Module Outline

SITE ASSESSMENT AND SYSTEM SIZING

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Relevance and Background

A solar power plant can be custom-designed to match the customer's energy requirements and the available installation site area. This customization is a key aspect of solar PV systems.

It is essential to perform a precise survey and evaluation of the site, energy demands, and the loads the system will support.

The economic success of any solar plant relies on the accuracy of this initial assessment and how well the system is designed accordingly.

Theme – Technical
Competency – Others
Code of the Module – T02C05M15

Learning Outcomes

By the end of this module, participants will be able to:

- Recognize the key parameters and considerations in conducting a comprehensive site survey.
- Apply various tools and techniques for accurate data collection and shadow analysis.
- Evaluate electricity bill savings and economic benefits from PV system installation.
- Understand the importance of safety practices during site surveys and adherence to standards.

Method of Delivery

Duration	Resource Code	Resource Delivery
60 min.	M15 L01	Lecture on Site Analysis and System Sizing

M15 L01: Lecture Presentation

- The lecture presentation delves deeply into site survey and load assessment for solar PV plants. It focuses on residential rooftops, microgrids, and large grid-connected projects with varying capacities. The main point is to stress how crucial precise site assessments are for achieving optimal solar PV plant performance and financial viability.
- During the session, the importance of accurate measurements, as well as physical, electrical, and commercial evaluations in the site survey process, is highlighted. It covers the survey steps, necessary tools, and considerations such as plant azimuth, tilt angle, inter-row spacing,

and Ground-Coverage Ratio (GCR) optimization. All of these aspects are discussed to enhance energy capture and efficiency.

- The technical aspect places strong emphasis on using online tools for power generation assessment and shadow analysis to reduce shading effects. Properly determining the location and connection point, selecting the right site, and following safety protocols during site surveys are essential for a smooth project implementation.
- The description includes a standard site assessment form that offers a structured way to record essential data during site surveys.

Key topics to be covered

1 Site Assessment Survey
2 Site Assessment Procedures
3 Tools for Site Assessment
4 Basics of System Sizing

Table of Contents

1 Introduction

Site surveys and load analysis are critical steps in successfully implementing solar PV plants. This technical description explores the importance of thorough site surveys and accurate energy bill analysis to optimize the performance and financial viability of solar PV installations across various scales: residential, microgrid, and grid-connected projects of various sizes. By conducting comprehensive assessments and efficient energy bill analysis, solar PV projects can achieve maximum energy generation, cost savings, and long-term sustainability.

2 Site Assessment Components and Procedures

A comprehensive site survey is fundamental to achieving optimal solar PV plant performance. It involves detailed evaluations of the site's location, topography, solar irradiation, shading analysis, and potential obstructions. Accurate site surveys enable proper placement of solar panels, maximizing energy capture and overall plant efficiency.

Precise measurements during site surveys provide the foundation for a well-designed solar PV plant. Accurate data collection, including roof dimensions, terrain contours, and shading patterns, is critical to identifying the best locations for solar panels, ensuring efficient solar energy utilization.

A holistic site survey includes physical assessments of the site's features, such as soil conditions, slope, and available space. Electrical evaluations focus on the existing grid infrastructure and the point of connection. Commercial considerations encompass project viability, cost analysis, and return on investment, ensuring the financial viability of the project.

Steps in Site Assessment

Site assessment includes two components, a survey and an analysis.

2.1 Site Survey

The site survey process involves several key steps, beginning with an initial site visit, data collection, identification of potential shadow objects, and feasibility studies. Each step contributes to informed decision-making in plant design and financial analysis.

Calculations using sun path diagrams aid in determining the optimal spacing between solar panels, ensuring efficient light capture and minimizing shading effects. In constrained spaces like rooftops, the site survey should indicate the ideal row spacing.

For distributed PV projects, data related to historical energy consumption, input voltage levels, future expansion plans, current tariff rates, and other relevant information must be gathered. In MW-scale projects on greenfield sites, data collection includes terrain, contours, soil types, the presence of boulders or rocks, existing infrastructure, accessibility, distance to the nearest substation, and its voltage levels and capacity.

2.2 Site Analysis

Site analysis involves working with the data collected during the survey and using it to design the system. For instance, a designer understands that the proper orientation and tilt angle of solar panels impact energy generation. However, in some locations, the site's orientation may reduce the overall capacity (in Wp) of the plant if modules are arranged ideally. Considering these factors, the site analysis should determine the optimal combination of system size and energy generation estimates.

Inter-row spacing is a critical element of plant design and is addressed during the analysis phase, using the sun path diagrams prepared during the survey.

The assessment of the plant's capacity involves analyzing solar resource availability, load requirements, and site-specific conditions. These steps ensure that the solar PV plant meets the energy needs of its intended application.

GCR optimization entails finding the ideal ratio of solar panel area to the total ground area. It balances panel density and energy yield, maximizing power generation potential. During the analysis stage, the site assessor should examine the parameters affecting the GCR so that the optimum solution can be determined during the design stage.

2.3 Shadow Analysis

Thorough shadow analysis identifies potential shading issues that may affect solar panel performance throughout the day and across different seasons. Proper shadow analysis helps mitigate shading and ensures optimal energy output. Shadow possibilities are more prevalent in rooftop PV installations due to the many surrounding objects that already exist on or near the site. There are ways to handle unavoidable shadows by grouping the modules under shadow into one string rather than spreading them across many. Placing modules in the unavoidable shadow in landscape mode, rather than portrait mode, also reduces the negative impact of shadows on generation.

