Empowering Sustainable Development of VET in Kenya by integrating Work Based Learning and upskilling ICT-Competences of Teachers and Students by using Solar Energy and Low Energy Devices

Deliverable

D3.2 – LWT 1: “Installation of Photovoltaic Systems for VET-schools”

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1. Introduction to Photovoltaic Systems

Photovoltaic Solar Energy. Why?

Photovoltaic (PV) systems, which convert sunlight directly into electricity, are increasingly important as a clean, renewable energy solution in regions with limited access to reliable power. In rural Kenya, where power grids are often unreachable or unreliable, solar energy presents a transformative opportunity. PV systems can provide power for essential needs such as lighting and powering devices, making them a practical solution for schools in remote areas. In these rural schools, the installation of PV systems will solve major problems such as limited access to modern teaching tools, lack of power for computers or educational equipment, and reliance on other inefficient and polluting energy sources such as diesel generators. Solar energy not only provides a clean, renewable energy source, but also saves on long-term energy costs, freeing up resources that can be reinvested in educational materials and infrastructure.

The installation of photovoltaic systems in Kenya's rural schools will have a far-reaching impact. More than 75% of Kenya's population lives in rural areas, and many of these communities lack access to the national power grid. For schools in these regions, the inability to access reliable power severely hampers educational outcomes. Teachers find it difficult to teach in the evening, students have no access to online educational resources, and it is often impossible to use modern pedagogical tools. By taking advantage of the abundant sunlight that Kenya receives year-round, photovoltaic systems can directly solve these problems. Solar panels can provide constant electricity to power classrooms, allowing students to study after dark and teachers to use computers, projectors and other learning technologies. They create a more conducive learning environment, improve student performance by extending teaching hours and reduce the financial burden of energy costs. In addition, the introduction of solar technology in schools raises awareness of renewable energy in the local community, promoting the use of solar energy in homes and small businesses.

The main objective of this Learning Work Task (LWT) is to train teachers in the installation and operation of photovoltaic systems so that they can teach their students the skills needed to install and maintain solar energy systems in rural Kenya. This training will not only enhance the education provided in schools but will also equip students with practical skills that they can use to improve their own communities by expanding access to renewable energy.

Specific objectives include:

- To provide teachers with basic knowledge of photovoltaic systems, including how solar panels convert sunlight into electricity, the types of systems available, and their components.
- Provide hands-on experience in the installation and maintenance of PV systems in schools, allowing teachers to guide students through practical installation tasks.
- To foster an in-depth understanding of the role of solar energy in addressing the energy challenges facing rural areas, promoting its use as a long-term, sustainable solution.
- Introduce safety protocols and best practices for working with PV systems, ensuring that teachers and students can handle electrical components safely and effectively.
- Engage teachers in troubleshooting exercises, where they will learn to identify and solve common problems in PV systems, such as faulty wiring or inefficient power generation due to improper installation.

One of the key aspects of this training is to tailor the installation and use of PV systems to the unique challenges and opportunities present in rural Kenyan schools. Rural areas face different logistical and environmental challenges that must be considered during installation. For example, schools in these regions can be in difficult terrain, which can complicate the transportation of solar panels and other equipment. Weather conditions, such as heavy rains or long dry seasons, can also affect the performance and maintenance of solar systems. Despite these difficulties, rural schools are also an ideal environment for PV installations due to their open spaces and abundant sunlight. Teachers will learn how to evaluate optimal locations for panel installation, ensuring that panels are installed at the correct angle and orientation to maximize solar energy collection. In addition, teachers will be trained to manage and maintain these systems with minimal external support, a crucial aspect in rural areas where access to professional technicians may be limited. This involves teaching students and community members how to perform basic maintenance tasks, such as cleaning the panels and checking for problems with wiring.

The installation of photovoltaic systems in rural schools has the potential to transform not only the educational experience, but also the overall quality of life in these communities. With access to reliable electricity, schools can stay open longer, utilize modern educational technologies and improve overall learning conditions. In addition, by teaching students about photovoltaic systems, schools become centres of renewable energy education, creating an environmentally conscious and technically skilled generation for solar power installation. This LWT will enable teachers to play a key role in expanding the use of solar energy in their schools and communities. By incorporating theoretical and practical lessons on photovoltaic systems into the curriculum, teachers will prepare students to become future installers, technicians and advocates of renewable energy.

2. Learning Objectives

The LWT for training teachers to install photovoltaic (PV) systems in rural schools in Kenya is designed to equip educators with the knowledge and practical skills needed to teach and implement solar energy solutions in their schools and communities. The training focuses on empowering teachers to create a sustainable and energy-efficient learning environment, while equipping students with valuable, job-relevant skills.

At the end of this training, teachers will be able to:

