**Solar Electric Technician Training**

**Module 5: Installation and assembly**

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| **Objectives:** By the end of this session, learners will be able to:   * Finalize all preparations to initiate the installation at selected site for different types of solar PV systems. * Prepare tools and accessories to install as per the installation manual. * Prepare, assemble, and install mounting structures (e.g. rails, clamps, brackets etc.) for ground mount, pole mount and roof mount systems. * Refer and comprehend the installation manuals of inverter, charge controllers, water pumps, pump controller, batteries and Balance of System (BoS) to prepare for installation. * Plan and perform cable routing, wiring and conduiting of cables as per safety standard for DC and AC single and three phase wiring including the power evacuation to the Main distribution Board (MDB) or designated termination point. * Connect solar PV modules, batteries, charge controller, inverter, water pumps, pump controller, switchgear, earthing system and protection device up to 10 kWp for single and three phases by referring to the Single Line Diagram (SLD) and wiring drawings, technical manuals and defined standard procedures. * Conduct 3-phase wiring and load distribution. * Perform site clearance. | **Instructor:** *[Name]* |
| **Session Duration:**   * 17 hours (Theory) * 72 hours (Practical) |

| **Trainers' activities** | **Learners’ activities** | **Teaching aids** | **Time** |
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| **Finalize all preparations to initiate the installation at selected site for different types of solar PV systems.** | | | **360’** |
| * Explain how different site conditions can impact the performance of solar PV systems. * Discuss site assessment factors (e.g., terrain condition, orientation, tilt angle, shading analysis, wind load). * Present case studies of different types of solar PV systems installed in varying environments. * Facilitate a group discussion on potential challenges during site preparation, including local regulations and environmental factors. | * Listen, take notes, and ask questions for clarification. * Participate in discussion, identify site assessment factors, and take notes. * Analyse case studies, discuss challenges, and propose solutions. * Engage in discussion, share experiences, and contribute ideas. | * Case study (E1) | 15'  45'  60'  30' |
| * Demonstrate how to use site survey tools (e.g., solar pathfinder, inclinometer) and techniques for accurate measurements. * Guide learners in conducting a mock site survey, including shading analysis and measurement of tilt and orientation. * Present and explain a comprehensive site preparation checklist for different solar PV systems. * Summarize key takeaways from the session and address any remaining questions. | * Observe demonstration, ask questions, and take notes. * Perform site survey in pairs or small groups, record measurements, and discuss findings. * Review the checklist, ask questions, and suggest any additions or modifications. * Reflect on learning, clarify doubts, and discuss how to apply the knowledge in real-world scenarios. | * Assignment: ground mount (E2) * Assignment roof mount (E3) | 90'  60'  45'  15' |
| **Prepare tools and accessories to install as per the installation manual.** | | | **240’** |
| * Provide an overview of the tools and accessories required for solar PV system installation. * Display various tools and accessories, explaining their names, functions, and importance in the installation process. * Demonstrate how to read and interpret the installation manual, focusing on sections related to tools and accessories. * Guide learners in selecting the appropriate tools and accessories based on a provided installation scenario. * Facilitate a discussion on common issues related to tool and accessory preparation, including troubleshooting tips. | * Listen, take notes, and ask questions for clarification. * Observe the tools, take notes, and participate in the identification process. * Follow along with the manual, highlight key sections, and ask questions. * Select tools and accessories individually or in pairs, and justify their choices. * Participate in discussion, share experiences, and take notes on solutions. | * Assignment (E4) |  |
| * Supervise learners as they practice preparing tools and accessories according to the manual's specifications. * Guide learners in using and maintaining the tools in the installation process. * Summarize the process for use and maintenance of tool based on the installation manual. | * Prepare tools and accessories, following the manual's guidelines, and ask for feedback. * Use and maintain tools under supervision. * Participate in the process. Reflect on learning, clarify doubts. |  |  |
