency of different types of Solar PV Systems:<br>-**by configuration**- Stand-alone, grid-tied, grid interactive, and hybrid<br>-**by deployment**- Ground Mount, rooftop, Agro PV, Floating PV and BIPV (**Building-integrated photovoltaics**). **Ref:10**<br>-**by appearance** -Monocrystalline, polycrystalline, thin-film (amorphous), **Ref:12**<br>Bifacial modules<br>-Half-cut solar cell technology: working and advantages | 2 | | 1 |

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| | | | | • Solar design<br>• Solar installer<br>• Solar panel cleaning<br>• Solar power plant<br>• Thin-film solar<br>• Solar Tracker<br>**Ref:9**<br>-Demonstrate the Manufacturing of solar cells.<br>-Identify the different components of a Solar PV system and understand its basic operation | | | | - Current manufacturers of half-cut cells.<br>**Ref:11** | | | |
| | 1 | 2,4,5 | 3 | **Solar Panel**<br>• Standard size and weight of the solar panel<br>• Demonstrate different types of solar panels.<br>• Specification of solar panel<br>**Ref:13**<br>**Terms used in solar panel**<br>• Open Circuit Voltage (Voc).<br>• Short Circuit Current (Isc),<br>• Maximum Power Point (Pmax),<br>• Maximum Power Point Current (Impp),<br>• Nominal Voltage.<br>• Module efficiency<br>• Maximum operating voltage<br>• Maximum operating current<br>• Maximum system Voltage<br>• Maximum series fuse rating<br>**-Interpretation of datasheet of PV module.**<br>**Ref:14** | 1 | | 3 | **Solar Panel sizing**<br>Sizing of a solar panel for an application<br>**Ref:15**<br>-Test a given solar panel<br>**Ref:15c** | | | 3 |
| | 1 | 1,2,5 | 4 | **Solar Batteries**<br>**Types of solar batteries:**<br>-Aadvantages, disadvantages, and applications.<br>• Lead-acid batteries<br>• Nickel cadmium batteries | 2 | | 2 | **Solar Batteries**<br>• Battery Sizing Calculation:<br>**Ref:19**<br>• Battery sizing guidelines<br>**Ref:20** | | | 3 |

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| | | | | • Flow batteries<br>• Lithium-ion batteries<br>**C- and E- rates:**<br>**Ref:16**<br>**Technical specification of batteries:**<br>• Nominal Voltage (V)<br>• Cut-off Voltage<br>• Capacity or Nominal Capacity (Ah for a specific C-rate)<br>• Energy or Nominal Energy (Wh (for a specific C-rate))<br>• Cycle Life (a number for a specific DOD)<br>• Specific Energy (Wh/kg)<br>• Specific Power (W/kg)<br>• Energy Density (Wh/L)<br>• Power Density (W/L)<br>• Maximum Continuous Discharge Current<br>• Maximum 30-sec Discharge Pulse Current<br>• Charge Voltage<br>• Float Voltage<br>• Charge Current<br>• Internal Resistance<br>• Battery Condition:<br>• State of Charge (SOC)(%)<br>• Depth of Discharge (DOD) (%)<br>• Terminal Voltage (V)<br>• Open-circuit voltage (V)<br>• Internal Resistance<br>**Ref:17**<br>Select a suitable battery for a given application:<br>**Ref:18** | | | | • Test the condition of the given battery | | | |
| | 1 | | **5** | **Developmental Assessment** | - | - | | **Assessment Review and corrective action** | | | **3** |

| | | | 6 | Industry Class + Assignment | 2 | | 3 | | | | |
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| **Week** | **CO** | **PO** | **Days** | **1st session (9 am to 1 pm)** | **L** | **T** | **P** | **2ND session (1.30 pm to4.30 pm)** | **L** | **T** | **P** |
| 3 | 1 | 2,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | **Solar panel in simulation**<br>• How to use solar panels in simulation **Ref:21**<br>• Simulation of Solar power generation for home using any software **Ref:22** | | | 3 |
| | 1 | 2,4,5 | 2 | **Charge controllers:**<br>• Types of charge controllers: PWM charge controller and MPPT<br>• Sizing of PWM and MPPT charge controller<br>• Efficiency of PWM and MPPT charge controller<br>• Specifications of PWM and MPTT charge controller.<br>**Ref:23** | 2 | | 2 | **Charge Controllers**<br>• Identification and testing of Charge controllers. **Ref:23**<br>• Connect the charge controller (12V, 10A) with a Solar battery (12V, 100Ah), Solar panel (75,W) and DC load and test.<br>**Power Optimizer**<br>**Ref:24**<br>• Demonstrate Power Optimizer installation and operation<br>• Specification | | | 3 |
| | 1 | 2,5 | 3 | **Connectors used in Solar module**<br>**-MC4 connector:**<br>**Ref:25**<br>• Wiring MC4 Equipped Modules in Series.<br>• Wiring MC4 Equipped Modules in Parallel.<br>-MC4 Connector Specifications:<br>**Ref:26**<br>-Solar branch connectors<br>**Ref:27** | 1 | | 3 | **Wires and Cables**<br>**Types of DC wire used in solar panels**<br>• PV wire<br>• USE-2<br>**Sizing of DC cable**<br>**Ref:28**<br>• Cable size between MPPT Controller and battery. | 1 | | 2 |

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| | | | | | | | • Selection of the current carrying capacity of PV string cables.<br>• Selection of the current carrying capacity of PV array cables.<br>• Determining Cable Sizes in an Off-grid PV.<br>**Ref:28** | | | |
| 1 | 1,2,4,5 | 4 | **Solar Inverters**<br>**Types of solar inverters**<br>• Centralized inverters<br>• String inverters<br>• Micro inverters<br>• Inverter Architecture Choice<br>**Ref:29**<br>-Specification of different types of Inverters<br>-Demonstration of working of different types of Inverters<br>**Grid-Tied Solar String Inverters**<br>-Specifications<br>**Sizing of solar inverter**<br>• Size a solar inverter for a given application<br>**Ref:29**<br>• Selection of inverter for a given solar application **Ref:29**<br>• Solar PCU<br>• Specification of solar PCU 1kW/24V,1kW/48V,2kW/48V,3kW/48V<br>**Ref:29** | 2 | | 2 | **Mounting of Solar Panels**<br>• Understand the different types, sizes, and specifications of foundations/ footings<br>• Identify the need of mounting structures<br>• Different types of mounting systems<br>• Advantages and disadvantages of the different mount structure.<br>**Ref:30**<br>**Selection of right footing/foundation**<br>• Select the right footing/foundation as per site location including suitability of roof condition or suitability of soil<br>• Practice on mounting structures | 1 | | 2 |
| | | **5** | **CIE 1– Written and practice test** | - | - | - | **Assessment Review and corrective action** | | | 3 |
| | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | |

| Week | CO | PO | Days | 1st session (9am to 1 pm) | L | T | P | 2ND session (1.30pm to 4.30pm) | L | T | P |
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| 4 | 1 | 2,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | **Design of off-grid rooftop PV System for a residence/commercial building**<br>• Calculate monthly load and the energy consumption of your home from the electricity bill.<br>• Calculate the requirement of total units/day for your home. Estimate the size of the PV system. **Ref:31** | | | 3 |
| | | 3,5 | 2 | **Design of off-grid rooftop PV System for a residence/commercial building**<br>Perform a site survey at rooftop area and prepare feasibility report including<br>• Inspection of field, Selection of site, Shadow analysis.<br>• Types of roofs, Weather monitoring. Solar path finder and sun path diagram.<br>• Wind Load conditions on Solar PV Panels like Wind Speed, Height of Panel above roof and Relative Location of Panels on roof.<br>• Create a rough layout of the rooms showing existing Grid meter line, MCB, nearest shaded & dry place for a solar PCU and place for panels.<br>• Prepare a layout of roof showing open areas and occupied areas and mark obstructions that can cause shadows. Take site photographs.<br>• Mark locations for components of solar PV electrical system on site. | 1 | | 3 | • Selection of suitable PV system (standalone DC system/ standalone AC system/Grid tied PV system/Hybrid system )<br>based on<br>Load requirements –<br>• AC/DC<br>• Budget<br>• Existing form of supply<br>System design :<br>• Module sizing and selection<br>• Battery sizing- Size the batteries and system voltage for the estimated PV system according to the required backup<br>• Size the charge controller for estimated battery system<br>• Select inverter, cable and conduit to match PV array:<br>• Sizing of inverters needed; | 1 | | 2 |

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| | | | | Data to be collected during site survey :<br>• Existing load and existing form of power supply.<br>• Location for placement of panel, battery, charge controller or PCU.<br>• Wire length from panel to battery and battery to load.<br>• Picture of site.<br>• Lay out of rooms, room type and floors.<br>• Available shadow free area.<br>Measuring instruments required for site survey :<br>• Digital multimeter<br>• Compass<br>• AC/DC clamp meter<br>• Digital Luxmeter<br>• Power Guard meter | | | | • Size and select the cable and conduit.<br>• Select suitable Module mounting structure for the above PV system<br>• Select suitable protective devices.<br>• Select the other miscellaneous system components<br>(Apply design thinking process ) | | | |
| | 1 | 3,5 | 3 | **Design of off-grid rooftop PV System for a residence continued...**<br>• Prepare bill of material for above solar PV system and estimate the cost of installation.<br>• Calculate Payback period<br>• Calculate Carbon footprint<br>**Introduction to solar PV design software**<br>• Design a PV system for the above residential/commercial building using any PV design software. | | | 4 | Design 100 KW solar PV system and estimate cost of installation and prepare a quotation, manually /PV design software.<br>• Calculate Payback period<br>• Calculate Carbon footprint<br>**Ref:32**<br><br>(Apply design thinking process ) | | | 3 |
| | 1 | 4,5 | 4 | **Design and implement solar pumping system Ref:42a** | 1 | | 3 | **Design and implement solar Street Light system Ref:39** | 1 | | 2 |

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| | | | | Design a PV system to operate a flour mill. **Ref:42b** | | | | (Apply design thinking process ) | | | |
| | 1 | | **5** | **Developmental Assessment** | - | - | | **Assessment Review and corrective action** | | | **3** |
| | | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | |
| **Week** | **CO** | **PO** | **Days** | **1st session (9am to 1 pm)** | **L** | **T** | **P** | **2ND session (1.30pm to 4.30pm)** | **L** | **T** | **P** |
| **5** | 2 | 1,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | Simulate PV MPPT **Ref:33** | 3 | | |
| | 2 | 4,5 | 2 | Simulate 3MW grid connected by PV system **Ref:34** | | | 4 | **Perform various measurements and tests pertaining to PV Modules and their installation as per IEC standards.**<br>• Performance standards IEC 62125/61646 (Diagnostic, Electrical, Performance, Thermal, Irradiance, Environmental, Mechanical)<br>• IEC 61215<br>• Safety Standards IEC 61730-1,2 (Electrical Hazards, Mechanical Hazards, Thermal Hazards, Fire Hazards) | 1 | | 2 |
| | 2 | 4,5 | 3 | Preparation for Installation<br>Measuring instrument required at the site:<br>• Digital multimeter<br>• AC/DC clamp meter<br>• Hydrometer<br>Tools used for installation<br>• Wire strippers<br>• Wire climpers<br>• Wire pliers<br>• Screw drivers<br>• Spanners<br>• Socket wrench | 1 | | 3 | Installing of PV components:<br>• Correct connection of batteries.<br>• Ventilation for batteries<br>• Connecting charge controller to battery ,panel and DC loads<br>• Connect solar power conditioning unit to battery bank<br>• Connect solar PCU to solar panel | | | 3 |

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| | | | | • Tester<br>• Hammer<br>• Drilling machine and drill bit<br>• Hacksaw blade<br><br>Safety precautions:<br>Potential risks :<br>• DC side wiring<br>• AC side wiring<br>• Battery<br>• Personal safety<br><br>Installation of Solar panel<br>• Steps for orienting of panels<br>Constructing the mounting structure<br>• Identifying the footing<br>• Types of footing<br>• Construction of mounting<br><br>Panel wiring :<br>• Difference between AC and DC wiring<br>• Earthing of panels<br>• Blocking and bypass diodes | | | | • Connect solar PCU to AC loads | | | |
| | 2 | 4,5 | 4 | **Installation and commissioning of Solar PV plant**<br>Wire the AC mains connection to the Solar PCU (Do not switch 'ON').<br>• Prepare a Checklist for finding out errors during above installation.<br>• Check as per the checklist and prepare a clearance certificate before commissioning.<br>• Perform Procedural first switch ON, observe No load test results and record. | | | 4 | **Testing of PV Modules**<br>• Carry out visual inspection of PV modules.<br>• Measure Insulation resistance and Wet Leakage Current of PV<br>Modules.<br>**Ref:35**<br>• Verify system grounding and measure insulation resistance. | | | 3 |

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| | | | | Perform 'ON Load' test, progressively add load till full load and record observation. Perform Overload test and record observation<br>• Prepare a First inspection report on the solar plant installation.<br>• Prepare a list of Do's and<br>• Don'ts in the installation<br>• Prepare a report on Customer orientation<br>• Prepare a report on Visible and audio annunciations, alarms or alerts in a solar PCU.<br>• Perform shutting down procedure of the above solar plant<br>**Prepare a report on Customer orientation**<br>• Prepare a report on visible and audio annunciations, alarms or alerts in a solar PCU.<br>Perform shutting down procedure of the above solar plant. | | | | • Perform Bypass Diode test - Pmax at STC and Pmax at low irradiance.<br>• -check continuity of the system and verify polarity.<br>• Measure Ground Continuity, Impulse Voltage, Reverse current and partial Discharge.<br>• Practice to undertake precautions against Module breakage.<br>• Demonstrate hot-spot on modules through audio visual aids.<br>**Ref:36**<br>• Measure DC voltages and currents for each string and array for proper operation of the system.<br>• Verify inverter operation including anti-islanding performance and measure AC system values. | | | |
| | 2 | | **5** | **CIE 2– Written and practice test** | - | - | - | **Assessment Review and corrective action** | | | | 3 |
| | | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | | |

| Week | CO | PO | Days | 1st session (9am to 1 pm) | L | T | P | 2ND session (1.30pm to 4.30pm) | L | T | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 2 | 4,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | **Maintain Solar Photovoltaic System**<br>• SOP (Standard Operation Procedures) of PV system.<br>• Types of Maintenance | | | 3 |