KNOWLEDGE	SKILLS	ATTITUDE
Understand the fundamental principles of photovoltaic systems: Explain how solar panels convert sunlight into electricity through the photovoltaic effect, including the basic components of a solar energy system such as panels, inverters, batteries and wiring. Recognize the importance of solar energy in rural settings: Articulate the environmental and socioeconomic benefits of using photovoltaic systems in off-grid rural schools, including cost savings, sustainability, and improved access to electricity for educational purposes. Understand the types of PV systems: Differentiate between grid-connected, off-grid and hybrid solar systems, focusing on off-grid applications suitable for rural schools in Kenya. Identify safety measures in PV installations: Describe the main protocols and safety measures required to handle electrical components and ensure safe installation and maintenance of PV systems.	Plan and design a basic photovoltaic system for your school: Assess the school's energy needs, evaluate the best location for the installation of panels, and design a system that meets those requirements using available resources. Install and maintain a small-scale solar energy system: Guide students through the installation process, including mounting solar panels, connecting wiring and inverters, and installing batteries for energy storage. Perform routine maintenance and troubleshooting tasks: Train students to perform periodic maintenance, such as cleaning panels and inspecting for damage, as well as diagnosing and troubleshooting common problems such as incorrect wiring or malfunctioning components. Use solar simulation tools for learning: Incorporate software tools or models to simulate PV system performance, helping students understand how to optimize energy production based on weather conditions and panel placement.	Promote a culture of sustainability: Promote environmental awareness and a positive attitude towards renewable energy by encouraging students to see solar energy as a long-term solution to rural energy problems. Encourage community involvement: Inspire students to apply their knowledge outside the classroom by teaching family members and community leaders about the benefits of solar energy and how to implement similar systems at home. Instil a sense of safety responsibility: Emphasise the importance of following safety guidelines during installation and maintenance of the PV system, ensuring that students and community members understand the risks and best practices for working with electrical systems.

3. Public Online Learning and Work Task

With the help of the online application “Task Manager”, trainers and teachers can develop project-based, competence-promoting and work process-oriented tasks (so-called learning and work tasks) for their trainees - if desired, also jointly or on a collaborative basis. A completed task can be made available to trainees via a link without them needing their own account.

Step by step, the Task Manager turns an idea into a learning and work task; existing digital training, teaching and work materials can be easily integrated.

The Task Manager also offers an ideal environment for managing learning and work tasks. It is an open resource and available for free for interested parties who want to use it within their company or school. For further information please contact: Vivian Harberts (harberts@uni-bremen.de)

The Learning and Work Task “Installation of Photovoltaic Systems for VET-schools”, which is Deliverable 3.2 of the project DEVISE4KE was created within this tool and can be found under the following link:

Learning and Work Task: Planning and Installation of Photovoltaic Systems for VET-schools	
Occupation	Electrician (Photovoltaics)
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Instance	https://intl.kwst.uni-bremen.de/
Link	**https://intl-am.kwst.uni-bremen.de/release/p/b9ISnUIACzko**

4. Theoretical Content for Teachers

4.1. Knowledge Check

The implementation of a pre-assessment questionnaire to pre-assess knowledge before starting a training is essential to adapt the educational content to the specific needs of the trainees. This questionnaire (Anex I) makes it possible to identify the level of pre-existing knowledge and skills, which facilitates the personalisation of learning and ensures that training time is used efficiently. In addition, by recognising and assessing learners' prior knowledge, it encourages their motivation and engagement with the course, creating a more effective and participatory learning environment.

4.2. Basic Training

Basic concepts in electricity

Analogy of Photovoltaic Energy with a Garden and a Water Tank

Photovoltaic Energy:

- Solar Panels: Imagine that solar panels are like a large rainwater collection system in a garden. The solar panels convert sunlight into electricity in the same way that the collection system gathers rainwater.

Consumption and Demand Concepts:

- Consumption (Energy): It's like the total amount of water you use in a day to water the garden, wash the car, and other activities. In electrical terms, consumption is measured in kilowatt-hours (kWh), which is the total amount of energy used over a period of time.

- Demand (Power): It's like the amount of water you need at any given moment, for example, when you open several taps at the same time. In electrical terms, demand is measured in kilowatts (kW), which is the amount of energy used at a specific moment.

Energy and Power:

- Energy: Imagine you have a water tank that fills with the rainwater collected by the system. Energy is like the total volume of water stored in the tank that you can use when you need it. In electricity, this is measured in kilowatt-hours (kWh).
- Power: It's the rate at which water can flow from the tank to the taps. The faster the flow, the greater the power. In electricity, this is measured in kilowatts (kW).

Practical Example:

- Solar Panels and Consumption: Suppose your solar panels generate 5 kWh of energy per day. This is like your collection system gathering 500 liters of water per day.
- Power and Demand: In your house, at any given moment, you may be using appliances that require 2 kW of power, similar to opening several taps that need a certain amount of water at that instant.

Management System:

- Batteries (if applicable): If you have batteries, it's like having an extra water tank to store the excess water (energy) collected during the day to use at night or on cloudy days.
- Inverter: The inverter is like a water pump that adjusts the water pressure (converting direct current to alternating current) to make it suitable for domestic use.

External Factors:

- Weather: Sunny days fill the tank quickly, while cloudy days collect less water, like how photovoltaic energy generation depends on sunlight.

Using this garden and water tank analogy, students can visualize how photovoltaic energy works and better understand the concepts of consumption and demand, as well as the difference between energy and power.

What is energy generation?

Energy generation is the process of converting different forms of energy into electrical power that can be used to power homes, businesses, industries, and transportation. It involves the transformation of resources such as coal, oil, sunlight, wind, water, and nuclear reactions into usable electricity. This electricity is then distributed through power grids for consumption.

Our Challenge: Energy Generation Problems and Possible Solutions

The current global challenge in energy generation revolves around finding sustainable and environmentally friendly ways to meet the world's growing energy demands while reducing pollution and minimizing the negative impact on the planet. Key Challenges:

- Environmental Impact.
- Resource Depletion.
- Energy Security.