| **Prepare, assemble, and install mounting structures (e.g. rails, clamps, brackets etc.) for ground mount, pole mount and roof mount systems.** | | | **1050’** |
| **Hands-on assembly:**   * Demonstrate the assembly of a ground mount structure and supervise learners as they assemble similar structures. * Guide learners in installing ground mount structures at given site. | * Assemble the ground mount structure in pairs or small groups, following the manual and trainer’s guidance. * Install ground mount structures under supervision, ensuring alignment and stability | * Assignment (E6) | 200' |
| * Demonstrate the assembly of a pole mount structure and supervise learners as they assemble similar structures. * Guide learners in installing pole mount structures at a given site. | * Assemble the pole mount structure in pairs or small groups, following the drawings/instructions and trainer’s guidance. * Install pole mount structures under supervision, ensuring correct orientation and stability. | * Assignment (E7) | 200' |
| * Demonstrate the assembly of a roof mount structure and supervise learners as they assemble similar structures. * Guide learners in installing roof mount structures at a given site, focusing on safety and precision. | * Assemble the roof mount structure in pairs or small groups, following the manual and trainer’s guidance. * Install roof mount structures under supervision, following safety protocols. | * Assignment (E8) | 200' |
| **Final adjustment and alignment:**   * Demonstrate how to adjust and align the mounted structures to ensure they are level and secure. * Facilitate to revise the checklist for assembling and installing mounting structures. * Summarize key points from the session, address any remaining questions, and discuss real-world application. | * Perform final adjustments on installed structures, ensuring they meet specified standards. * Review the checklist with peers and trainer and finalize. * Reflect on learning, clarify doubts |  | 90'  90'  30' |
| **Refer and comprehend the installation manuals of inverter, charge controllers, water pumps, pump controller, batteries and balance of system (BoS) to prepare for installation.** | | | **450’** |
| * Explain the importance of installation manuals and their role during installation. * Present an overview of the key components (inverter, charge controllers, etc.) and share their respective manuals. * Guide learners through the inverter manual, explaining critical sections such as wiring diagrams, settings, and safety precautions. * Guide learners through the charge controller manual, focusing on installation steps, and configuration. * Explain the installation and setup procedures outlined in the water pump and pump controller manuals. * Discuss the battery installation manual, emphasizing safety, and connection types. * Explain the manual for BoS components, focusing on integration with other system parts and adherence to standards. | * Listen to the explanation, take notes, and ask questions for clarification. * Review the provided manuals, identify key sections, and highlight important information. * Follow the inverter manual, ask questions, and take notes on key instructions. * Follow the charge controller manual for installation. * Follow the manuals, identify key setup steps. * Follow the battery manual, take notes on safety and connection methods, and ask questions. * Study the BoS manual, note key integration points, and clarify any uncertainties. |  | 30'  45'  60'  60'  45'  45'  45' |
| **Practical exercise:**   * Facilitate a practical exercise where learners refer to the manuals for the installation of the system components. * Lead a group discussion on the challenges faced during manual interpretation and share best practices for overcoming them. * Recap key points from each manual, address any remaining questions, and emphasize the importance of following manual instructions. | * Refer the manuals and plan for installing of each component, ensuring all steps are covered. * Participate in the discussion, share experiences, and take notes on best practices. * Ask any final questions if any. | * Assignment (E9) | 60'  30'  30' |
| **Plan and perform cable routing, wiring and conduiting of cables as per safety standard for DC and AC single and three phase wiring including the power evacuation to the MDB or designated termination point.** | | | **360’** |
