Module Outline

DESIGNING SOLAR PARKS

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Relevance and Background

Solar parks are large-scale solar energy projects that involve the installation of numerous photovoltaic (PV) plants within a designated area. These parks may be commonly connected to the grid, allowing savings of cost and electrical losses in individual connections of the small-capacity plants within the park. However, designing and developing solar parks involves futuristic infrastructure planning, legal agreements, and cost assessments.

This module provides valuable background knowledge on the evolution of solar parks, their importance in the context of quick deployment of renewable energy, and the various components and considerations that go into their design and implementation.

Theme – Project Management
Competency – Project Development (Utility Scale)
Code of the Module – T03C07M20

Learning Outcomes

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

- Understand solar park concepts and their significance
- Gain technical knowledge of solar park design and grid integration
- Identify the regulatory and legal aspects of solar park development
- Conduct cost and benefit assessments for solar park projects
- Understand the role of shared infrastructure in optimizing solar park operations
- Gain insights into industry guidelines and best practices for solar park projects
- Develop skills for planning, designing, and managing solar park projects

Method of Delivery

Duration	Resource Code	Resource Delivery
60 min.	M20 L01	Lecture on Designing Solar Parks

M20 L01: Lecture Presentation

The MS PowerPoint presentation will cover comprehensive information about technical, financial, and regulatory aspects related to designing grid-connected solar parks.

Key Topics to be Covered

1. Solar Park Concept and Requirements
2. Common Infrastructure Facilities and Benefits
3. Cost and Benefit Assessment of Solar Parks
4. Ultra Mega Solar Parks
5. Options in Implementation of Solar Parks
6. Guidelines for Solar Park Development

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1 Introduction

A solar park is a designated area carefully planned for the installation of multiple solar power plants, aiming to generate renewable energy on a larger scale. The specific type of solar technology used, whether photovoltaic (PV) or concentrated solar power (CSP), depends on factors such as sunlight availability, land availability, and local conditions. Solar parks play a crucial role in advancing sustainable energy production.

2 Solar Park Concept and Requirements

Solar parks are strategic locations designed for efficient solar energy deployment. They offer several advantages:

- They enable the rapid deployment of solar energy projects across regions or countries.
- These parks can attract a multitude of medium-scale investors by allowing individual projects with smaller capacities.
- Government agencies find it easier to evacuate power from centralized solar parks, ensuring maximum utilization of high-quality electricity.
- Centralized O&M activities can help maintain high performance and extend the lifespan of solar installations within these parks.

Stakeholders in Solar PV Business: The solar PV business involves various stakeholders, each contributing to its growth and success:

- **Project Developer/Investor:** These entities play a crucial role in facilitating funds for solar energy projects.
- **Off-Taker/Consumer:** Individuals or organizations that purchase solar power generated, often benefiting from cost savings.
- **Renewable Energy Nodal Agency:** Solar policy enablers that help dispense subsidies on behalf of the government, promoting renewable energy adoption.
- **EPC & I&C Companies:** The engineering, procurement and construction contractor and installation and commissioning (I&C) company are responsible for the design, supply, installation, and documentation of solar plants.

- **Technical Consultants:** They provide valuable services such as feasibility assessments, tender preparation, technology selection, and third-party inspections (TPI), contributing to project success and compliance with standards.

The roles of key stakeholders in the solar energy sector can be categorized as below:

Stakeholder Role	Description
Power Producers	
Project Developers	Initiate and oversee solar energy projects, from planning to execution.
EPC & I&C Companies	Handle the design, procurement and construction of solar installations.
O&M Company	Responsible for the ongoing O&M of solar facilities.
Power Off-Taker/Consumer	
PPA with Power Producer	Agreements where consumers buy solar power from producers.
Tri-Party Agreement	An arrangement involving the power producer, consumer, and other parties.
RPO Fulfilment	Ensures that power consumers meet their Renewable Purchase Obligations (RPO)
Enablers	
Banks/Financial Bodies	Provide funding and financial support for solar projects.
Installers/Designers/Operators	Professionals and companies involved in the installation, design, and operation of solar systems.
ERC/DISCOM/TRANSCO	Electricity Regulatory Commissions (ERC), Distribution Companies (DISCOMs), and Transmission Companies (TRANSCOs) play regulatory and operational roles in the solar energy ecosystem.