In the ground mounting of the PV array, external shadows can be easily handled and avoided if sufficient area is available. In constrained ground areas, proper grouping of subarrays and the placement of plant internal components, such as lightning arrestors, inverters, control rooms, light poles, or surrounding walls, are essential to avoid shadows on the arrays. A proper shadow analysis needs to be carried out for all ground-based projects, and this facility is included in any simulation software that a designer would use to design the plant and estimate energy generation.

2.4 Site Selection for Different Types of Systems

Site assessment methodologies vary based on the type and scale of the solar PV project. Rooftop projects, ground-mounted MW-level installations, and mini-grid plants require specific assessment approaches to achieve optimal results.

Site assessment for grid-connected PV

- Shadow-free area availability
- Consumption details, both historical and future, for the energy requirement from the proposed plant
- Shadow objects, both nearby and long-distance objects

- Grid interconnection point details, such as voltage levels and distance

Additional information for grid-connected MW scale PV

- Contour and terrain of the ground
- Land ownership details
- Water bodies and drainage system information from the plot
- Right of way for evacuation lines

Additional information for solar mini-grid

- Locations of all components
- Number and locations of consumers
- Possible routing of cables and right of way
- Present and future loads, including types, AC/DC, voltage, and current requirements
- Hours of operation for each load for each consumer

2.5 Tools Required in Site Surveys

The final recommended solar PV system capacity is determined by calculating various factors, including available area, permitted capacity under applicable regulations, the customer's budget, and the energy requirement. The existing electricity consumer can decide on the PV system capacity only with reference to the potential savings on their current electricity bill to the maximum possible level. The study and analysis of the consumer's energy demand can be best done through the study of electricity bills to understand historical consumption and through discussions to understand any possible future additions to the energy requirement.

A comprehensive case study is presented to evaluate the impact of solar PV generation on electricity bill savings. By comparing pre- and post-solar installation energy bills, this analysis demonstrates the financial benefits and cost savings achieved through solar PV technology adoption.

In the survey for off-grid systems, the load in wattage would determine inverter capacity, while the energy requirement in kWh would determine solar modules and battery capacities. Therefore, the survey should clearly outline both the power and energy requirements.

In conclusion, accurate site surveys and electricity bill assessment play pivotal roles in the successful deployment of solar PV plants, providing crucial data for optimal plant design, cost optimization, and financial viability. By adhering to international standards and employing modern tools, solar PV projects can maximize energy generation and contribute to a sustainable energy future.

2.6 Solar Sizing

A preliminary PV system sizing can be determined upon the completion of the site survey and the collection of other relevant information regarding applicable rules and regulations, the client's budget, and energy requirements. Mainly, it is important to decide on the DC capacities of solar modules, which are based on the daily energy requirement. The inverter AC capacity is based on the load power

to be supported in the case of off-grid systems and on module generation capacity in the case of on-grid systems. Finally, the battery capacity in the case of off-grid systems is based on the daily hours the load needs to be supported.

The final system design is carried out later once the project is finalized for execution, and decisions about the site, regulations, and client budget are received. At this stage, the technology of different components is selected, and then detailed design and engineering are carried out.

2.7 IEC Standards in Site Assessment and Planning

Adherence to relevant International Electrotechnical Commission (IEC) standards ensures the reliability, safety and compatibility of solar PV plants with grid requirements and international best practices. Following few standards are relevant to information collection and analysis during site assessment stage.

IEC Standard	Title	Description
IEC 62446	Grid-connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests, and inspection	Provides guidelines for the installation, operation, and maintenance of PV systems, including site assessment and planning considerations.

IEC 61724	Photovoltaic system performance monitoring - Guidelines for measurement, data exchange, and analysis	Outlines performance monitoring and assessment requirements for PV systems, useful for planning and evaluating the performance of the solar plant.
IEC 61836	Photovoltaic (PV) array - On-site measurement of current-voltage characteristics	Provides general guidelines for PV system reliability and safety requirements, which are relevant during site survey and planning to ensure system durability and safety.
IEC 61853	Photovoltaic (PV) module performance testing and energy rating	Specifies performance testing and power rating calculations for PV modules, helping determine the expected output of the solar plant based on the modules used.
IEC 61730	Photovoltaic (PV) module safety qualification	Focuses on the safety requirements for PV modules, including their installation, crucial during the planning stage to ensure safe and compliant installation practices.
IEC 61400-15	Wind energy generation systems - Part 15: Assessment of site-specific wind conditions for wind turbines	Addresses the assessment of site-specific wind conditions for wind turbines, which may be relevant for solar plant planning in areas with wind considerations.

Reading Material

1. *Utility Scale Solar Power Plants – A Guide for Project Developers and Investors by International Finance Corporation*

   (https://documents1.worldbank.org/curated/en/868031468161086726/pdf/667620WP00PUBL005B0SOLAR0GUIDE0BOOK.pdf)

2. *Handbook for Rooftop Solar Development in Asia by Asian Development Bank* (https://www.adb.org/sites/default/files/publication/153201/rooftop-solar-development-handbook.pdf)