Solar Energy: Why It’s a Sustainable Solution

Solar energy is one of the most promising solutions to the energy generation challenge because it harnesses sunlight, an abundant and renewable resource, to generate electricity. Here’s why solar energy is crucial:

- Renewable and Abundant: The sun provides an almost limitless supply of energy, which can be captured and converted into electricity.
- Low Operating Costs: Once solar panels are installed, the cost of maintaining and operating a solar energy system is relatively low.
- Scalability: Solar energy systems can be deployed on a small scale for individual homes or on a large scale for utility companies and industries.
- Energy Independence: Solar energy allows regions to generate their own electricity without relying on imported fuels.

Calculation

ENERGY GENERATED
=
INSTALLATION POWER x LIGHT HOURS x PANEL EFFICIENCY

Default efficiency is usually 90% + possible dirt, non-ideal inclination, etc.

Peak Sun Hours (PSH) in Kenya:

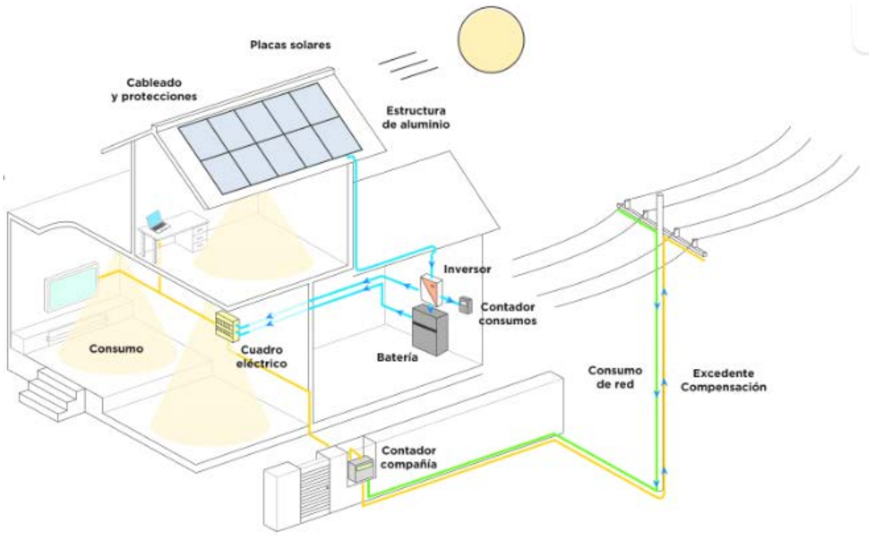
- DATA ACCES VIEWER: https://power.larc.nasa.gov/data-access-viewer/
- PV Watts: https://pvwatts.nrel.gov/pvwatts.php

4.3. Advanced Training

Types of photovoltaic installations

There are different types of photovoltaic systems, each suitable for specific contexts. In rural Kenyan schools, the focus will primarily be on off-grid systems due to the lack of connection to the national grid.

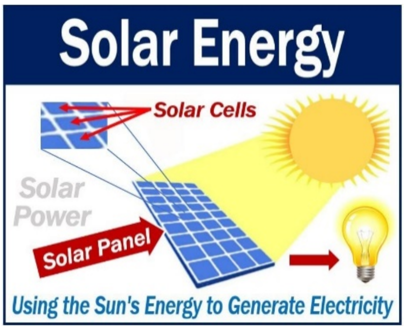
- Off-Grid PV Systems: Off-grid systems operate independently of the electrical grid, making them ideal for rural schools. They rely on batteries to store energy for nighttime or cloudy days.
- Grid-Tied PV Systems: These systems are connected to the national power grid and can feed excess energy back into it. While useful in urban settings, they are less common in rural areas without grid access.
- Hybrid PV Systems: Hybrid systems combine the benefits of both grid-tied and off-grid systems. They use batteries for storage but can also draw power from the grid when needed.



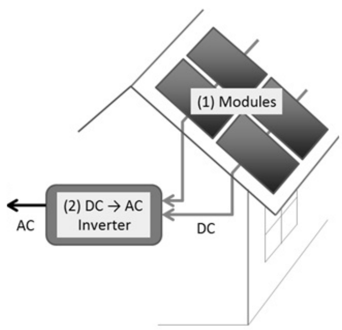
Parts of a photovoltaic installation

A photovoltaic system consists of several key components that work together to generate and deliver electricity. Each of these components has a specific role in the overall system.

- Solar Panels: Converts sunlight into direct current (DC) electricity through the photovoltaic effect.

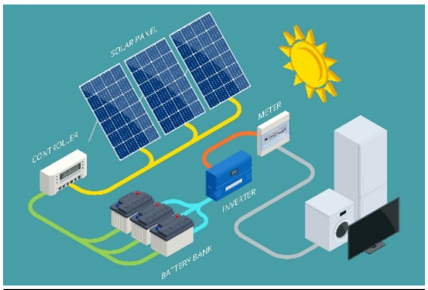


- Inverter: Converts the DC electricity produced by the solar panels into alternating current (AC) electricity, which can be used by school.