The primary needs and challenges addressed by parks are given below:

Primary Needs	Major Challenges
Best Possible Sunlight	• **Site Assessment:** Identifying suitable locations with optimal sunlight. • **Reliability of Meteorological Data:** Ensuring accurate solar data for project planning. • **Variability Factor:** Managing fluctuations in solar energy generation.
Infrastructure for SPV Plant	• **Land-Related Issues:** Acquiring and utilizing land for solar projects.

Primary Needs	Major Challenges
	• **Geopolitical Issues & Permits:** Navigating regulatory and political hurdles. • **Power Evacuation:** Efficiently transmitting electricity from solar farms.
3M - Man, Machine, Money	• **Skilled Manpower:** Training and employing personnel with solar expertise. • **Solar-Specific Tools & Tackles:** Acquiring and maintaining specialized equipment. • **Project Approval by Banks & PPAs:** Securing financial backing and power purchase agreements (PPAs).

The requirements for a successful solar park include:

- **Solar Irradiance:** The area should receive ample sunlight throughout the year to ensure efficient energy generation.
- **Land Availability:** The solar park requires a sizable area of relatively flat, unshaded land to accommodate the solar panels and other infrastructure.
- **Grid Connection:** Proximity to electrical grid infrastructure is essential for power distribution and selling excess electricity.
- **Topography:** A relatively flat terrain aids in efficient installation and maintenance of solar panels.
- **Minimal Shading:** Trees, buildings, or other obstructions that cause shading should be avoided to maximize energy production.

- **Environmental Regulations:** Adherence to environmental regulations is necessary to minimize ecological impact and maintain biodiversity.

These factors collectively contribute to the success of a solar park by ensuring optimal energy generation and efficient operation.

3 Common Infrastructure Facilities and Benefits

One of the key elements that make solar parks attractive is the provision of common infrastructure facilities. The advantages of such shared infrastructure and how it enhances the viability and sustainability of solar park projects are outlined here:

- **Convenience for Customers:** Solar parks provide a single location for plant owners or other types of customers to access multiple solar energy providers, making it more convenient for them. This reduces the need to visit various locations, saving time and effort.
- **Business-Friendly Environment:** Solar Park infrastructure creates a conducive environment for solar energy businesses, offering shared resources and support services.
- **Efficient Governance:** Local administrations find it easier to manage and govern solar parks due to centralized infrastructure.
- **Lower Investment Risk:** Solar parks reduce investment risk by sharing infrastructure costs among multiple projects, making each project financially more viable.
- **Streamlined Operations:** Common facilities like access roads, security measures, drainage systems, power evacuation infrastructure and maintenance facilities, streamline operations for all park residents.

- **Enhanced Security:** Shared security measures, such as surveillance systems, guards, and access controls, enhance overall security, protecting solar assets from theft and vandalism.
- **Effective Land Use:** Proper drainage and water management systems prevent waterlogging, ensuring efficient land use within the park.
- **Efficient Power Evacuation:** Given the solar park size, dedicated transmission lines and substations are established for the efficient evacuation of generated power to the grid.
- **Reduced Environmental Impact:** By centralizing infrastructure, solar parks minimize land disturbance and environmental impact.

Overall, common infrastructure facilities in solar parks benefit customers, businesses, and local authorities while reducing costs and improving operational efficiency.

4 Cost and Benefit Assessment of Solar Parks

These factors below, collectively contribute to the overall cost-benefit analysis of solar parks, highlighting their significance in renewable energy production and economic development:

Cost assessment factors	
Cost Category	**Description**
Land Acquisition	Cost of acquiring land for the solar park, influenced by location, quality, and real estate prices.
Infrastructure Setup	Investment in roads, fencing, security measures, drainage systems, and power evacuation infrastructure.
Solar Panel Installation	Procurement and installation costs of solar panels, influenced by type, efficiency and capacity.
Inverter and Balance of System Equipment	Costs for inverters, wiring, and other components for efficient energy conversion.
Grid Connection	Expenses associated with connecting the solar park to the electrical grid, including transformers and lines.
Maintenance and Operations	Ongoing costs for cleaning and maintaining solar panels, ensuring optimal performance and longevity.

Benefit assessment factors	
Benefit Category	**Description**
Renewable Energy Generation	Solar parks generate clean and renewable energy, contributing to environmental sustainability and reduced emissions.
Stable Energy Costs	Solar power provides stable energy prices, protecting against fluctuations in conventional energy markets.
Job Creation	Solar Park development, construction and maintenance create job opportunities, benefiting the local economy.
Economic Growth	Increased economic activity stimulates growth in the region, including local businesses and services.
Tax Revenues	Higher economic activity generates increased tax revenues for local governments, supporting public services.
Reduced Energy Imports	Solar energy reduces dependence on imported fossil fuels, enhancing energy security and reducing trade deficits.
Green Image and Corporate Social Responsibility	Adoption of solar energy enhances environmental image and sustainability efforts.