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| | | | | | | | | (Preventive/Corrective/Condition Based).<br>• Electrical maintenance /Solar Panel maintenance/ Battery maintenance/ Charge Controller Maintenance.<br>• Maintenance record | | | |
| | 2 | 4,5 | 2 | **Maintain Solar Photovoltaic System Continued.**<br>• Demonstrate Standard Operating Procedures of PV system.<br>• Demonstration of Solar Panel Maintenance: - Cleaning,<br>• Precautions While Cleaning<br>DC Array Inspection **Ref:37** | | | 4 | **Maintain Solar Photovoltaic System Continued.**<br>Demonstrate Electrical Maintenance of Inverters/Cables/Junction Boxes, Fault Indications of Inverters/PCU. | | | 3 |
| | 2 | 2,3 | 3 | **Maintain Solar Photovoltaic System Continued.**<br>• Demonstration of Battery Maintenance- Checking of Electrolyte Level, Specific Gravity Using Hydrometer, Physical Damage, Terminal Voltage, Cleaning of Battery Terminals. | | | 4 | **Maintain Solar Photovoltaic System**<br>• Inspection of Mounting Structure of Solar modules<br>Procedure for replacement of defective Fixtures. | | | 3 |
| | 2 | 4,5 | 4 | **Case Studies on solar PV plants**<br>Case study on 1MW PV solar system<br>**Ref:38**<br>Case study of 2GW solar power plant at Pavagada solar park<br>**Ref:40**<br>**Power Evacuation Scheme**<br>**-Allocation to ESCOMS from solar park**<br>**Ref:41** | | | 4 | **Solar Policies**<br>• Central MNRE Solar policies (National Solar Mission, target 2030)<br>• State Solar and rooftop Policies, Solar Financing<br>• Economic Analysis of a Photovoltaic System: Energy economics basic concepts, unit cost of power generation from solar PV | 3 | | |

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| | | | | | | | • Payback period, LCC(life cycle costing) and benefit cost analysis. | | | |
| | 2 | | **5** | **Developmental Assessment** | - | - | | **Assessment Review and corrective action** | | **3** |
| | | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | |
| **7** | 2 | 1,5 | 1 | **Peer discussion on Industrial assignment.** | | **4** | | **Introduction to SCADA:**<br>• What is SCADA?<br>• SCADA SYSTEMS<br>• Evolution of SCADA<br>• Objective of SCADA.<br>• Benefits of SCADA<br>• Functions of SCADA:<br>• SCADA APPLCIATIONS<br>• Real-Time Monitoring and Control using SCADA<br>**Ref:43** | 2 | | 1 |
| | 2 | 1,5 | 2 | **SCADA HARDWARE:**<br>• SCADA Hardware Functions,<br>• Remote Terminal Units (RTU): RTU Hardware: A typical single board RTU.<br>• Hardware functionality in an RTU, RTU Software functions<br>• Basic operation: RTU Standards.<br>• Difference between PLC and RTU<br>• Features of SCADA<br>**Ref:43**<br>• Intelligent Electronic Devices (IEDs) | 2 | | 2 | **SOFTWARE AND PROTOCOLS.**<br>• ISO MODEL,<br>• DNP3 Protocol: Important Features of DNP3.<br>• IEC60870 PROTOCOL<br>The two widely used protocols for SCADA Applications :<br>• HDLC (High Level Data Link Control)<br>• MODBUS<br>The widely used open software for SCADA systems :<br>• Citect and Wonder ware.<br>**Ref:43** | 2 | | 1 |
| | 2 | 4,5 | 3 | **Solar energy SCADA system**<br>• Monitor inverter data | | | 4 | **Solar energy SCADA system**<br>**Weather monitoring station**<br>Monitor radiation | | | 3 |

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| | | | | • Monitor power generation plant, sub plant and string level<br>**Ref:44** | | | | • Ambient temperature<br>• Humidity<br>**Ref:44** | | | | | |
| | | 4,5 | 4 | **Solar energy SCADA system**<br>• HT panel Incomer Relay data, Outgoing relay data,<br>Incomer MFM's and Annunciator alarms and trip status. | | | 4 | FIELD VISIT | | | | | 3 |
| | 2 | | **5** | **CIE 3– Written and practice test** | - | - | - | **Assessment Review and corrective action** | | | | | 3 |
| | | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | | | |
| 8 | 3 | 1,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | Necessity of Renewable Sources of Electricity to charge Electric Vehicles?<br>**Ref:49**<br><br>**Key Terminologies used in the EV Ecosystem:**<br>• Electric Vehicle (EV)<br>• Battery Electric Vehicle (BEV)<br>• Hybrid Electric Vehicle (HEV)<br>• Plug-in Hybrid Electric Vehicle (PHEV)<br>• Charging Station/ Electric vehicle Charging Station (EVCS)<br>• Charging Point/ Electric Vehicle Supply Equipment (EVSE)<br>• Charging Pool, Connector<br>• Charge Point Operator (CPO).<br>-Types of Electric vehicle,<br>types of Engines<br>-Stakeholders in EV Ecosystem<br>**Ref:50** | | 2 | | 1 |

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| | 3 | 1,4,5 | 2 | **Charging technologies for Electric Vehicles:**<br>• Classification of EV charging technologies<br>• EV charging infrastructure classification<br><br>**Conductive (Plug-in/Wired) charging:**<br><br>• Modes of Charging (IEC 61851 standard)<br>• Charging levels as per IEC 62196, IEC 61851 and SAE J1772<br>• Comparison between charging levels<br>• Demonstrate (Video/physical) different EV charging technologies<br>• Demonstrate (Video/physical) different modes of charging<br>**Ref:50**<br>-Necessity of Power Converters for Charging Electric Cars from PV and wind? **Ref:51** | 2 | | 2 | **Technical Details of EV charger:**<br>• Electric Vehicle battery charger components.<br>• Block diagram of on-board EV charger,<br>• Demonstrate (Video/ physical) of EV charger components<br>• Identify different EV charger components<br>**Ref:50**<br>• Charging: Level 1, Level 2 and Level 3 charging<br>**Level 3 charging:**<br>• Block diagram of DC charging station.<br>• Communication and power flow between EV and EVSE:<br>• DC charging station AC/DC converter and control<br>• DC charging station DC/DC converter and control<br>**Ref:50** | 1 | | 2 |
| | 3 | 1,4,5 | 3 | **-Charging speed**<br>**-Connector Types**<br>• Type 1/Yazaki (SAE J1772, IEC 62196-1)<br>• Type 2 (IEC 62196-2)<br>• Combined Charging System (CCS 1)<br>• CHAdeMO<br>• Combined Charging System (CCS 2)<br>• GB/T DC Charger<br>• Tesla Supercharger<br>• Selection of charger for given vehicle type, power rating and voltage<br>**Ref 52** | 2 | | 2 | **Solar charging stations for electric vehicles (EV's)**<br>• On-Grid solar charging stations<br>• Off-Grid Solar charging station<br>• Components needed for a solar charging station **Ref:53**<br>How Many Solar Panels Does It Take to Charge an Electric Car?<br>**Ref:54** | 2 | | 1 |