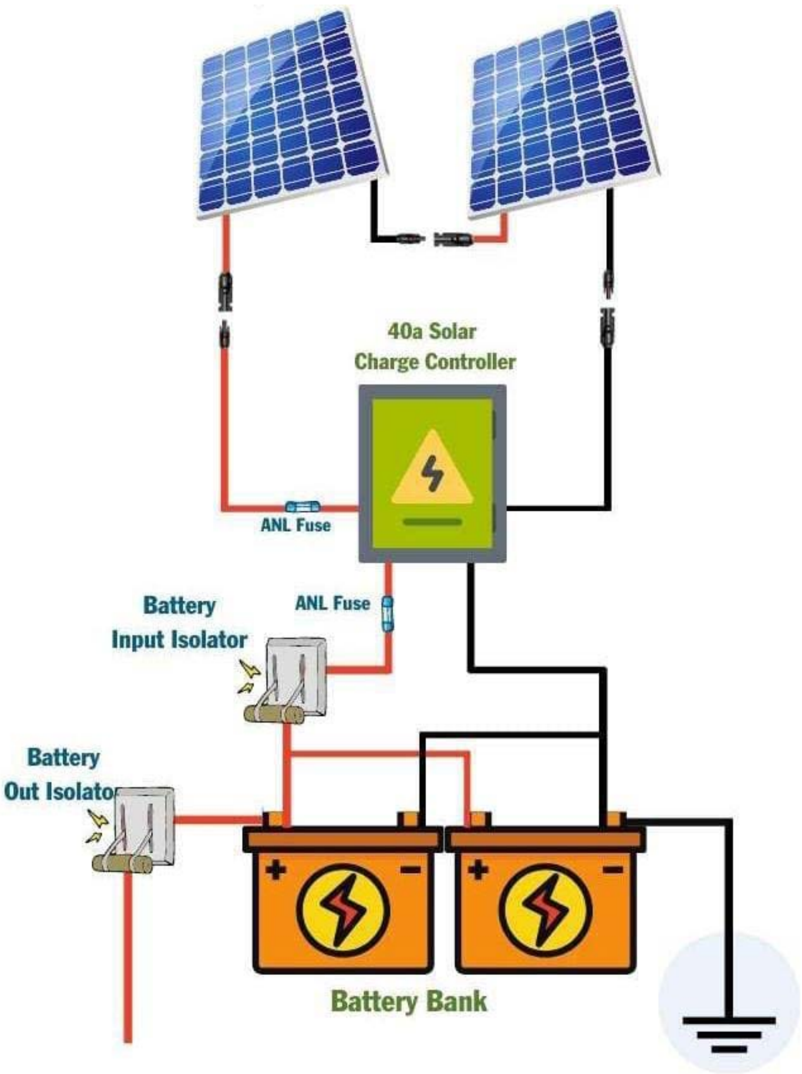


- Charge Controller (for off-grid systems): Regulates the voltage and current coming from the solar panels to the battery, preventing overcharging and prolonging battery life.

- Battery bank: Stores excess energy generated by the solar panels for use when sunlight is not available, such as during the night or cloudy days.



Electrical diagram of the installation



Cable cross-section calculation

To calculate the cross-section of an electrical cable, several factors must be considered to ensure the safety and efficiency of the electrical system. Here is a summary of the most important steps and considerations:

1. <u>Determination of the Maximum Current (I)</u>

Total Load: Sum the power (in watts) of all the devices that will use the cable.

Voltage: Know the system voltage (for example, 230V for residential installations in Europe).

Current: Calculate the current using the formula: I=PV·cos(ϕ)

2. <u>Selection of Cable Material</u>

Copper: Better conductivity and more common.

Aluminium: Lighter and cheaper, but less conductive.

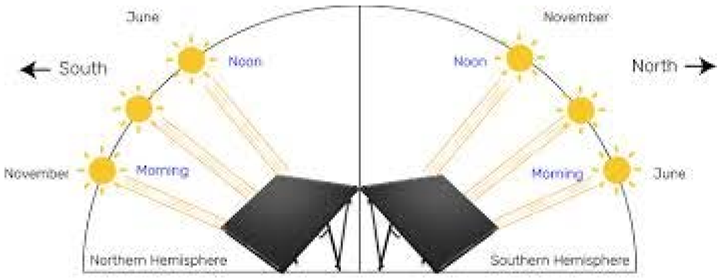
3. <u>Calculation of the Cable Cross-Section (A)</u>

Basic Formula: The cross-section of the cable can be calculated with the formula: A=I/δ [where δ\delta is the permissible current density, which depends on the material and installation conditions].

Length Correction: If the cable is very long, the voltage drop must be considered using the formula: S=2·L·I·ρ/VadmS [where L: Length of the cable, I: Maximum current, ρ: Resistivity of the cable material, Vadm: Permissible voltage drop (generally 3% of the nominal voltage)].

Panels installation angle calculation

For a fixed photovoltaic solar panel installation that maintains the same inclination throughout the year, we should find an angle that maximizes solar energy capture across all seasons. This angle is typically close to the latitude of the location where the panels will be installed.



Moreover, if the installation is in the south hemisphere, the panel should be installed facing north. As Kenia is in the south hemisphere, it must be like that.

Steps to Calculate the Fixed Installation Angle:

1. Determine the Latitude of the Location: This is the fundamental value you will use to calculate the angle. You can find the latitude using a map or online tools.

2. Recommended Fixed Inclination Angle: As a rule, the optimal inclination angle for a fixed installation is equal to the latitude of the location.

Example: If you are installing the panels at a location with a latitude of 40 degrees, then the optimal inclination of the solar panels will be approximately 40 degrees.