| * Explain the importance of proper cable routing and wiring according to safety standards for DC and AC systems. * Present an overview of DC and AC single and three-phase wiring, including the different types of cables and conduits used. * Guide learners to interpret wiring diagrams and cable routing plans, focusing on the layout for DC and AC systems. * Explain safety standards and best practices for cable routing and conduiting, including NEC and local regulations. * Facilitate a planning exercise where learners design a cable routing and conduiting plan for a sample solar PV system. | * Listen to the explanation, take notes on key safety standards, and ask questions for clarity. * Listen the information provided, identify the differences between DC and AC wiring, and participate in discussions. * Study wiring diagrams, practice interpreting them, and ask questions for better understanding. * Take notes on safety standards, participate in discussions on best practices, and ask questions for clarification. * Work in groups to design a cable routing and conduiting plan, applying safety standards and best practices. |  | 30'  45'  45'  30'  45' |
| **Hands-on practice:**   * Supervise hands-on practice by learners for cable routing and conduiting for a small-scale system. * Demonstrate the process of connecting cables to the designated termination point for both DC and AC systems using cable lugs, and tools such as cable strippers, crimping tools, insulation tape, heat shrinks etc. * Testing the wiring setup for continuity, and proper functioning. * Facilitate a group discussion on the challenges encountered during the practice session and the lessons learned. | * Perform cable routing and conduiting, ensuring adherence to the planned design and safety standards. * Practice connecting cables to the termination point under supervision, ensuring proper techniques and safety. * Perform tests on the wiring setup ensuring that the installation meets safety standards. * Share experiences, discuss challenges, and take notes on the solutions and lessons learned. | * Assignment (E10) * Assignment (E11) | 45'  45'  45'  30' |
| **Connect solar PV modules, batteries, charge controller, inverter, water pumps, pump controller, switchgear, earthing system and protection device up to 10 kWp for single and three phases by referring to the single line diagram (SLD) and wiring drawings, technical manuals and defined standard procedures.** | | | **1080’** |
| **SLD and wiring drawings**   * Explain the importance of SLDs and wiring diagrams. * Demonstrate how to interpret SLDs for single and three-phase systems. * Provide examples and guide learners through interpreting SLDs. | * Listen and take notes. * Ask questions for clarification. * Participate in group discussions to interpret provided SLDs. | * Whiteboard/Flipchart * Projector * Sample SLDs and wiring diagrams | 90' |
| **System components and their connections**   * Introduce and explain the function of each system component (PV modules, batteries, etc.). * Demonstrate how to connect each component as per SLD. | * Identify each component and its function. * Participate in a hands-on activity to match components with symbols on SLDs. * Engage in Q&A sessions. | * Real components (PV modules, batteries, etc.) * SLDs * Wiring diagrams * Technical manuals | 120' |
| **Hands-on practice:**   * Demonstrate the process of connecting PV modules in series and parallel configurations. * Monitor learners as they practice the connections. * Provide feedback and correct any mistakes. | * Follow the trainer's instructions to connect PV modules according to SLD. * Test the connections using a multimeter. * Record results and discuss findings with peers. | * PV modules * Multimeter * SLDs and wiring diagrams * Toolkits. * Assignment (E12) | 90' |
| **Connecting batteries and charge controllers**   * Explain battery configurations and demonstrate the connection to charge controllers. * Monitor learners’ progress and ensure correct connections. * Provide guidance on troubleshooting common issues. | * Connect batteries to the charge controllers as demonstrated. * Use a multimeter to verify connections. * Engage in troubleshooting exercises if issues arise. | * Batteries * Charge controllers * Multimeter * SLDs and technical manuals * Assignment (E13) | 90' |