- **Independent Solar PV Plant vs Within a Solar Park**

Solar parks offer streamlined processes and shared infrastructure, making them attractive for those seeking cost-effective and faster project deployment over independent projects. Developing an independent SPV plant with a PPA is another approach. Both methods have their advantages and disadvantages, and the choice between them depends on various factors, including project goals, available resources, and local conditions. Below is a comparative analysis of these two approaches:

Advantages	Installing in Solar Park	Acquiring Land and PPA
Infrastructure Benefits	Shared infrastructure facilities reduce setup costs and time.	Direct control over project design and location.
Economies of Scale	Potential cost savings due to shared resources and bulk purchasing.	Customized plant size and technology.
Grid Access Efficiency	Efficient grid connection due to proximity to existing grid infrastructure.	Tailor site selection for maximum solar irradiance.
Permitting and Approvals	Centralized permitting process may streamline regulatory approvals.	Direct management of approvals and permits.
Technical Support	Shared maintenance and technical support services provided.	Control over project-specific maintenance.
Risk Mitigation	Sharing costs with other projects mitigates unforeseen challenges.	Project-specific economics for optimized ROI.
Project Control and Customization	Limited customization due to shared facilities and infrastructure.	High degree of customization and project control.
Direct PPA Negotiations	Negotiating PPAs may be coordinated by solar park management.	Direct negotiations for favorable PPA terms.
Site Selection Flexibility	Potential limitations in site selection based on available land in the park.	Freedom to choose the best location for solar efficiency.
Brand Identity and Autonomy	Operating within a solar park may impact standalone brand identity.	Enhanced brand identity as an independent producer.
Project-Specific Financial Considerations	Potential for standardized financial arrangements.	Project-specific economics tailored to your goals.

It is seen normally that the developers of smaller size plants, such as 1 / 2/ 3 MW capacity, prefer to go in a park so that efforts and costs get favorably distributed rather than carrying out all the work like access roads, fencing, grid connectivity, security, etc. for each small capacity plant. The developers of the higher capacity plants have an option of both and normally decide based on whether they have

capability and interest in operating and maintaining their plant independently or rather go with centralized agency, the park operator.

5 Ultra Mega Solar Parks

Ultra Mega Solar Parks are large-scale solar power projects, typically above 1,000 MW capacity, often planned and implemented by government agencies to accelerate solar energy adoption on a national scale. These projects encompass a series of individual solar power installations, each with a predefined minimum capacity. Governments may provide financial support to fund the construction and operation of these Ultra Mega Solar Parks, as they can attract both domestic and international investments.

These parks also may face challenge of getting land parcels of such a large area as well as connectivity to the grid of such a large capacity power and that is the main reason that government agencies are best placed to take up development of such ultra mega solar parks.

6 Options in Implementation of Solar Parks

Different implementation options offer flexibility in how solar parks are developed and managed, involving various combinations of government agencies, private sector partners, and semi-

government entities. The choice of option depends on factors like government policy, funding availability, and the desired level of private sector involvement.

Implementation Option	Description
Option 1 – Special Purpose Vehicle (SPV)	The designated government agency undertakes the development and management of the solar park. This agency can be an existing government-owned Public Sector Undertaking (PSU) or a new SPV of the government, possibly in partnership with the private sector.
Option 2 – Joint Venture (JV)	A JV is established between the government agency or company and a private or semi-government company for the development and management of the solar park. Equity is divided between the partner and the government agency, often based on agreed-upon percentages.
Option 3 – Solar Park Developer And Operator	The government designates a semi-government company as the nodal agency, and this company takes on the responsibility for developing and managing the solar park on behalf of the government, following mutually agreed terms and conditions.
Option 4 – Private Sector Solar Parks	Private entrepreneurs initiate the development of solar parks, either independently or with varying degrees of equity participation from the government, depending on the specific arrangement.

- **Green Corridor - Requirement for Solar Park**

A green corridor is a dedicated and specialized transmission network designed specifically to efficiency transmit renewable energy, due to their intermittent nature. Solar and wind power generation can vary due to weather conditions, making it challenging to integrate them seamlessly into the conventional grid.

By facilitating the smooth and reliable transfer of renewable energy, a green corridor enhances the overall reliability of the electrical grid. It minimizes disruptions and ensures a stable power supply to consumers, even when renewable sources experience variability.