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| | | | | • Identify different EV charging connectors.<br>**The Indian standards of charging connectors derived from the international standards**<br>• Bharat AC-001<br>• Bharat DC 001<br>• Selection of DC charger connector GB/T, CHAdeMO, CCS-1 and CSS-2<br>• Selection sizing of Charger connector cable | | | | Tesla Model 3 Charging Costs: Solar vs. Utility<br>**Ref:55**<br>• Demonstrate solar charging stations | | | |
| | 5 | 4,5 | 4 | • **Installing a Solar At-Home EV Charger**<br>**Ref 56**<br>• **Install and Test solar powered EV charging station**<br>Solar powered EV charging station<br>**Ref 59**<br><br>SRTPV powered charging station<br>**Ref 57** | 1 | | 3 | • Advantages of utilizing RE sources for EV charging.<br>• Cost comparative analysis of RE based charging stations.<br>**Ref:50**<br>• Utilization of EVs for better RE Grid Integration<br>**Ref 58** | 1 | | 2 |
| | | | **5** | **Developmental Assessment** | **-** | **-** | **-** | **Assessment Review and corrective action** | | | 3 |
| | | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | |

| **Week** | **CO** | **PO** | **Days** | **1st session (9am to 1 pm)** | **L** | **T** | **P** | **2ND session (1.30pm to 4.30pm)** | **L** | **T** | **P** |
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| 9 | 4 | 1,4,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | **Wind Energy Resources**:<br>• Types of wind, wind profiling, turbulence, hill, and tunnel effect.<br>• Demonstrate **Wind energy resources**: Types of wind, wind profiling, turbulence, and hill and tunnel effect.<br>• Measure wind speed at different time period during day using | 1 | | 2 |

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| | | | | | | | | anemometer and calculate wind pattern factor.<br>• Energy in the wind, energy production and simple problems<br>• Energy and Power, Energy Pattern factor, simple problems | | | |
| | 4 | 1,5 | 2 | **Wind Power Plant**<br>• Classification of wind power plant<br>• Wind turbine classes.<br>**Study of parts of Wind power plant:**<br>• Rotor nacelle, tower,<br>• High speed and low speed shafts,<br>• Gear box,<br>• Generator,<br>• Sensors and yaw drive,<br>• Power regulation and controlling units,<br>• Safety systems.<br>• Demonstrate working operation of each component of WPP | 3 | | 1 | **Wind Power Plant**<br>**Wind energy conversion:**<br>• Introduction<br>• Rotating principle.<br>• Drag and lift principle<br>• Force on rotor blade<br>• Factors affecting performance of rotor<br>• Simple problems<br>**Overview of Wind turbine Aerodynamics:**<br>• Aerodynamic power regulation<br>• Stall controlled WPP<br>• Pitch controlled WPP<br>• Active controlled WPP<br>• Halting a WPP | 2 | | 1 |
| | 4 | 1,3,5 | 3 | **Wind turbine generators:**<br>• Limited variable speed generator Type1<br>• Limited variable speed generator Type2<br>• Variable Speed with Partial Power Electronics conversion Type 3<br>• Variable Speed with Full Power Electronics Conversion Type4<br>• Demonstrate working and operation of each Wind turbine generators | 3 | | 1 | **Small Wind Turbines:**<br>• Introduction<br>• Small Wind Turbine Topologies<br>• Need of SWT, SWT classification<br>• Off-Grid SWT<br>• On-grid SWT<br>• Applications of SWT | 1 | | 2 |

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| | | | | **Ref:45** | | | | **Ref:46**<br>• Design considerations of small wind turbine<br>• Technical specification of small wind turbine<br>• Design a 1kw small wind turbine | | | |
| | 4 | 3,5 | 4 | • Estimate cost of a 1 KW horizontal/vertical wind turbine and<br>• Prepare a quotation<br>• Simulate Wind power plant model<br>**Ref:47** | 1 | | 3 | Perform a site survey at your location and prepare a feasibility report including<br>• Area availability<br>• Wind speed assessment<br>• wind profiling<br>• Demonstrate working of Traffic powered wind turbines **Ref:48**<br>• Case studies on wind turbine | | | 3 |
| | 4 | | **5** | **CIE 4– Written and practice test** | - | - | | **Assessment Review and corrective action** | | | **3** |
| | | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | |
| **10** | 4 | 1,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | **BIO ENERGY**<br>• Bio mass as fuel for power generation<br>• Technological options to generate electricity by using biomass as fuel.<br>• Combustion<br>• Gasification<br>• Demonstration (Video/physical) of Bioenergy technologies. | 2 | | 1 |

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| | | | | | | | | • Biomass based power plants Installed in Karnataka | | | |
| | 4 | 1,4,5 | 2 | **Biomass feedstock**<br>• Agri and forest residues.<br>• Industrial and domestic waste.<br>• Food and food processing.<br>• Waste, energy crops.<br>• Sewage water and landfills.<br>• Potential of Biomass: Energy (calorific value /hectare)<br>• Relation between calorific value and efficiency<br>• Biomass availability in Karnataka<br>**Ref 60**<br>Demonstration on Biomass feedstock<br>Case study on biomass energy<br>**Ref 60b** | 2 | | 2 | • Biogas- Benefits of Biogas, Biogas Feedstock,<br>• Technology of Bio-gas production.<br>• Biogas plant components, types of biogas digesters and plants.<br>Municipal Waste based Bio -gas plants- working, Advantages and disadvantages<br>• Size and Site Selection for Biogas plant<br>**Ref 61**<br>• Construct a simple model of 10kg waste biogas plant in your campus. (from the waste available in campus only) | 1 | | 2 |
| | 4 | 1,4,5 | 3 | **Biofuels: Classification by generation**<br>• Bioethanol<br>• Biodiesel<br>• sustainable aviation fuel (SAF)<br>**Renewable Natural Gas**<br>• Renewable compressed natural gas (R-CNG)<br>• Liquified renewable natural gas (bio-LNG)<br>**Bioethanol**<br>• Production | 2 | | 2 | • Extraction of oil form algal biomass for biodiesel Production<br>**Ref 62**<br>• Algal biofuel from urban wastewater in India :<br>**Ref 68**<br>• The Algae House: Generating Energy | 1 | | 2 |

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| | | | | • Application<br>Demonstrate production of Bioethanol<br>**Ref 63**<br>**Renewable Natural Gas**<br>• Production<br>• Application<br>**Ref 64**<br>**sustainable aviation fuel (SAF)**<br>• Production of SAF<br>• Importance of SAF<br>• Saving of Carbon using SAF<br>**Ref 65**<br><br>**Biodiesel :**<br>• Production<br>• Application<br>Demonstrate production of Biodiesel :<br>**Ref 66**<br>**Algal biodiesel:** the next generation biofuel for India<br>• Algal biomass production in tubular photobioreactor<br>• Innovative Approaches for improving algal biomass Yield<br>**Ref 67** | | | | from Living Algae on its Façade<br>**Ref 69**<br>• Scope of IS 15607: Is standard for Biofuels<br>**Ref 70** | | | |
| | 5 | 2,5 | 4 | **Feasibility study for a Biodiesel plant**<br>**Ref:70** | | | 4 | Design of 15 kW Micro Hydro Power Plant for Rural Electrification<br>**Ref:71**<br>(Apply design thinking process ) | | | 3 |
| | | | **5** | **Developmental Assessment** | - | - | | **Assessment Review and corrective action** | | | **3** |
| | | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | |

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| **11** | 5 | 1,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | **Introduction to Hydrogen Energy**<br>Hydrogen Production:<br>Types of Electrolysers<br>• Alkaline Electrolyser Polymer electrolyte membrane **Ref 78**<br>• Working of Solid oxide Electrolyser **Ref 78**<br>• Specification of Solid oxide Electrolyzer.<br>Color-coding of hydrogen based on the source of production **Ref 78**<br>Demonstration of (video ) various hydrogen production methods. | 2 | | 1 |
| | 5 | 1,4,5 | 2 | • Hydrogen storage<br>• Hydrogen Transportation<br>• Production of Blue and Green Hydrogen<br>• Hydrogen End Use<br>• cost of Hydrogen production **Ref 72**<br>• Demonstration of (video) hydrogen storage and transport | 2 | | 2 | • Hydrogen Generation by Anaerobic Digestion of Biomass.<br>• Demonstrate Hydrogen Generation by Anaerobic Digestion of Biomass. **Ref 73**<br>• Generating green hydrogen from biomass **Ref 79** | 2 | | 3 |
| | 5 | 1,5 | 3 | • Utilization of Hydrogen gas<br>• Hydrogen as Alternate fuel for motor vehicles | 2 | | 2 | **Design and simulate Fuel cell to produce power. Ref 76a.** | | | 2 |

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| | | | | **Fuel cells**<br>• Types of fuel cells<br>• Characteristics of fuel cells<br>• Comparison among different fuel cells.<br>**Ref:86**<br>Hydrogen fuel cell<br>• Working of hydrogen Fuel cell (Proton exchange membrane fuel cell )<br>**Ref:87**<br><br>**Fuel Cell Electric Vehicle**<br>• Working of hydrogen engine **Ref 74**<br>• The pros and cons of hydrogen-powered cars for users<br>**Ref 75**<br>• Hydrogen fuel cell cars: what you need to know<br><br>• **Hydrogen Fuel Cell Bus**<br>**Ref 76**<br><br>**India's first Hydrogen fuel cell bus.**<br>**Ref 88a**<br>**Hydrogen powered Two wheeler.**<br>**Ref 88b**<br>**Application of fuel cell in Un manned Aircraft(UAV)**<br>• 600U HYDROGEN FUEL CELL<br>• 1200U HYDROGEN FUEL CELL<br>**Ref 89**<br>Hydrogen Trains **Ref 90**<br>Safety and management<br>• Causes of fires and preventive management.<br>• Demonstrate the preventive management. | | | | | | | |

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| | 5 | 1,5 | 4 | • Specification of Electrolyzer and Fuel Cell<br>• Test and Trouble shoot a Fuel cell<br>**Ref :76b**<br>• **Run a Small DC motor using Hydrogen fuel Cell.**<br>**Ref 91** | | | 4 | **Hydrogen Technology Development in India**<br>• Hydrogen initiatives of the ministry of petroleum & natural gas<br>**Ref 77a**<br>• A Green Hydrogen Economy for India:<br>**Ref 77 b**<br>**-Demonstration of Hydrogen Technology in India**<br>• The Future of Hydrogen in India<br>• Current cost economics of green hydrogen production in India<br>• Future Price Trajectory of Green Hydrogen<br>• Most optimistic green hydrogen price trajectory<br>**Ref77c** | 1 | | 2 |
| | 5 | | **5** | **CIE 5– Written and practice test** | - | - | - | **Assessment Review and corrective action** | | | | 3 |
| | | | **6** | **Industry Class + Assignment** | **2** | | 3 | | | | | |
| **12** | 5 | 1,5 | 1 | **Peer discussion on Industrial assignment.** | | 4 | | **Concept of energy storage**<br>• Classification of Storage Technologies.<br>• Different Technologies for Different Purposes.<br>• Comparison of Power Output (in watts) and Energy Consumption | 2 | | | 1 |

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| | | | | | | | | (in watt-hours) for Various Energy Storage Technologies<br>• Differentiating Characteristics of different Battery Technologies<br>• Present and Future Battery Technologies.<br>• Discharge Time and Energy-to-Power Ratio of Different Battery Technologies<br>**Ref 80**<br>• Demonstration of Different storage Technologies for Different Purposes. | | | |
| | 5 | 1,5 | 2 | • Components of a battery energy storage system (BESS)<br>• Schematic of a Utility-Scale Energy Storage System.<br>• Grid applications of battery energy storage systems.<br>• Technical requirements:<br>• Round-Trip Efficiency<br>• Response Time<br>• Lifetime and Cycling<br>• Sizing<br>• Frequency Regulation | 2 | | 2 | **Renewable Energy integration:**<br>• Solar Photovoltaic Installation with a Storage System.<br>• Wind-power generation.<br>Peak Shaving and Load Leveling:<br>• Use of Energy Storage Systems for Peak Shaving<br>• Use of Energy Storage Systems for Load Leveling<br>Challenges of reducing carbon emissions: | 2 | | 1 |

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| | | | | | | | | • Energy Storage Services and Emission Reduction<br>**Ref 81** | | | |
| | 5 | 1,4,5 | 3 | • Gravity energy storage Characteristics<br>**Ref 82**<br>• Demonstrate Gravity energy storage<br>**Battery recycling and re-use risks:**<br>• Examples of Battery Reuse and Recycling<br>• Reuse of Electric Vehicle Batteries for Energy Storage<br>**Ref 83**<br>• Demonstrate Reuse of Electric Vehicle Batteries for Energy Storage | 2 | | 2 | **Micro-grids**<br>• What are micro-grids<br>• Need for micro-grid<br>• Benefits of micro-grids<br>**Ref 84**<br>• Micro-grid projects in India<br>Green Hydrogen Microgrid Project<br>**Ref 84b**<br>• Micro-grid projects in Karnataka<br>• Simulation of small scale micro grid<br>**Ref 85** | 1 | | 2 |
| | 5 | 3,4,5 | 4 | Perform feasibility study to suggest appropriate sustainable energy and energy storage solutions for an educational institute/commercial building/industry. -1 | | | 4 | Perform feasibility study to suggest appropriate sustainable energy and energy storage solutions for an educational institute/commercial building/industry. -2 | | | 3 |
| | | | **5** | **Developmental Assessment** | - | - | | **Assessment Review and corrective action** | | | **3** |
| | | | **6** | **Industry Class + Assignment** | **2** | | **3** | | | | |

| **Week** | **C O** | **P O** | **Days** | **1st session (9am to 1 pm)** | **L** | **T** | **P** | **2ND session (1.30pm to 4.30pm)** | **L** | **T** | **P** |
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| **13** | 1,2,3,4,5 | 2,3,4,5 | | **Internship**<br>a) Secondary research on various industries and their operations to identify at least 3 companies along with the areas of work | | | 4 | **Project**<br>a) Identification of the problem statement (from at least 3 known | | | 3 |

