Module Outline

PROJECT DEVELOPMENT – UTILITY SCALE

Disclaimer

Relevance and Background

The global energy landscape is experiencing a transformative shift towards sustainable and renewable energy sources, and solar energy is at the forefront of this transition. Utility-scale solar energy projects are gaining prominence due to their potential to generate clean electricity, reduce emissions, and enhance energy security. Also, several stakeholders, including manufacturers, contractors, government entities, etc., are involved in executing such projects, making collaboration and coordination essential for success. Therefore, it is important to understand the often-complex issues related to "Project Development – Utility Scale".

Theme – Project Management
Competency – Project Development (Utility Scale)
Code of the Module – T03C07M19

Learning Outcomes

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

- Navigate the phases of utility-scale solar project development.
- Evaluate legal and regulatory frameworks.
- Understand financial considerations and risk mitigation strategies.
- Manage project risks related to utility-scale project development
- Master project management skills specific to such solar projects.
- Understand critical infrastructure and contractual agreements.
- Incorporate sustainability principles into project planning.

Method of Delivery

Duration	Resource Code	Resource Delivery
60 min.	M19 L01	Lecture on Project Development – Utility Scale

M19 L01: Lecture Presentation

The MS PowerPoint presentation will cover comprehensive knowledge about project development issues related to utility-scale solar PV projects, including the legal and regulatory frameworks, financing considerations, project risks and their mitigation, planning, scheduling and implementation.

Key Topics to be Covered

1. Project Management as an Effective Tool
2. Critical Aspects of Components
3. Legal and Infrastructural Components
4. Contracts in Utility-Scale Solar Projects
5. Financing the Project
6. Project Scheduling
7. Solar Plant Implementation Phases

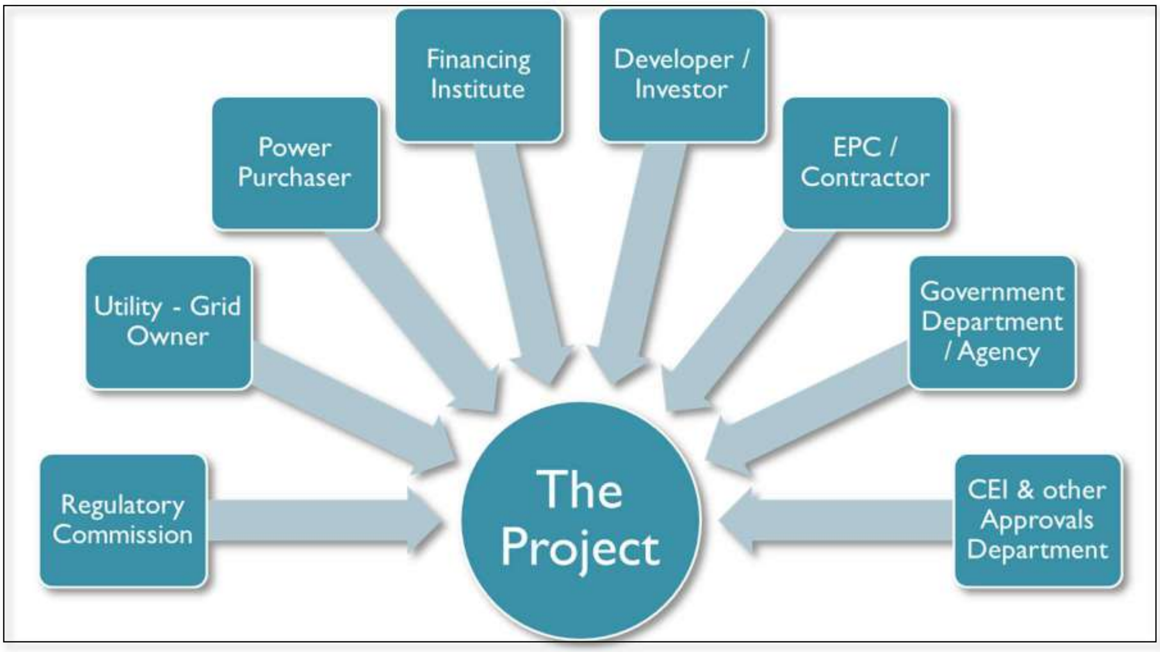
Table of Contents

1 Background

Utility-scale solar projects, often operating in the megawatt (MW) or multi-megawatt range, have become a focal point in the renewable energy landscape. Typically, these projects are initiated through government tenders aimed at procuring solar energy. They can take various forms such as solar parks developed for multiple stakeholders or standalone plants for self-consumption or third-party energy sales. While the specifics of their development strategies and progress stages may vary, they share common aspects that are worth exploring.