Additional Considerations:

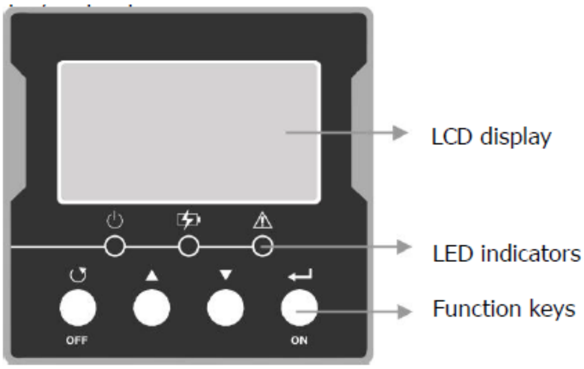
- Seasonal Compromise: Although latitude provides a good estimate, you can slightly adjust this angle to better optimize energy capture based on specific energy needs. For example:

- Latitude ± 5 degrees: Some guides suggest adjusting the inclination within a range of ± 5 degrees relative to the latitude to better suit local solar irradiation conditions.

- Shading: Ensure that there are no shadows cast on the solar panels during peak sunlight hours throughout the year.

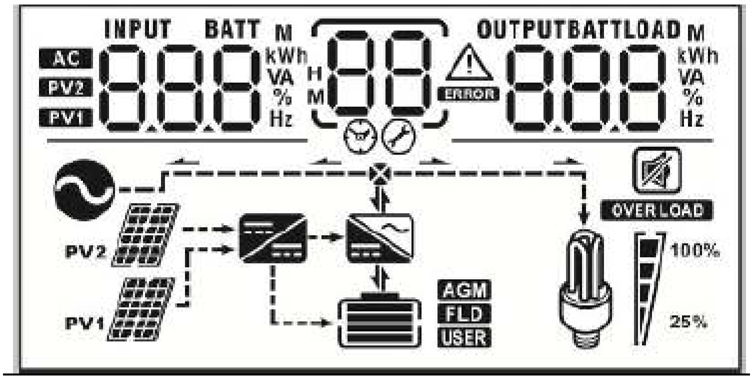
4.4. Inverter Main Information Screen

The Operation and Display Panel of the solar inverter is the primary interface for monitoring and controlling the system. It consists of an LCD screen and several buttons that allow users to view system information, adjust settings, and manage the overall operation of the inverter. Below is a detailed description of the key components and their functions.



LCD Display Screen

The LCD screen is the central element of the operation panel, providing real-time data about the inverter's performance and the overall status of the solar power system. The screen is divided into various sections, each displaying different types of information:



Input Source Indicators: Icons indicate which input sources are currently active, such as utility power (AC), and the PV panels (PV1 and PV2). These icons help the user to quickly identify the sources of power feeding into the system.

System Metrics

- Input Metrics: Includes voltage and frequency readings for the AC input, as well as voltage levels for the PV panels (PV1 and PV2).
- Output Metrics: Shows the output voltage, frequency, and load percentage, along with the load in watts and VA (volt-amperes). These

metrics are essential for ensuring that the system is providing stable and sufficient power to the connected loads.

- Battery Information: Displays battery voltage, charging status, and the current battery level. This section helps users monitor the battery’s health and ensures that it is properly charged to meet the system’s power demands.
- Charger Information: Indicates the charging power from the PV panels (PV1 and PV2) and the current being supplied to the battery. This helps to assess how much solar energy is being converted and stored.

Operating Mode: Icons or text indicate the current operating mode of the inverter, such as whether it is in grid-tied mode, off-grid mode, or running on battery power.

Warning and Fault Codes: The display will show specific codes in case of any issues or errors in the system. These codes are crucial for troubleshooting and resolving problems to maintain system performance.

Operation Buttons

The operation panel includes several buttons that allow users to interact with the system:

Up and Down Buttons: These buttons are used to navigate through different menus on the LCD screen. They allow users to scroll through various system metrics, settings, and historical data.

Enter Button: The enter button is used to select options or confirm actions within the menu. It is essential for adjusting settings or activating specific functions of the inverter.

Escape (ESC) Button: This button allows users to exit the current menu or cancel an operation. It is used to return to the previous screen without saving changes.

Function Buttons: Depending on the inverter model, there may be additional buttons for specific functions, such as muting alarms, turning the backlight on or off, or switching between different display modes.

Indicator Lights

In addition to the LCD screen, the panel may feature indicator lights (LEDs) that provide quick visual cues about the system's status:

Power Indicator: This light indicates that the inverter is powered on and operational.

Fault Indicator: A red light that illuminates if there is a fault or error in the system, prompting the user to check the LCD display for details.

Charge Indicator: This light shows whether the battery is currently being charged by the PV panels or another power source.

Summary of Display Functions

The Operation and Display Panel is designed to provide a comprehensive overview of the inverter's performance and the solar power system's status. It allows users to:

Monitor real-time data on power input, output, and battery levels.

Navigate through different settings and historical data logs.

Respond to system alerts and troubleshoot issues using displayed codes.

Adjust operational settings to optimize system performance based on current conditions.

4.4.1. Basic Maintenance Through the Inverter Display

The inverter display is a crucial tool for performing basic maintenance on your solar power system. By regularly monitoring and interacting with the inverter display, you can ensure that the system is operating efficiently and identify potential issues before they become serious problems. Here are the key steps for conducting basic maintenance through the inverter display:

Regular Monitoring of System Performance

Daily Checks: Every day, check the inverter display for key performance metrics such as input voltage from the PV panels, output voltage and current, battery status, and energy production. This will help you ensure that the system is generating power as expected.

Weekly or Monthly Reviews: At least once a week or month, review the energy production logs available on the display. This includes tracking the total kilowatt-hours (kWh) produced, which helps in understanding how well the system is performing over time.

Inspecting and Verifying Input and Output Values

Input Voltage and Current: Use the inverter display to monitor the voltage (Vmp and Voc) and current (Imp and Isc) coming from the solar panels. Compare these values with the expected values listed in the system’s technical specifications. Significant deviations might indicate shading, dirt accumulation, or panel degradation.