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| | | | | interest and develop an internship plan that clearly highlights expectations from the industry during the internship.<br>b) Design and develop a cover letter for an internship request to all 3 identified companies and the resume to be submitted to potential companies.<br>c) Prepare for an internship interview to highlight your interests, areas of study, career aspirations and personnel competence – including the areas of learning you expect to learn during internship | | | | problems) the students would like to work as part of the project – either as provided by faculty or as identified by the student. Document the impact the project will have from a technical, social and business perspective.<br>b) Design and develop the project solution or methodology to be used to solve at least one of the problems identified.<br>Prepare a project plan that will include a schedule, WBS, Budget and known risks along with strategies to mitigate them to ensure the project achieves the desired outcome. | | | |

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| Sl No | Description | |
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| 48 | Demonstrate working of Traffic powered wind turbines | a. https://www.goodnewsnetwork.org/onshore-wind-turbines-powered-by-traffic/<br>b. https://www.shell.com/inside-energy/turbine-turns-traffic-into-energy.html<br>c. https://highways.today/2020/04/09/highway-wind-turbines/<br>d. https://www.euronews.com/green/2021/11/04/turning-traffic-into-clean-energy-how-this-startup-plans-to-power-the-streets-of-istanbul<br>e.www.osti.gov › biblio › 1225476-small-wind-site |
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| 50 | Technical Details of EV charger | https://e-amrit.niti.gov.in/assets/admin/dist/img/new-fronend-img/report-pdf/Report1-Fundamentals-ofElectricVehicleChargingTechnology-and-its-Grid-Integration_GIZ-IITB.pdf |
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| 52 | Selection of charger for given vehicle type, power rating and voltage | https://e-amrit.niti.gov.in/standards-and-specifications |
| 53 | Solar charging stations for electric vehicles (EV's) | https://sinovoltaics.com/learning-center/electric-vehicles/solar-and-electric-vehicles-part-1/ |
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|---|---|---|
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| 79 | Generating green hydrogen from biomass | https://iisc.ac.in/events/generating-green-hydrogen-from-biomass-an-abundant-renewable-energy-source/ |

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| 81 | Challenges of reducing carbon emissions | www.adb.org/sites/default/files/publication/479891/handbook-battery-energy-storage-system.pdf |
| 82 | Gravity energy storage | a.https://gravitricity.com/technology/<br>b.https://www.eqmagpro.com/gravitricity-is-go-energy-storage-pioneer-commissions-demonstration-project/ |
| 83 | Battery recycling and reuse risks | www.adb.org/sites/default/files/publication/479891/handbook-battery-energy-storage-system.pdf |
| 84 | Micro-grids | a.https://www.weforum.org/agenda/2022/05/what-are-microgrids-renewable-power/<br>b. https://www.ntpc.co.in/en/media/press-releases/details/ntpc-awards-india%E2%80%99s-first-green-hydrogen-microgrid-project |
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**CIE and SEE Assessment Methodologies**

| CIE Assessment | Assessment Mode | Duration In hours | Max Marks |
|---|---|---|---|
| Week 3 | CIE 1– Written and practice test | 4 | 30 |
| Week 5 | CIE 2– Written and practice test | 4 | 30 |
| Week 7 | CIE 3– Written and practice test | 4 | 30 |
| Week 9 | CIE 4– Written and practice test | 4 | 30 |
| Week 11 | CIE 5– Written and practice test | 4 | 30 |
| | On line Course work (Minimum 10 hours online course with certification from (SWAYAM/NPTEL/Infosys Springboard) | | 40 |
| | Profile building for Internship / Submission of Synopsys for project work | | 20 |
| Portfolio evaluation (Based on industrial assignments and weekly developmental assessment) * | | | 30 |
| **TOTAL CIE MARKS (A)** | | | **240** |
| **SEE 1 - Theory exam (QP from BTE) Conducted for 100 marks 3 hrs duration reduced to 60 marks** | | **3** | **60** |
| **SEE 2 – Practical** | | **3** | **100** |
| **TOTAL SEE MARKS (B)** | | | **160** |
| **TOTAL MARKS (A+B)** | | | **400** |

* The industrial assignment shall be based on peer-to-peer assessment for a total of 10 marks (on a scale of 1 to 10) and in the event of a group assignment the marks awarded will be the same for the entire group, the developmental assessment will be for a total of 20 marks and based on MCQ/case study/demonstration and such other assignment methods

**Assessment framework for CIE (1 to 5)**

**Note: Theory to be conducted for 1 hour and practice for 3 hours, total duration of exam – 4 hours**

| **Programme** | **Electrical & Electronics Engineering** | **Semester** | **V** |
|---|---|---|---|
| **Course** | **Renewable Energy** | **Max Marks** | **30** |
| **Course Code** | **20EE531** | **Duration** | **4 hours** |
| **Name of the course coordinator** | | | |

Note: Answer one full question from each section.

| **Qn.No** | **Question** | **CL L3/L4** | **CO** | **PO** | **Marks** |
|---|---|---|---|---|---|
| | **Section-1 (Theory) – 10 marks** | | | | |
| 1.a) | Select a suitable PV system for a domestic purpose to sell excess power to grid by<br>a. configuration,<br>b. deployment<br>c. solar panel with specification<br>With proper justification. | L3 | 1 | 1 | 10 |
| 2.a) | Size the solar panel and charge controller for 3kW solar PV system | L3 | | 2 | 10 |
| | **Section-2 (Practical) - 20 marks** | | | | |
| 1)a | Test the following for the good condition<br>1. Solar panel<br>2. Charge controller<br>3. Battery<br>4. Inverter | L3 | 1 | 4 | 15 |
| b. | Find out the following from the given solar panel/datasheet<br>1. Voc<br>2. Isc<br>3. Pmax<br>4. Model Efficiency | L3 | 1 | 1 | 5 |

**Note : Theory questions shall be aligned to practical questions**

**Assessment framework for SEE 1 (Theory)**

| | | | | |
|---|---|---|---|---|
| **Programme** | : | **Electrical & Electronics Engineering** | | |
| **Semester** | : | **V** | | |
| **Course** | : | **Renewable Energy** | **Max Marks** | : **100** |
| **Course Code** | : | **20EE53I** | **Duration** | : **3 Hrs** |