Challenges and Characteristics of Utility-Scale Solar Projects: Solar project development, especially at this scale, is marked by its complexity. Several unique features set these projects apart including demanding timelines, tight budgets, limited pre-development groundwork, and a shortage of experienced personnel in some countries. In this dynamic landscape many newcomers such as developers, engineering, procurement, and construction (EPC) companies, consultants, and financial institutions are entering the solar sector all over the world. Additionally, multinational companies including suppliers, investors, developers, and contractors, are also actively participating in national markets.

- Utility-scale solar projects come in various forms and configurations.
- They can utilize different types of **PV technologies** like thin-film (Amorphous Silicon (aSi), Copper Indium Gallium Selenide (CIGS), Cadmium Sulfide-Cadmium Telluride (CdS-CdTe), crystalline (Mono, Poly, Mono-PERC (Passivation Emitter Rear Contact), Poly-PERC), bifacial and others.
- The choice of **mounting systems**, whether fixed, single-axis, double-axis, or seasonal, is influenced by factors like location and project requirements.
- The selection of **inverters** (central, string, micro) depends on the project's scale and design.
- These projects are scattered across **diverse geographic locations**, each with its unique environmental conditions, including temperature, dust, and water availability.
- The **surface types** for solar installations also vary encompassing rooftops (flat, sloping, with different roofing materials), and ground-mounted systems (on rocky terrain, hard soil, clayey soil, ash, or soft soil).
- **Interconnection to the grid** can occur at high or extra-high voltage levels further adding to the project's complexity.
- Different entities including manufacturers, EPC contractors, and instrumentation and control (I&C) contractors are involved in executing utility-scale solar projects making collaboration and coordination essential for success.



2 Project Management as an Effective Tool

Project management is the disciplined application of knowledge, skills, tools, and techniques to project activities, to achieve its objectives. This involves five crucial process groups:

- **Initiation:** This phase involves identifying the project's requirements and addressing various needs, concerns, and expectations at every stage of the project.
- **Planning:** During this stage, project managers define the project's objectives. For instance, consider a project to complete a 1 MW solar PV (Photovoltaic) power plant. The planning process may include:
  - **Identifying Requirements:** Clearly specify the project's requirements and identifying stakeholders and beneficiaries.
  - **Addressing Needs and Concerns:** Ensuring that all aspects of the project, from licensing and sanctions to safety and utility grid connectivity, are considered.
  - **Project Definition:** Defining the project within the constraints of time, budget and quality. For instance, the project must be completed within the allotted time, budget, and regulatory constraints.
  - **Optimization:** While achieving maximum output may not always be possible, the goal is to optimize performance. This involves designing the plant efficiently, using high-quality materials, ensuring skilled workmanship, sequencing project development in a logical way, and sourcing reliable components.

- **Execution:** This phase involves carrying out the project plan. In the case of a solar power plant, it includes constructing the plant, installing equipment, and implementing the project as outlined in the planning phase.
- **Control and Monitoring:** Continuous monitoring is essential to ensure that the project stays on track. This includes tracking the project's progress, comparing it to the project management plan, and adjusting as needed.
- **Closing:** Upon project completion, i.e., when the plant is being handed over for O&M after commissioning (and synchronizing with the grid), it is important to ensure that all project requirements have been met, approvals to operate obtained, and the project has achieved its intended objectives.

3 Critical Aspects of PV System Components

In the development of utility-scale solar projects, the choice and quality of components play a pivotal role in ensuring efficiency, reliability, and long-term performance. Here are some critical components and considerations:

- **Solar Modules:** Solar panels, or modules, are at the heart of any solar power system. Their efficiency, durability, and warranty terms are key factors. Key considerations include:
    - Efficiency: High-efficiency panels generate more electricity per unit area.
    - Durability: Panels should withstand environmental factors like hail, wind, and extreme temperatures.
    - Warranty: Warranty terms should be evaluated for both product and performance guarantees.
- **Inverters:** Inverters convert DC power generated by solar panels into AC power for grid connection. Key considerations include:
    - **Type:** Choose between central inverters, string inverters, or microinverters based on project size and design.
    - **Efficiency:** Inverter efficiency impacts overall system performance.
    - **Reliability:** The durability and lifespan of inverters are crucial.
- **Mounting Structures:** Proper mounting structures are essential for securing solar panels. Key considerations include:
    - **Type:** Choose between fixed, single-axis, or dual-axis tracking systems.
    - **Material:** Ensure the materials used are corrosion-resistant and durable.
    - **Orientation:** Optimize the tilt and orientation for maximum sunlight exposure.
- **Cables and Connectors:** Electrical connections are vital for system performance. Key considerations include:
    - High-quality, UV-resistant cables are necessary for outdoor use.
    - Connectors should have proper sealing to prevent moisture ingress.
- **Evacuation Infrastructure:** This includes transformers and meters for grid connection. Key considerations include:
    - **Transformer Capacity:** Adequate transformer capacity for power conversion.
    - **Metering:** Proper metering for accurate energy measurement and billing.
- **Hardware for Mounting Modules:** Bolts, clamps and brackets are used for securing solar panels. Ensure the hardware material is corrosion-resistant and of high quality to ensure structural integrity.
- **Earthing for Different Components:** Earthing or grounding systems are required for safety and protection against electrical faults.
- **Lightning Protection:** Systems to safeguard against lightning strikes and protect equipment are necessary components.
- **Data Monitoring and Weather Station:** Monitoring systems are necessary to track system performance and weather conditions.

- **Roads, Fencing, Security, etc.:** These are critical infrastructure for site access, security, and protection.

Matrix for Component Selection Criteria: When selecting components, it is important to create a matrix of criteria. Examples of criteria include:

Components	Factors to be considered before selection			
Modules	Temperature coefficient	Tolerance levels in supply	PID effect; EL testing	Lamination, cells, JB, frame
Inverter	Efficiency at part load	Temperature effect on performance	Dust factor	Component replaceability and availability
Structure	Galvanizing over worked steel	Flexibility and rigidity	Fixing stability to the ground	Alignments; maintenance requirements
Cabling	UV resistance	Resistance to temperature, moisture, rodents, etc.	Losses in cable lengths	Laying; identification
Civil	Material quality & deliveries	Sequence of operations	Suitability to soil and atmosphere	Water drain

- **PID = Potential Induced Degradation**
- **EL = Electro Luminance**
- **JB = Junction Box**
- **UV = Ultraviolet**

Selecting the right components based on these criteria is essential for the success of utility-scale solar projects, ensuring optimal performance and long-term viability.

4 Legal and Infrastructural Components

In the development of utility-scale solar projects, several legal and infrastructural components are crucial for a seamless and compliant project implementation process. These components vary depending on the project's size, location, and type. Here's an overview of some key legal and infrastructural aspects:

- **Project Implementation Types:**
  - **Consulting and EPC:** This involves hiring a consulting firm to plan and design the project, followed by the selection of an EPC contractor to execute the construction.
    - **Conceptualization:** The initial phase where the project idea is conceived and feasibility studies are conducted.
    - **Financing:** Securing the necessary financial resources for project development.
    - **Design:** Detailed engineering and design of the solar power plant.
  - **EPC:** The main phase where engineering, procurement of components, and construction of the project take place.
  - **EPC Lite:** A variation of EPC where part of the procurement is done by the developer, often to reduce costs.
  - **EPC (part) & O&M (Operations and Maintenance):** The EPC contractor also provides limited O&M services for a defined period besides a regular EPC services.
- **Legal and Infrastructural Components:**
  - **Land Type Registration:** Ensuring that the land where the solar project is located is registered appropriately for the intended use.

- **Local Body No-Objection Certificate (NOC):** Obtaining clearance from local authorities for project development.
- **Access Permissions:** Ensuring unrestricted access to the project site during construction and operation.
- **Water Drawing Permissions:** If water is required for project activities, obtaining the necessary permits for water usage.
- **Electrical Connections for Construction:** Ensuring that temporary electrical connections are in place for construction activities.
- **Grid Operator Specifications, Inspections, and Brands:** Meeting grid operator requirements for interconnection, including inspections and adherence to branding guidelines if required.
- **Government Appointed Electrical Authority for Grid Connection:** Complying with government regulations related to electrical connections.
- **Concessional Import Duty Certificates:** If applicable, obtaining certificates for concessional import duties on equipment.
- **Safety Audits and Checks - Permit to Work:** Ensuring safety audits are conducted, and necessary permits are obtained for work activities.
- **Developer's (Client's) Engineer Permissions and Inspections:** Involving engineers for project oversight and compliance.
- **Lender's Engineer Inspections:** If the project is financed, inspections by the lender's engineer may be required.
- **Labor Laws - Register, Provident Fund, Health Insurance, Workman Compensation Policy, Lodging, and Boarding:** Compliance with labor laws, including registering employees, providing benefits, and ensuring safe working conditions.