Output Power: Check the output voltage and current to ensure the inverter is providing stable power to your loads. Consistent output indicates that the inverter is functioning correctly and that there are no issues with the load demand.

Monitoring Battery Health

Battery Voltage: Regularly check the battery voltage displayed on the inverter to ensure it is within the optimal range. Low voltage could indicate that the battery is not being charged properly or that there is an issue with the battery itself.

State of Charge (SOC): The display often shows the state of charge of the battery, typically as a percentage. Ensure that the battery maintains a healthy charge level, avoiding deep discharges that could shorten its lifespan.

Checking for Warning or Fault Codes

Warning Codes: The inverter display will show specific warning codes if there are any minor issues that need attention. Review these codes and consult the inverter manual to understand their significance and the appropriate corrective actions.

Fault Codes: More serious issues will trigger fault codes on the display. These codes indicate that immediate action is required, such as checking connections, resetting the system, or contacting a professional for service. Always address fault codes promptly to prevent damage to the system.

Performing System Resets and Adjustments

System Reset: If the system is not performing as expected or after resolving a fault, you may need to reset the inverter. This can typically be done through the display by navigating to the appropriate menu option.

Adjusting Settings: The inverter display allows you to adjust various system settings, such as the charging parameters for the battery or the grid-tie settings if applicable. Regularly review these settings to ensure they are optimized for current operating conditions.

Cleaning and Visual Inspections

Display Cleaning: Keep the inverter display clean and free of dust, as this can interfere with visibility and operation. Use a soft, dry cloth to clean the screen.

Visual Inspection: Use the information from the display to guide a visual inspection of the inverter and related components. Check for loose connections, signs of wear or overheating, and ensure the inverter is properly ventilated.

Logging and Reviewing Data

Data Logging: Many inverters have the ability to log performance data over time. Regularly download or review this data through the display to analyse trends and identify any gradual declines in performance.

Reviewing Historical Data: Use the display to compare current performance with historical data. This can help you detect early signs of system degradation or external issues, such as increased shading or dirt accumulation on panels.

5. Energy Production Register

Regular monitoring of the solar panels is essential to ensure that the system is operating at its maximum capacity and to detect any problems early. In rural Kenya, where environmental conditions can vary and affect the efficiency of the panels, it is particularly important to keep detailed records of their performance. This chapter provides a framework for schools to collect, analyse, and use performance data from their solar systems effectively, with the goal of optimizing energy efficiency and ensuring a reliable supply of electricity.

To maintain proper monitoring of the PV system, it is recommended that schools perform weekly or monthly monitoring. This allows to detect changes or anomalies in the performance of the panels early enough to make necessary adjustments or repairs.

5.1. Monitoring

The solar inverter has a display that shows the amount of power generated. The energy produced, voltage and current should be noted daily or weekly.

In addition to technical data, a weekly visual inspection of the panels and wiring can help identify problems such as dust accumulation, physical damage, or loose connections.

During monitoring, it is important to record several key parameters that can indicate the status and efficiency of the system:

- Energy Generated (kWh): the amount of energy the system produces on a daily or weekly basis. A sudden drop in generated power can indicate problems such as panel shading, dust build-up, or equipment failure.
- Voltage: Recording the voltage at maximum power point and the open circuit voltage helps to assess whether the panels are operating within expected parameters.
- Current: Rated current and short circuit current should be measured and compared to the data sheet values to ensure that the system is operating correctly.

- Operating Temperature: If possible, recording the temperature of the panels can help to understand how environmental conditions affect efficiency. Excessively high temperatures can reduce panel performance.

5.2. Data to be recorded

It is essential that schools keep a systematic record of all monitoring data. It is recommended that a logbook or digital spreadsheet be used to store and organize the information:

Date	Energy production (kWh)	System status (Voltage and Current)	Weather conditions	Notes

Compare one month's or week's data with previous months or weeks to identify trends or changes. A steady decline in the energy produced could indicate a problem that needs attention. If unusually low voltage or current values are observed, or if the energy produced decreases for no apparent reason, a more detailed inspection should be performed to identify the cause of the problem. At the end of each month, calculate the overall efficiency of the system by comparing the power generated with the rated capacity of the panels. This allows an assessment of whether the system is operating near its maximum potential.

With continuous data recording and analysis, schools will be in a strong position to make informed decisions about maintenance and possible improvements to the PV system.

As corrective actions, if a drop-in efficiency is detected, the first action may be a cleaning of the panels to remove dust or dirt. In case of persistent problems, a detailed technical inspection of the entire system, including the inverter, connections, and batteries, should be performed. If faulty components are found, such as worn cables or a damaged inverter, it is important to make the necessary repairs as soon as possible to avoid interruptions in the power supply.

In terms of preventive planning and based on the data collected, a preventive maintenance schedule can be established, ensuring that the system receives the necessary attention before serious problems arise. Analysing long-term data can reveal opportunities to improve system efficiency, such as adjusting the tilt of the panels, improving inverter ventilation, or considering technology upgrades.

6. Basic care of the installation

Why should we take care of the installation?

By following these preventive care and maintenance steps, you can ensure the longevity, efficiency, and safety of your photovoltaic installation.

- Regular Cleaning of Solar Panels: Remove dirt, dust, and debris from the surface of the solar panels to ensure maximum sunlight absorption. This can be done with water and a soft brush, or a cleaning kit designed for solar panels.