**Instruction to the Candidate:** Answer one full question from each section.

| Q.No | Question | CL | CO | Marks |
|---|---|---|---|---|
| | **Section-1** | | | |
| 1 | A house consists of the following load: Design an off-grid solar PV system. Identify main components, calculate panel wattage b. Number of modules in series -parallel combination. c. Battery sizing d. Charge controller rating e. cable wiring.<br>Floor (Eg. Ground, first...etc) / Room Type (kitchen, hall, garden, etc) (Provide room size for DC Lighting) / Load type (ex: motor, pump, etc) / AC or DC / Load Wattage (ex: 20W) / No. of appliances / Hours of usage/ day / Usage mainly Day or Night? (Day time usage / Night time usage)<br>Ground / Small room / 1 LED light / DC / 5 W / 1 / 2 hours / 1 / 1<br>Ground / Small room / 1 LED light / DC / 2 W / 1 / 4 hours / 1 / 3<br>Ground / Small room / 1 LED light / DC / 4 W / 1 / 3 hours / 1 / 2<br>Ground / Small room / Fan / DC / 18 W / 1 / 8 hours / 4 / 4 | L4 | 1 | 20 |
| 2.a) | Customer wants to buy charge controller for his 3kw rooftop PV system. what type of charge controller and its rating you recommend the customer . Justify your recommendation | L3 | | 5 |
| b) | A solar panel has following specifications<br>$V_{OC}$ 43.42V<br>$I_{SC}$ 4.48A<br>$V_{mp}$ 35.82V<br>$I_{mp}$ 4.26A | L3 | | 5 |

| | | | | |
|---|---|---|---|---|
| | Calculate the peak capacity of the capacity of the panel and the energy generated considering the effective sunshine hours to be 5 hours. | | | |
| c) | Design a solar powered DC water pump where we need 50 m3 water per day from a depth of 20 m. It has elevation, standing water level, and drawdown of 10 m, 10 m, and 4 m respectively. Water density is 2000 kg/m3 and acceleration due to gravity (g) is 9.8 $m^2/s$. The peak power rating of the solar module is 36 WP, as the modules do not operate at its rated peak power capacity, operating factor is 0.75. The pump efficiency is around 40 % and the mismatch factor is 0.85 as the modules do not operate at the maximum PowerPoint. | L4 | | 10 |
| | **Section-2** | | | |
| 3.a) | Suggest troubleshooting procedures and corrective actions for Solar PV system for the following faults.<br>1. The system works but runs out of power too quickly<br>2. The system stops working<br>3. Power output is low | L4 | 2 | 15 |
| b) | For solar plants capacity 2GW, how will you optimize operation and maintenance process .Suggest any innovative method to increase cleaning cycle 24 to 365, to increase operational efficiency. | L4 | | 5 |
| 4.a) | Management of thousands of solar panels on the field was a challenge. As the assets were being managed manually, it required the investment of a lot of manpower. Hence the customer desired to optimize and automate the tracking, monitoring and configuration activities of all the assets of the plant, including solar panels and various electric motors.<br>1. Why was the Current Method of Monitoring Assets not efficient?<br>2. What was required to overcome the Limitations of Manual Monitoring and Achieve the Desired outcome?<br>3. How to automate tracking, monitoring and configuration activities of all the assets of the solar power plant.<br>4. List key highlights of your solution. | L4 | | 10 |
| b) | For 2 GW solar plant which communication protocol you recommend for SCADA. Justify your recommendation. Can you Suggest typical SCADA hardware and software required for the plant? | L3 | | 10 |
| | **Section- 3** | | | |

<table>
<tr><td>5.a)</td><td>Differentiate between level 1, Level 2 and Level 3 charging. Select suitable charging levels for Two wheelers and Four wheeler vehicle. Select type connectors for only DC charging .</td><td>L3</td><td rowspan="5">3</td><td>10</td></tr>
<tr><td>b)</td><td>How Many Solar Panels does it take to Charge an Electric Car? Justify your answer with calculations</td><td>L4</td><td>5</td></tr>
<tr><td>c)</td><td>Compare charging costs Solar vs. Utility</td><td>L4</td><td>5</td></tr>
<tr><td>6.a)</td><td>Is Keeping RE sources and Battery energy storage systems (BESS) systems in EV charging stations techno-economically feasible? Justify the statement with facts and figures</td><td>L4</td><td>10</td></tr>
<tr><td>b)</td><td>Can you Use EV for Better RE grid integration? Justify your answer</td><td>L4</td><td>10</td></tr>
<tr><td colspan="5">Section-4</td></tr>
<tr><td>7.a)</td><td>
<table>
<tr><th></th><th>KITTERY</th></tr>
<tr><td>Turbine Information</td><td></td></tr>
<tr><td>Model</td><td>Entegrity EW50</td></tr>
<tr><td>Capacity</td><td>50-kilowatts (kW) 177-m$^2$ swept area</td></tr>
<tr><td>Tower Height</td><td>125-ft lattice tower</td></tr>
<tr><td>Site Characteristics</td><td></td></tr>
<tr><td>Elevation</td><td>~26.8 meters (m)</td></tr>
<tr><td>Latitude/Longitude</td><td>43.119/-70.749</td></tr>
<tr><td>Surrounding Terrain/ Obstacles</td><td>Developed on the crest of a hill, above some trees at the town transfer station with a big gap facing the principal wind direction down by the river (see wind rose B-6); trees are 70 ft high in the area</td></tr>
<tr><td>Performance</td><td></td></tr>
<tr><td>Estimate (kWh)</td><td>58,000 kilowatt-hours (kWh) annually[15]</td></tr>
<tr><td>Actual (KWh)</td><td>~35,000 kWh/year (yr.)[16] (approx. 60% of estimate)</td></tr>
<tr><td>Maintenance Issues</td><td>Main brakes malfunctioned, locking the blades in place</td></tr>
<tr><td>Current Operating Status</td><td>Turbine is still located at the transfer station, but does not currently generate energy[17]</td></tr>
</table>
Study the above case and answer the following questions.<br>1. Does the presence of seventy-foot trees in the vicinity of the Kittery project has any effect of wind turbine performance?</td><td>L4</td><td>4</td><td>10</td></tr>
</table>