- **These legal and infrastructural components are essential for the successful development and operation of utility-scale solar projects.**

5 Contracts in Utility-Scale Solar Projects

Contracts play a pivotal role in the successful execution of utility-scale solar projects. These contracts govern various aspects of the project, from sourcing equipment to service and safety. Here's an overview of the key considerations related to contracts in the context of such projects:

Contracts in Utility-Scale Solar Projects	Considerations
Sourcing of Major Equipment	
- Local or imported?	Decision factors: Price, Availability, Serviceability, Certifications, Warranties, Local Regulations.

- Global Leaders	Modules: China, USA, Europe, India; Inverters: China, Europe, USA, India; Cables, Connectors: Local, China; Structures: Local.
- Main Decision Factors	Price, Availability, Serviceability, Certifications, Warranties.
Procurement Contracting	
- Specifications and Part Numbers	Specify equipment details, part numbers.
- Delivery Schedule	Outline planned delivery schedule, implement checks for adherence.
- Packing and forwarding	Consider warehousing, transportation, documentation requirements.
- Test Certificates	Include self-testing and third-party test certificates.
- Warranties and Insurances	Detail equipment warranties and insurance coverage.
- Identification Standards	Establish standards for packaging and equipment identification.
- Payment Terms	Define payment terms, penalties, spares provision, on-site supplier scope.
Service Contracting	
- Contractor Qualifications	Ensure contractors have necessary licenses.
- Scope of Work	Define precise scope of work, schedules, and manpower allocation.
- Guarantees	Include advance and performance bank guarantees, audits, and checks.
- Documentation	Specify documentation requirements, certification for work acceptance.
Safety Contracting	
- Performance Warranty	Define conditions, security types, third-party insurance, bank guarantees.
- Product Warranty	Ensure warranties, corporate guarantees, and bank guarantees are in place.
- Payment Terms	Align pricing with payment terms, credit types, profit participation, and escrow accounts.

Contracts in utility-scale solar projects are comprehensive documents that require meticulous attention to detail. They serve as the foundation for project planning, execution, and risk management, making them a critical component of successful project development.

6 Financing the Project

Financing a utility-scale solar project is a crucial aspect of its successful implementation. Various financing possibilities and requirements need to be considered to ensure the project's viability. Below are key considerations:

Financing Aspects	Considerations
DE Ratio (Debt-Equity Ratio)	• Common D/E Ratio: 2.33 (70% debt, 30% equity)
Equity Financing	• Developer's Own Funds • Private Equity Participation • Community/Group Equity
Debt Financing	• Banks (Nationalized/Cooperative) • Foreign Banks or Foreign Institutional Investors (FII) • Non-Banking Financial Companies (NBFCs)
Collateral Security	• Percentage varies (20% to 100% of loan amount) • Collateral may include project assets or land
Project Financing vs. Balance Sheet	• Project Financing: Creates a separate SPV for the project
Financing	• Balance Sheet Financing: Uses the developer's financials
Bank Guarantees (BGs) and Securities	• Required for international projects or with foreign lenders • Acts as a guarantee and risk mitigation for lenders

- **D = Debt**
- **E = Equity**
- **SPV = Special Purpose Vehicle**

7 Project Scheduling

Typical work divisions to be considered for project scheduling are as follows:

Work Division - Contractors for DC Electrical	Work Division - Contractors for AC Electrical	Work Division - Contractors for Civil	Work Division - Contractors for Security and Infrastructure
- Structure erection.	- Inverters to transformers with protective gear.	- Leveling and/or contouring of land.	- Fencing to the plot.
- Module mounting.	- Metering and fuses.	- Foundations for structures.	- Internal and access roads.
- Module interconnections.	- Interconnection to the grid.	- Earthing and pits.	- Security.
- Earthing of modules and structures.	- Auxiliary power requirement like plant lighting, AC, etc.	- Cabling routing trenches and pits.	- Cabins and rooms.
- Cabling till inverters through combiner boxes.		- Water layout and drainage.	