7 Guidelines for Solar Park Development

Guidelines serve as a foundation for successful solar park development and should be tailored to specific project requirements and local conditions.

Aspect	Details
Minimum Capacity (xxx MW)	Solar parks should have a minimum capacity to ensure economies of scale and efficient power generation.

Transparent Project Developer Selection	Ensure transparent and fair selection processes for project developers to encourage participation.
Suitable Land	Careful land selection, considering factors like solar irradiance and grid connectivity.
Shared Infrastructure	Infrastructure like roads, fencing, and drainage systems should be developed collectively to reduce project costs.
Preferential Access	Ensure preferential access to green corridors for efficient power evacuation.
Centralized Approvals	Streamline the approval process for solar park projects to reduce delays and uncertainties.
Centralized Facility Management	Implement centralized facility management to optimize grid integration and renewable energy distribution.
Government Support	Government support availability through policies, incentives, and subsidies to promote the development of green corridors.
Power Purchase Agreement (PPA)	Encourage the use of PPAs to facilitate the integration of renewable energy generated within the solar parks.

- **Mitigating Measures Necessary for Solar Parks**

Such large capacity at a location also poses other challenges and these need to be addressed. One of the critical necessary measures is to have healthy and high-quality grid for evacuation of generated power from these parks and then transmit it to the other parts of the country or the region. This requires not only an advance planning but also high investments. Measures like establishing grid stabilizing technologies and monitoring systems are equally important. Some of the major measures are explained in the table below.

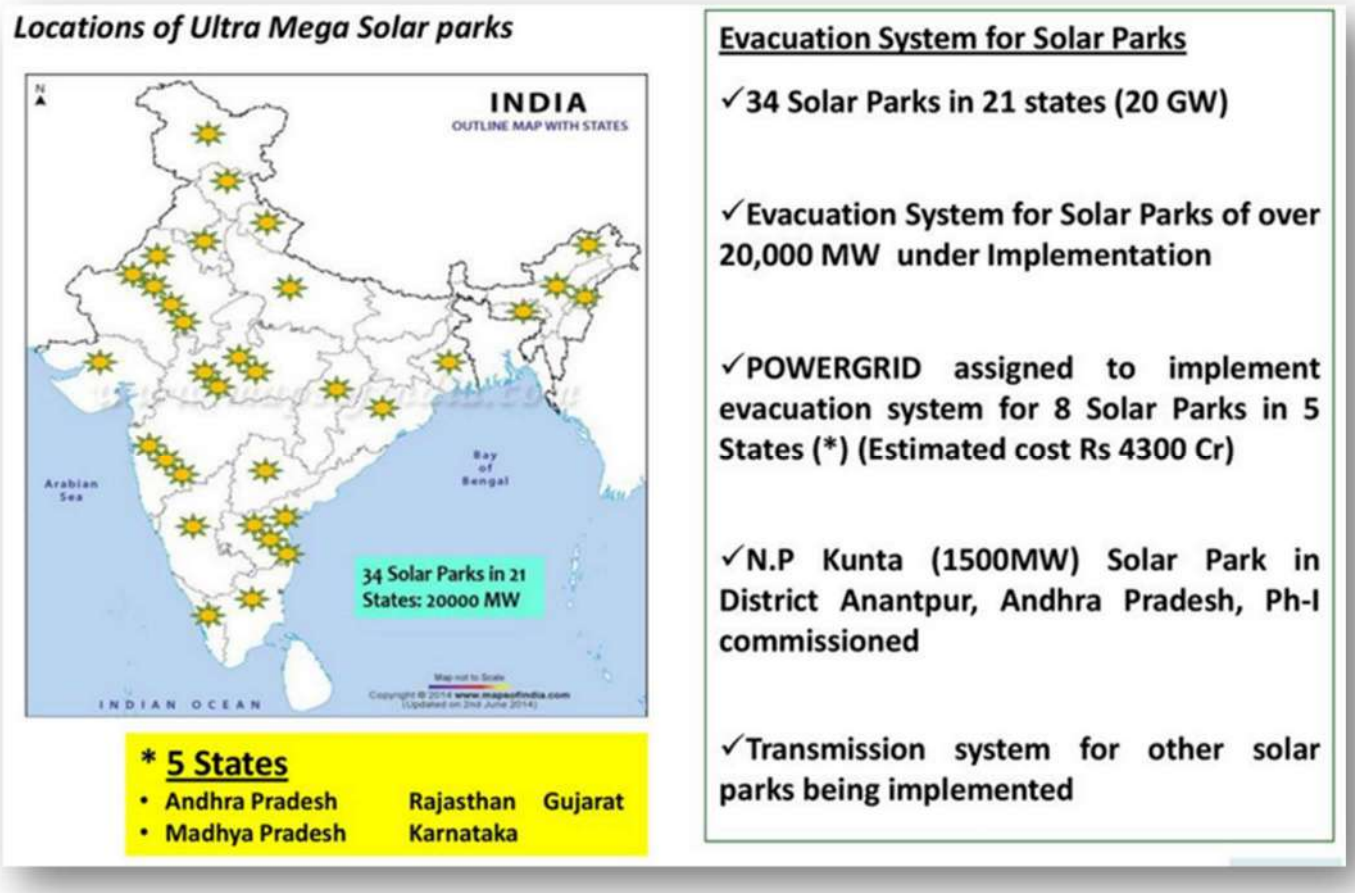
Mitigating Measures	Explanations
Flexible Generation	Deploy flexible backup generation sources like natural gas plants that can quickly adjust their output to match variations in renewable generation.
Ancillary Services for Supply-Balancing	Provide ancillary services such as frequency regulation, voltage control, and reserves to ensure stable grid operation in the presence of variable renewables.
Technical Standard Requirements	Establish technical standards and grid codes that define the rules and requirements for connecting renewable energy sources to the grid.
	Develop connectivity standards to ensure consistent and reliable integration of renewable generation into the existing power infrastructure.