| **Connecting inverters and pump controllers**   * Introduce inverters and pump controllers, discussing their roles in the system. * Demonstrate the connection process for these components. * Supervise the learners as they replicate the connections. | * Connect inverters and pump controllers to the system following the SLD. * Test the connections by powering on the system. * Report any issues and participate in troubleshooting. | * Inverters * Pump. controllers * SLDs * Wiring diagrams * Technical manuals * Assignment (14) | 120' |
| **Connecting switchgear and protection devices**   * Explain the importance of switchgear and protection devices. * Demonstrate the installation and connection of these components. * Guide learners through the process, ensuring safety protocols are followed. | * Install switchgear and protection devices according to SLDs. * Perform continuity tests. * Simulate fault conditions and verify the operation of protection devices. | * Switchgear * Protection devices (circuit breakers, fuses, etc.) * Continuity tester * SLDs and technical manuals | 120' |
| **Earthing system and grounding connections**   * Discuss the importance of proper earthing and grounding. * Demonstrate how to connect earthing systems for single and three-phase systems. * Monitor learners as they perform grounding connections. | * Connect earthing systems as per SLDs, ensuring all components are grounded. * Measure earth resistance and verify grounding effectiveness. | * Earthing rods * Ground resistance meter * SLDs * Technical manuals * Assignment (15) | 120 |
| **Integrating and testing the full system**   * Guide learners through the final integration of all components. * Demonstrate the sequence of powering up the system and performing initial tests. * Monitor and assist learners during testing. | * Integrate all components and prepare for testing. * Perform system checks, ensuring proper operation. * Record test results and discuss with peers. | * Complete system setup (all components) * Test equipment (multimeter, etc.) * SLDs and wiring diagrams | 120' |
| **Troubleshooting and fault finding**   * Present common faults and demonstrate troubleshooting techniques. * Introduce faults into the system and guide learners in identifying and fixing them. | * Engage in fault-finding exercises. * Apply troubleshooting techniques to resolve issues. * Discuss the troubleshooting process with the trainer. | * Fault simulation tools * SLDs and wiring diagrams * Technical manuals | 90' |
| **Final system verification and commissioning**   * Supervise learners as they perform a final system check. * Provide feedback and ensure all components are working correctly. * Guide learners in completing commissioning documentation. | * Perform a final verification of the entire system. * Complete and present commissioning documentation. * Discuss any remaining issues or improvements. | * Full system setup * Commissioning checklists. * SLDs and technical manuals. * Assignment (16) | 120' |
| **Conduct 3-phase wiring and load distribution.** | | | **1440’** |
| * Explain the fundamentals of 3-phase wiring, including star and delta configurations. * Use diagrams and examples to illustrate the concepts. | * Listen and take notes. * Participate in a Q&A session to clarify concepts. | * Whiteboard/Flipchart * Projector * Wiring diagrams | 120' |
| * Explain the principles of load distribution and balance in 3-phase systems. * Provide examples of balanced and unbalanced loads. | * Engage in discussions and ask questions to understand load distribution. * Participate in group exercises to analyse load scenarios. | * Whiteboard * Sample load distribution charts * Projector | 120' |
| * Discuss safety protocols specific to 3-phase wiring, including the use of PPE and lockout/tagout procedures. * Demonstrate the correct use of safety equipment. | * Take notes on safety procedures. * Participate in a demonstration of safety practices, including PPE usage. | * Safety gear (PPE) * Lockout/tagout kits * Safety posters/handouts | 180' |
| * Demonstrate the process of wiring a 3-phase distribution board, including connecting circuit breakers, neutral bars, and earthing. * Supervise learners as they perform the wiring task. | * Follow the trainer’s demonstration to wire a 3-phase distribution board. * Test the connections for accuracy and safety. | * 3-phase distribution board * Circuit breakers * Multimeter * Wiring tools * Assignment (17) | 180' |
| * Explain and demonstrate how to connect various 3-phase loads to the distribution board. * Provide examples of motor and heater connections in both star and delta configurations. | * Practice connecting 3-phase loads as demonstrated. * Test the operation of connected loads and troubleshoot any issues. | * 3-phase motors * Heaters * Lighting fixtures * Wiring tools | 180' |