8 Solar Plant Implementation Phases

Solar Power Plant Installation: The installation of a solar power plant is primarily managed by the EPC contractor, who holds significant responsibilities throughout the process such as:

- **Handling of Total Installation:** The EPC contractor is responsible for the complete installation of the solar power plant, from setting up the solar modules to the electrical connections and commissioning.
- **Commissioning of Plant:** Commissioning involves ensuring that all components and systems of the solar plant are working correctly. This process includes testing, fine-tuning, and optimizing the plant's performance.
- **Executing Working Demonstration:** The EPC contractor is also responsible for demonstrating the operational capacity of the solar power plant to the investor or client.

The EPC contractor typically manages and coordinates several sub-contractors for different aspects of the project:

- **Civil Contractor:** Responsible for civil engineering work, including foundation and structural support for the solar modules.

There are other suppliers and contractors for the installation of:

- **Earthing & Lightning Protection:** Ensures that the solar plant is properly grounded and protected from lightning strikes.
- **Inverter:** Converts DC electricity generated by the solar panels into AC electricity for use.
- **AJB (Array Junction Box)/SCB (String Combiner Box)/SMB (String Monitoring Box):** Junction boxes and monitoring equipment.
- **LV Panel:** Manages the low-voltage electrical panels.
- **Transformer:** are required for voltage conversion for transmission or distribution.
- **HT Panel:** Manages the high-tension electricity.
- **Switch Yard:** An interface between the solar plant and the electric grid providing points for switching and isolating the various elements.

Manpower Requirement: A typical project of a 25 MWp solar power plant requires following dedicated workforce:

- Electrical/Electronic Engineer: 2 engineers
- Civil Engineer: 1 engineer
- Technicians: A team of 5 technicians with expertise in various aspects of installation
- Helpers: A significant number of helpers are needed for various tasks:
  - Mechanical Mounting Structure (MMS): 30 helpers
  - Solar Module Installation: 30 helpers
  - Electrical Wiring: 10 helpers

It is important to note that the target completion time for this size plant is approximately five months. Therefore, reliable, trained and experienced workforce is essential to meet the project's timeline and

quality standards.

Stages of installation: These stages represent the comprehensive process of installing a solar power plant, from site preparation to commissioning. Each step is crucial to the plant's successful operation and energy generation.

Sl. No.	Installation Stage	Description
1	AutoCAD Drawing for Preparation of Land	Preparation of land layout plans and surface contours using AutoCAD.

Sl. No.	Installation Stage	Description
2	Fencing Marking and Execution	Installation of perimeter fencing around the plant area.
3	Water Supply - Bore Wells, Storage Tank	Installation of bore wells and water storage facilities.
4	Security Room	Construction of a security room for plant protection.
5	Leveling of Land	Leveling and grading of the land for infrastructure.
6	Boundary Lighting	Installation of boundary lighting for safety.
7	Construction of Inverter & Control Room	Building the inverter and control room infrastructure.
8	Civil Work for MMS	Civil engineering work for module mounting structures.
9	Earthing	Installation of grounding systems for safety.
10	Trenches for Cable Laying	Digging trenches for cable laying.
11	Structure Assembly	Assembly of MMS.
12	PV Module Mounting	Mounting of PV modules on structures.
13	AJB/SMB Structure & AJB Installation	Installing array junction boxes and structures.
14	Module Interconnection Wiring	Wiring connections between PV modules.
15	Earthing System of DC Field	Grounding the DC field for safety.
16	Lightning Arrestor Installation	Installation of lightning arrestors.
17	DC Cable Installation in Conduits and MC4 Termination	Laying DC cables in conduits and terminations.
18	Cable Laying from AJB to Inverter	Laying cables from array junction boxes to inverters.
19	Inverter Installation	Installation of solar inverters.

Sl. No.	Installation Stage	Description
20	SCADA Installation	Installation of Supervisory Control and Data Acquisition (SCADA) system.
21	Transformer Erection, Cable Termination & Testing	Installation, cabling, and testing of transformers.
22	HT Panel Erection, Cable Termination & Testing	Installation, cabling, and testing of high-tension panels.
23	Commissioning of Plant	Final testing and commissioning of the entire solar plant.

AJB/SMB = Array Junction Box / String Monitoring Box

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)