Mitigating Measures	Explanations
Demand Side Management and Response	Implement demand side management strategies to influence and adjust consumer electricity usage to align with renewable generation patterns.
	Deploy demand response programs that allow consumers to reduce or shift their electricity consumption during peak demand or low renewable generation.
Energy Storage for Load Balancing	Utilize energy storage technologies such as batteries and pumped hydro storage to store excess renewable energy and release it during high-demand periods.
Forecasting of Renewable Generation	Develop advanced forecasting techniques that use historical data and weather predictions to accurately predict renewable energy generation.
Forecasting of Demand	Implement demand forecasting tools to predict electricity consumption patterns and adjust energy supply accordingly to avoid imbalances.
Phasor Measurement Units (PMUs) and Wide Area Monitoring Systems (WAMS)	Install PMUs at pooling stations and interconnect them with a centralized control center to provide real-time data for grid monitoring and control.
Policy and Regulatory Advocacy	Engage with policymakers and regulators to advocate for favorable policies that support power balance markets and pricing mechanisms for renewables.
Renewable Energy Management Centers (REMC)	Establish REMCs as control centers that monitor and manage the integration of renewable energy into the grid, ensuring stable and efficient operation.

Reading Material

India Experience in Solar Park Development

- **Implementation Agency**
  - Solar parks in India are developed in collaboration with State Governments.
  - The Ministry of New and Renewable Energy (MNRE) Nodal Agency for solar park development is the Solar Energy Corporation of India (SECI) on behalf of the Government of India.
  - Originally, in February 2017, the Union Cabinet increased the total number of planned solar parks to 50 with a total capacity of 40 GW.
  - By April 2017, 34 solar parks were under construction across 21 states.



- **Implementation of Solar Parks Modes**
  - Mode 1: The State-designated nodal agency undertakes the development and management of the solar park. This agency could be a State Government PSU or an SPV of the State Government.
  - Mode 2: A JV is set up between the State-designated nodal agency and SECI for the development and management of the solar park. The equity is shared, with 50% from SECI and 50% from the State Agency (more than one agency allowed).
  - Mode 3: The State designates SECI as the nodal agency, and SECI undertakes the development and management of the solar park on behalf of the State Government on mutually agreed terms.
  - Mode 4: Private entrepreneurs promote solar parks without any equity participation from SECI but may have equity participation from the State Government or its agencies.
- **Financing Model by MNRE**
  - The total cost of development, including land acquisition, forms the project's total cost. An estimate is prepared by the nodal agency.
  - Based on this estimate, the implementing agency formulates a recovery model to ensure the sustainability of the park.
- **Support by MNRE**
- The State Government identifies the nodal agency for the solar park and the land for the proposed solar park.
- The State Government sends a proposal to MNRE for approval.
- After MNRE approval, the implementing agency may apply for a grant of Indian Rupees (INR) 2.5 million for preparing a Detailed Project Report (DPR) of the solar park and conducting surveys.
- Subsequently, an application may be made for a grant of up to INR 2.0 million per megawatt (MW) or 30% of the project cost, including grid connectivity cost, whichever is lower.