| * Demonstrate how to measure the load on each phase using ammeters and voltmeters. * Explain the importance of balancing loads across phases and the methods to achieve it. | * Measure the load on each phase of a wired circuit. * Adjust the connections to balance the load if necessary. | * Ammeters * Voltmeters | 120' |
| * Present common issues in 3-phase wiring, such as unbalanced loads, faulty connections, and voltage drops. * Guide learners through troubleshooting scenarios. | * Engage in troubleshooting exercises to identify and fix issues in 3-phase wiring setups. * Discuss findings with the trainer and peers. | * Fault simulation tools * Troubleshooting guides * Multimeter | 120' |
| * Introduce advanced load distribution techniques, including phase shifting and power factor correction. * Provide examples and case studies for analysis. | * Participate in group discussions to analyse advanced load distribution scenarios. * Apply techniques to simulated setups and test results. | * Case studies * Simulation software * Power factor correction devices | 180' |
| * Assign a project with single line diagram where learners implement a 3-phase wiring system. * Provide guidance and feedback throughout the project. | * Interpret the SLD of 3-phase wiring system, prepare wiring diagram and share with the trainer. * Implement the wiring diagram. | * SLD of project work * Wiring tools * Projector for presentations * Assignment (18) | 120' |
| * Conduct a review session to reinforce key concepts learned throughout the training. * Provide individual and group feedback on performance. | * Participate in the review session, asking questions and discussing any unclear concepts. * Reflect on feedback and identify areas for improvement. | * Whiteboard * Feedback forms * Projector | 120' |
| **Perform site clearance.** | | | **360’** |
| * Introduce the concept of site clearance, its importance, and the steps involved. * Discuss common challenges and safety considerations. | * Listen and take notes. * Ask questions to clarify understanding. | * Whiteboard * Projector * Site clearance checklist | 30' |
| * Conduct a safety briefing focusing on potential hazards during site clearance. * Supervise the proper use of PPE and tools. | * Participate in the safety briefing. * Use PPE | * PPE (helmets, gloves, boots, etc.) * Sample tools | 60' |
| * Explain and demonstrate how to identify and mark the boundaries of the site for clearance. * Discuss the use of marking tools and methods to ensure accuracy. | * Observe the marking process and practice marking the site under trainer supervision. | * Marking tools (stakes, flags, spray paint, etc.) * Measuring tape * Site plans | 60' |
| * Guide learners for safely clearing vegetation and debris. * Supervise learners as they clear the site using appropriate tools. | * Clear vegetation and debris using hand tools and equipment as demonstrated. * Work in teams to ensure efficiency and safety. | * Hand tools (machetes, shovels, rakes). * Wheelbarrows. * Debris disposal bags. | 90' |
| * Explain methods and guide for removing large obstructions from the site. * Provide guidance on the safe use of tools and equipment. | * Work in teams to remove large obstructions, following safety protocols. * Use tools and equipment under trainer supervision. | * Heavy-duty tools (crowbars, pickaxes) * Mechanical equipment (if available) | 45' |
| * Instruct and guide how to level the site after clearance. * Discuss the importance of a level site for subsequent construction activities. | * Level the site using appropriate tools, ensuring evenness across the area. * Inspect the site for any remaining debris or uneven areas. | * Levelling tools (spirit levels, rakes) * Shovels * Measuring tape | 30' |
| * Guide learners through the process of inspecting the cleared site to ensure it meets the required standards. | * Conduct a thorough inspection of the site, identifying any issues. | * Inspection checklist | 15' |
| * Conduct a debriefing session to review key points from the site clearance activity. * Address any questions or concerns learners may have. | * Participate in the debriefing by sharing experiences and asking questions. | * Whiteboard * Feedback forms | 15' |
| * Supervise the cleanup of the site and ensure all tools are cleaned and stored properly. * Emphasize the importance of tool maintenance. | * Clean and store tools used during the session. * Participate in a final site cleanup to leave the area tidy. | * Cleaning supplies * Tool storage area * Assignment (E19) | 15' |
| **Total time** | | | **5340’** |