<table>
<tr><td></td><td>2. In case of Kittery project what is not considered in site-evaluation and selection.<br>3. Does the presence of ground clutter in Kittery project affect life span of wind turbine?<br>4. Does ground clutter influence a project's annual energy output?<br>5. What do you suggest to improve annual energy output of wind turbine?</td><td></td><td rowspan="10"></td><td></td></tr>
<tr><td>b)</td><td>Calculate the power developed and speed in rpm for a small wind turbine generator with the following particulars.<br>Rotor efficiency =40%<br>Generator efficiency =70 %<br>Rotor swept area =2.11 $m^2$<br>Wind speed = 8.6 m/s<br>Tip Speed Ratio =7<br>Radius of rotor = 0.82 m</td><td>L3</td><td>10</td></tr>
<tr><td>8.a)</td><td><table><tr><th>Sr.no</th><th>Sample</th><th>Calorific value(KCAL)</th><th>Efficiency (%)</th></tr><tr><td>1</td><td>Straw</td><td>3061.30</td><td>47</td></tr><tr><td>2</td><td>Cow dung</td><td>3123</td><td>46</td></tr><tr><td>3</td><td>Sawdust</td><td>3141.86</td><td>45</td></tr><tr><td>4</td><td>Cotton stick</td><td>3770.23</td><td>38</td></tr><tr><td>5</td><td>Coal</td><td>6500</td><td>22</td></tr></table>Study the above table which shows calorific values and efficiency for different samples and answer the following questions.<br>1. Which samples are good enough to be used in biomass power plant for power generation and why<br>2. What is the inference you draw from the above table.<br>3. Which sample suits best and which suits least for biomass power generation with proper reasoning.</td><td>L4</td><td>10</td></tr>
<tr><td>b)</td><td>Discuss Innovative Approaches for improving algal biomass Yield</td><td>L4</td><td>5</td></tr>
<tr><td>c)</td><td>Discuss any one method of extraction of oil from algal biomass for biodiesel Production</td><td>L4</td><td></td><td>5</td></tr>
<tr><td colspan="5">Section-5</td></tr>
<tr><td>9.a)</td><td>Can we use green hydrogen on a massive scale? Justify your answer</td><td>L4</td><td rowspan="2">5</td><td>5</td></tr>
<tr><td>b)</td><td>Is a fuel cell vehicle the same as an electric vehicle? Justify your answer</td><td>L4</td><td>5</td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| c) | Name the device or process used to produce hydrogen. How will you produce hydrogen in cost-effective manner? | L4 | | 5 |
| d) | Suggest suitable storage solutions to store electrical energy generated 1MW floating solar PV system. | L4 | | 5 |
| 10.a) | Is producing green hydrogen profitable at present? How can it made profitable in future, Suggest changes in technology to be made to make it profitable. | L4 | | 5 |
| b) | Is hydrogen a sustainable fuel? Justify your answer.<br><br>OR<br><br>What are the potential challenges for Green hydrogen? | L4 | | 5 |
| c) | India's Largest integrated energy company has awarded project of "Stand alone Fuel cell based Microgrid with green hydrogen production using electrolyser at NTPC Simhadri. This will be India's first Green Hydrogen based Energy storage project and one of World largest.<br><br>1. Which type of Electrolyze would you think could be used in this project and its rating in KW<br>2. What is the source of Input power to Electrolyze.<br>3. How hydrogen energy could be stored in this project.<br>4. Draw a single line diagram of this microgrid project. | L4 | | 5 |
| d) | How will you use design thinking process to setup hydrogen fuelling station in your city. | L4 | | 5 |

**Scheme of Evaluation for SEE 2**

| Sl. No | Description | Marks |
|---|---|---|
| 1 | Identify charging level, plugs, connectors, sockets as per given requirements | 10 |
| 2 | Design install, commission, test and trouble shoot solar PV system as per customer requirements. | 40 |
| 3 | Simulation exercise on solar/SCADA/wind/Fuel cell/micro grid | 30 |
| 4 | Feasibility study report to suggest appropriate sustainable energy and energy storage solutions for an educational institute/commercial building/industry. | 10 |
| 5 | Viva voce | 10 |
| | **Total** | **100** |

**Required Equipment/software list with Specification**

| Sl. No. | Particulars | Specification | Quantity |
|---|---|---|---|
| 1 | 3kW offgrid rooftop solar PV system with Battery backup | 3kW | 1 |
| 2 | 5kW ongrid rooftop solar PV system | 5kW | 1 |
| 3 | Pyranometer | | 1 |
| 4 | Solar Insulation meter | | 3 |
| 5 | Rooftop Mounting Structure For 4 x 250 W solar panels mounting practice, with tilt adjustment | | 2 set |
| 6 | Weather monitoring station | To monitor and record Sunshine, wind velocity, temperature, rainfall etc with software. | 1 |
| 7 | Solar cell based sunlight radiation meter | For Solar power measurement up to 2000 w/square meter | 1 |
| 8 | Cut models of photo voltaic cell assembly | | 1 |
| 9 | Cut model of Lead acid battery | | 1 |
| 10 | Lead Acid battery | 12V, 40Ah, 75Ah | 5 |
| 11 | Lead Acid battery | 12V, 100 Ah | 5 |
| 12 | Solar simulator for solar cell characteristic study | To study IV curve of a solar cell of minimum 2 watt under variable illumination, temperature and suitable load | 1 |
| 13 | Solar tracker demonstrator kit | To study manual and automatic control of 10 W solar panel in East-west and North-south &back | 1 |
| 14 | Solar PV e-learning software using animations for training | | 1 |
| 15 | Lux meter | Lux meter LCD read out 0.05 to 7000 Lumens with battery. | 1 |
| 16 | Solar photovoltaic module | 75 W mono crystalline module<br>75 W amorphous silicon module<br>250 W thin film module 5W, 10W, 40W poly crystalline module | 2 each |
| 17 | Solar panels | 250 Wp | 5 |
| 18 | Solar Charge controller with Dusk to Dawn automatic switching | 12V, 10A | 2 |
| 19 | Solar charge controller with manual switch ( Day lighting) | 12V, 10A | 2 |

| | | | |
|---|---|---|---|
| 20 | Array junction box | for connecting 250W x 4 Nos. solar panel with DC fuse, DC MCB, and surge suppressor protection | 2 |
| 21 | Solar lantern | LED type | 1 |
| 22 | Solar lantern | CFL type | 1 |
| 23 | Solar lantern assembly sets | | 1 |
| 24 | Home light system | 12 V DC with FM receiver, LED bulb and mobile charger as loads | 1 |
| 25 | Anemometer | for wind speed measurement | 1 |
| 26 | PWM Controller | | 1 |
| 27 | MPPT Charge Controller | | 1 |
| 28 | Inverter with Battery | 1 KVA with 12 V Battery Input- 12 volt DC, Output- 220 volt AC | 1 |
| 29 | Solar PCU Off grid | 1 KW MPPT Sine wave Solar Power Conditioning Unit | 1 |
| 30 | Solar Grid tied inverter Demonstrator kit | 300W KW | 1 |
| 31 | Solar Street Light | 12V, 75Ah battery, 75 Wp solar panel, 12V, 10A dusk to dawn charge controller, 60 W LED lights and 9 m height pole all dismountable | 1 |
| 32 | Solar, wind and hybrid power plant | 1 KW cumulative | 1 |
| 33 | solar DC pump | 1 HP | 1 |
| 34 | 1 Kw Wind Turbine | 500 watts, For Domestic Purpose ; Power, 1 KW ; Blades Number, 6 ; Efficiency, 80 ; Max Speed, 400 ; Start Up Wind Speed, 2.5. | |
| 35 | Wind mill kit(DIY kit) | 1kw | |
| 36 | Small hydro turbine kit(DIY kit) | 1kw | |
| 37 | Biogas Portable Kit | Plant Size: 1 Cubic Meter<br>Waste Input: 25 kg<br>Usage/Application: Domestic | 01 |
| 38 | UPS 5KVA | 1 phase online ups input 240v+/-10 V ac ,50 Hz 3 wire,output:5Kva,230v,Reglation +/-2%,eff 80%,charger mode should provide, battery of SMF or VRLA type backup of 4 hr at full load, functional test certificate, insulation resistance and HV test, load regulation and transient response test, efficiency , repulse ,battery capacity test , ups functional test and spare pc's - cards test reports. | 2 |
| 39 | Fuel Cell | Double Reversible 5W, Electrolyser Mode: 10 $cm^3$/min H2; 5 $cm^3$/min O2; 2.33 W, Fuel Cell Mode (O2): 600 mW, Fuel Cell Mode (Air): 200 mW, H x W x D: 56 x 42 x 57 mm, Wt: 63 g | 5 |