- Inspection of Electrical Components: Periodically check the wiring, connectors, and inverters for signs of wear, corrosion, or damage. Ensure all connections are tight and secure.

- Visual Inspection of Mounting Structures: Examine the mounting system for any signs of rust, loose bolts, or other structural issues. Ensure the panels are securely mounted and correctly angled.

- Battery Maintenance (for off-grid and hybrid systems): Check battery connections and electrolyte levels if applicable. Ensure batteries are kept in a temperature-controlled environment and replace them when their efficiency declines.

- Check for Shading: Ensure no new obstructions (like growing trees or new buildings) are causing shading on the solar panels. Remove or trim any obstacles that might block sunlight.

- Safety Checks: Ensure all safety devices, such as disconnect switches and grounding equipment, are functioning correctly. This helps prevent electrical hazards.

Work safety, electrical hazards

Each country has its own safety regulations, so it is important that these regulations be followed, both electrically and in the field of construction of the photovoltaic panel.

In Kenya, electrical safety regulations are governed by the "Energy (Electricity Licensing) Regulations, 2012" and other related laws aimed at ensuring safety in electrical installations and protecting both users and workers in the sector.

Key points of the regulations include:

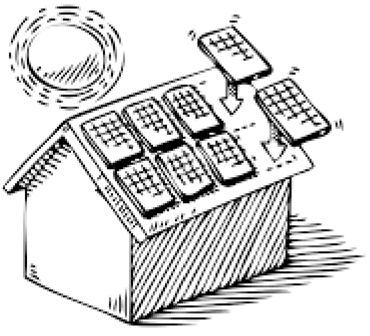
- Requirements for Electrical Installations: All electrical installations must comply with the standards set by the Kenya Bureau of Standards (KEBS). This includes using certified equipment and the correct installation and maintenance of electrical systems.
- Licenses and Certifications: Installers and electricians must be properly licensed and certified by the Energy and Petroleum Regulatory Authority (EPRA) of Kenya. This authority ensures that electrical sector professionals are qualified and meet safety requirements.
- Regular Inspections: Electrical installations must undergo periodic inspections to ensure continued compliance with safety standards. Inspections are conducted by EPRA-authorized inspectors.
- Safety Measures: Regulations require specific safety measures, such as the use of circuit breakers and ground fault protection devices. Additionally, proper safety procedures must be followed during the installation, maintenance, and repair of electrical equipment to prevent electrical accidents.
- Documentation and Reports: Owners of electrical installations are required to keep detailed records of the installation and maintenance of their electrical systems. This documentation must be available for review during inspections.

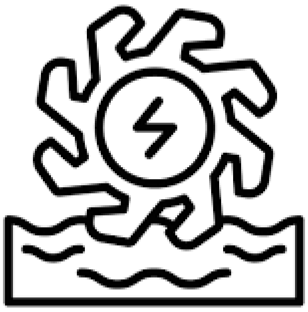
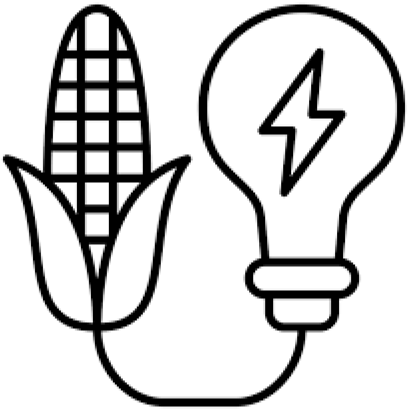
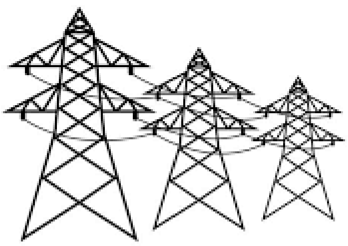
7. Possible Exercises and Simulations

To reinforce theoretical knowledge and develop the necessary skills for photovoltaic (PV) system installation, practical exercises and simulations are essential. These activities should focus on hands-on experience, troubleshooting, and problem-solving to ensure that students are fully prepared to install and maintain PV systems in real-world settings, such as rural Kenyan schools. Below are suggested practical exercises and simulations designed to provide both individual and group learning opportunities.

1. TYPES OF ENERGY SUPPLY
Select the most suitable power supply solution for your school. Analyse the requirements: Consider the power needs of the location (e.g., constant voltage, portabili backup power). Think about the environmental conditions (e.g., access to sunlight, availabi of grid power). Justify your choice: Provide reasons why the selected power supply is the best fit for the locatio Consider factors such as efficiency, cost, reliability, and environmental impa

In a school, several types of energy supplies can be used to ensure efficient and sustainable operation. Here are some options:

Solar Power: Uses solar panels to convert sunlight into electricity	

Wind Energy: Generates electricity from wind by means of wind turbines	
Geothermal energy: Harnesses the Earth's internal heat for heating and cooling	
Hydropower: Uses the movement of water to generate electricity	
Biomass Energy: Generates energy from organic materials such as agricultural and forestry residues	
Power from the Grid: Conventional supply of electricity through the public grid	

Selected power supply is… (add justification and challenges)

2. SIDE INSPECTION
Evaluate and determine the most suitable location for installing photovoltaic (sol equipment. Identify the advantages and disadvantages of the chosen site.

Review the location of the school and form small groups to discuss and analyze the location.
Each group will inspect the site map to identify possible locations for photovoltaic equipment.
Consider factors such as:

- Sunlight exposure (orientation and shading)
- Accessibility for installation and maintenance
- Structural integrity (for rooftop installations)
- Space availability

ADVANTAGES	DISADVANTAGES

Discuss within your group to select the most suitable site based on your analysis. Ensure that all group members agree on the chosen site.

3. RESOURCE PLANNING
Plan and allocate the necessary resources (temporal, organizational, financial, personal, and material) for the installation of solar panels in a school.

Brainstorming session (2 groups):
Focus on 5 main categories:

- Temporal Resources: Timeframe for each stage of the project, deadlines, scheduling.
- Organizational Resources: Project management, coordination among team members, roles, and responsibilities.
- Financial Resources: Budget estimation, cost analysis, funding sources.
- Personal Resources: Skills and expertise required, team members, external experts.
- Material Resources: Equipment, tools, solar panels, installation materials.

How much time is needed for planning, installation, and testing?	
What organizational structure will ensure smooth execution?	
What are the estimated costs, and how can the project be funded?	
Who are the key personnel, and what skills are required?	
What materials and equipment are essential for installation?	
How much time is needed for planning, installation, and testing?	
What organizational structure will ensure smooth execution?	

Each group will prepare a summary of the results of their brainstorming and detailed plans (add resources, justification and difficulties).

4. SUPPLYER CHOICE
Evaluate and decide on the most suitable solar panel supply provider based on various criteria. Understand that selecting a supplier depends on preconditions, available resources, and specific criteria.

Review the profiles of 4 different solar panel supply companies.

Company A: GreenTech Solar
Advantages: High-efficiency panels, excellent customer service, long warranty (25 years).
Disadvantages: Higher cost, longer delivery time.

Company B: SunPower Solutions
Advantages: Competitive pricing, fast delivery, flexible payment options.
Disadvantages: Shorter warranty (10 years), lower efficiency panels.

Company C: EcoEnergy Corp
Advantages: Eco-friendly manufacturing, mid-range pricing, solid performance.
Disadvantages: Limited customer support, moderate warranty (15 years).

Company D: SolarMax Inc.
Advantages: High-efficiency panels, strong warranty (20 years), good customer reviews.
Disadvantages: Higher upfront cost, limited availability in some regions.

Each company has distinct advantages and disadvantages.

COMPANY	ADVANTAGES	DISADVANTAGES
1		
2		
3		
4		

Lists the criteria for evaluating suppliers: …

Each group will decide on the most appropriate provider based on their criteria. Explain the reasons for your decision.

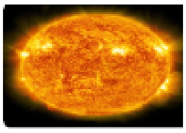
8. Assessment and Evaluation

Assessment and evaluation are critical components of the Learning Work Task (LWT) for photovoltaic system installation training. They ensure that students have acquired the necessary theoretical knowledge, practical skills, and problem-solving abilities to successfully install, maintain, and troubleshoot photovoltaic (PV) systems in real-world settings, such as rural schools in Kenya. Below is a comprehensive plan for both formative and summative assessment methods, incorporating peer assessment and feedback mechanisms.

EVALUATION FORM
How would you rate the organization of the activity? • Very good • Good • Fair • Poor
Was the information provided during the activity clear and sufficient? • Yes • No
Which aspects of the activity did you find most useful?
What benefits do you expect the school to gain from implementing solar energy
What are the main obstacles to implementing solar energy in the school?
How would you rate your current knowledge about solar panels and th installation? (1 being the least and 5 being the most knowledgeable)
Please share any additional comments or suggestions about the activity.

9. Appendices

9.1. Annex I



1 - Quiz

Fill in the Blank: Solar power is energy obtained by harnessing the sun's _____.

- ▲ gravitational pull ✗
- ◆ gases ✗
- ● sunlight ✓
- ■ matter ✗

2 - Quiz

Fill in the Blank: In concentrated solar power, sunlight is _____ into a small beam.

10 sec

- ▲ reflected ✓
- ◆ transfered ✗
- ● bended ✗
- ■ pulled into ✗

3 - Quiz

True or False: Solar panels convert sunlight into AC electricity, and then into DC electricity.

- ▲ True ✗
- ◆ False ✓

4 - Quiz

True or False: Solar Power is a renewable source of energy.

10 sec

- ▲ True ✓
- ◆ False ✗

5 - Quiz

True or False: Solar Power is high maintenance.

10 sec

- ▲ True ✗
- ◆ False ✓

6 - Quiz

True or False: Solar Power does not require a lot of space.

10 sec

- ▲ True ✗
- ◆ False ✓

7 - Quiz

True or False: Solar Power energy storage is expensive.

10 sec

- ▲ True ✓
- ◆ False ✗

8 - Quiz

Which of these environmental impacts are associated with solar power?

20 sec

- ▲ land use ✓
- ◆ habitat loss ✓
- ● water use ✓
- ■ hazardous materials in manufacturing ✓

9 - Quiz

What is the solar power cost per watt?

10 sec

- $2.87 ✗
- $3.00 ✓
- $3.87 ✗
- $4.00 ✗

10 - Quiz

What is the price range for installation of an average sized system?

10 sec

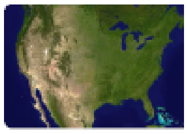
- $15,000-$29,000 ✓
- $18,000-$26,000 ✗
- $21,000-$30,000 ✗
- $28,000-$39,000 ✗

11 - Quiz

Which country uses the most solar power?

20 sec

- China ✗
- United States ✗
- Germany ✓
- Spain ✗



12 - Quiz

True or False: Solar power makes less than 1% of the electricity in the United States.

- True ✓
- False ✗

Project Partners:

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